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Effect of different ethephon doses on grain yield and yield components of in barley (*Hordeum vulgare* L.)

Arzu MUTLU[1]* Abdullah OKTEM[2]
Akçakale Vocational School, University of Harran, Şanlıurfa,
(https://orcid.org/0000-0001-8992-8371)
Field Crop Science, Faculty of Agriculture, University of Harran Şanlıurfa,
(https://orcid.org/0000-0001-5247-7044)
*: e-mail: amutlu@harran.edu.tr

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Abstract: This study was carried out under supplementary irrigated conditions in the Harran Plain in 2008-2009 and 2009-2010 growing seasons. The study aimed to assess the effects of various ethephon doses on durum wheat and barley cultivars. Nine ethephon dosages (0, 240 g/ha, 360 g/ha, 480 g/ha, 600 g/ha, 720 g/ha, 840 g/ha, 960 g/ha, 1080 g/ha) were applied in the study. The results of the combined analysis of two years indicated that the highest grain yield was recorded for Sur-93 cultivar with 4365.63 kg/ha in 600 g/ha ethephon application, while the lowest grain yield of barley was obtained from land race black barley with 1978.00 kg/ha (in control application). The result revealed that ethephon had positive effect on to grain yield. There was not any statistical significants between 960 g/ha and 1080 g/ha ethephone doses in terms of grain yields for land race black barley cultivar. When the years and barley cultivars is evaluated together, the highest grain yield is obtained with 960 g/ha dose of ethephon. Results showed that ethephon application to barley shortened plant height and increased 37-46% of barley yield, and the effects of ethephone varied were connected to cultivar specific. In addition Sur-93 600 g/ha, and a land race black barley cultivar 960 g/ha could be recommended.

Keywords: Barley, ethephon, yield, quality, lodging

Arpa Bitkisinde Farklı Etephon Dozlarının Tane Verimi ve Verim Komponentleri Üzerine Etkisi

Öz: Bu çalışma, 2008-2009 ve 2009-2010 yetiştirme sezonlarında Harran Ovası ilave sulanan koşullarda yürütülmüştür. Bu çalışma ile farklı dozlardaki ethephon uygulamalarının makarnalık buğday ve arpa çeşitleri üzerine etkilerini belirlemek amaçlanmıştır. Denemede 9 ethephon dozu (0, 240 g/ha, 360 g/ha, 480 g/ha, 600 g/ha, 720 g/ha, 840 g/ha, 960 g/ha, 1080 g/ha) uygulanmıştır. İki yılın birleşik analiz sonuçlarına göre arpa bitkisinde de artan ethephon dozlarına paralel olarak tane veriminde artış meydana gelmiştir. Sur-93 arpa çeşitinde en yüksek tane verimi 600 g/ha ethephon uygulamasında 4365.63 kg/ha iken en düşük tane verimi Yerli arpa çeşitinde 960 g/ha ethephon uygulamasında 1978.00 kg/ha olmuştur. Yerli arpa çeşitinde 960 g/ha ile 1080 g/ha ethephon uygulamaları arasında istatistiki açıdan bir farklılık görülmemiştir. Yıllar ve çeşitler birlikte değerlendirildiğinde arpada en yüksek tane verimi 600 g/ha ethephon uygulamasında elde edilmiştir. Sonuç olarak, arpada ethephon uygulamasının bitki boyunu kısalttığı ve verimi %37-46 yükselttiği, çeşite göre uygulanan dozun değiştiği anlaşılmıştır. Yerli arpa çeşitinde 960 g/ha, Sur-93 çeşidinde 600 g/ha ethephon uygulamalarının tavsiye edilebilir ve ekonomik anlamda en uygun uygulamalar olduğu söylenebilir.

Anahtar kelimeler: Arpa, ethephon, verim, kalite, yatma

1. Introduction

Barley, based on the production area (26.1 million ha) and total yield (7.4 mil. ton), is the second important cereal following wheat in Turkey. In southeast of Turkey, barley has been produced on 372,030.5 ha and total produced grain yield was 556,876 ton (Anonim 2020). Compared to wheat, early maturation of barley allows cultivation of a second crop within the same season which is very important in irrigated areas such as Harran Plain. Barley as a winter cereal is widely planted in southeast of Turkey. However, barley is very sensitive to lodging and even under normal precipitation and fertilization conditions lodging is widely observed and it causes significant yield reduction. Therefore, lodging prevention would make significant contribution to the region and the state economy.

Lodging causes yield reduction by reducing plant growth, reduced photosynthesis and prevented carbohydrate assimilation. Severe lodging generally occurs prior spiking stage which causes 27-40% yield reduction while lodging during kernel maturation causes 20% yield reduction (Rademacher 2009). Lodging is major risk and issue for intensive cereals production and it causes reduced yield and low quality cereals.

Plant growth regulators (PGR) have been applied to cereals from sowing to harvest to increase yield and quality of cereals in Turkey and around the world (Karakus and Koker 2007; Rademacher 2009), reported that some of the PGR reduce plant height, stabilize shoot, auricle and other plant parts growth and increase resistance against lodging by improving plant root development. Ethephon has been reported as one of the PGR that reduces cereals lodging.

In this study, we intended to determine the effect of ethephon on loading reduction of barley cultivars Sur-93 and a local barley cultivars.

2. Materials and Methods

The study was conducted in Şanlıurfa - Harran plain during 2008-2009 and 2009-2010 growing seasons. Climate data about the growing seasons of the study was conducted has been given in Table 1. In this study, Sur 93 and a local barley cultivar were used as plant materials. Both barley cultivars, during high precipitation and under irrigated conditions, have been shown to be highly susceptible to lodging. The study was carried out as split plot experimental design with four replications. Main plots were barley cultivars while Ethephon [(2-chloroethyl) phosphoric acid] dosages were the subplots. Applied ethephon dosages were 0, 240, 360, 480, 600, 720, 840, 960 and 1080 g/ha.

Ethephon was applied to foliar with a backpack sprayer according to Feekes' scale at 8-9 stages during flag leaf development (Akkaya 1994). Untreated (control) plants were treated with water only. Screens were placed in between plots to prevent drift of the applications. Each plot was 5 m long and covered 6 rows of the crops. There was 20 cm spacing between the rows.

Table 1. Some monthly climatic values of Şanlıurfa belong to research years of 2008-2010.
Çizelge 1. *2010 Yılları Şanlıurfa İline ait aylık iklim değerleri*

Month	2008-2009			2009-2010		
	Temperature (**^{0}C**)	Precipitation **(mm)**	Moisture (%)	Temperature (^{0}C)	Precipitation **(mm)**	Moisture (%)
November	14.1	35.3	62.4	12.2	35.5	62.6
December	7.0	37.7	58.6	10.1	121.2	73.4
January	5.8	29.8	59.1	8.4	95.7	68.8
February	8.0	56.6	72.2	9.1	23.5	67.4
March	10.0	55.3	65.6	13.8	42.7	55.7
April	15.8	48.8	53.0	17.4	26.2	46.7
May	22.8	4.7	33.6	24.0	7.1	34.3
June	29.6	9.2	29.2	29.4	0.5	31.2
Average/Total	14.14	337.4	50.09	15.53	352.4	55.01

Planting density was 600 seeds / m^2 and seeds were sown with a seeder. The seeds were sown during 2008-2009, 2009-2010 growing seasons within month of October. All plots were irrigated with sprinklers until soil water holding capacity is reached.

During irrigations water runoff was not allowed. The plots were re-irrigated when 40% of the soil moisture was used up to restore the soil moisture (Rawlins, 1976). During sowing 15-15-15 compound fertilizer was applied based on 80 kg NPK / ha. Based on soil analysis, P and K fertilizers were applied at 80 kg/ha rate during planting while N fertilizer was applied at 180 kg/ha throughout of the vegetative growth. Half of the N fertilizer was applied during planting while the other half was applied during tillering stage. Granstar (%75 tribenuron methyl) herbicide was applied at 1.5 kg/ha rate to control broadleaf weeds and İlloxan (284 g / L diclofop methyl) was applied to control grasses. Barleys were harvested in June for both years. The

2008

recorded data were analyzed using ANOVA and means were separated by LSD.

Table 2. The Results of Variance Analysis
Çizelge 2. *Varyans analiz sonuçları*

		Squares Average				
Source of variation	DF	Grain yield	Plant height	Lodging	Kernels/Spike	1000-kernel weight
Year	1	160981.501	49.351	311.103	2.176	84.671
One year	6	512.840	2.577	41.639	4.595	1.807
Cultivar	1	492909.306	2155.281	9529.182	603.112	1295.880
Year x Cultivar	1	22397.617	14.887	3336.012	0.012	2.007
Error 1	6	503.625	11.038	86.246	1.865	0.608
Ethephon	8	35656.723	2556.516	7611.927	372.373	192.893
Year x Ethephon	8	1417.001	11.730	35.266	0.065	2.176
Cultivar x Ethephon	8	4181.356	154.492	1263.735	13.714**	14.086
Year x Cultivar x Ethephon	8	499.725	5.327	71.475	0.057	18.121
Error	96	604.962	5.495	19.019	1.181	1.275
General	143	7514.000	172.400	714.994	26.903	23.340

*: Significant at P=0.05, **: Significant at P=0.1

3. Results and Discussion

3.1. Grain yield (kg /ha)

Yield of Sur 93 cultivar was 2557.5 kg/ha during 2008-09 growing season when it was not treated with ethephon while 600 g/ha ethephon treated Sur 93 barley cultivar produced 3874.5 kg/ha (Table.3). During 2009-2010 growing season grain yield increased proportional to the rates of applied ethephon. The cultivars produced 2947 kg/ha when was not treated with ethephon while 600 g/ha ethephon treated barley plants produced 4856.75 kg /ha. Increased rate of ethephon (600, 720, 840, and 960 g/ha) did not significantly increased yield while 1080 g/ha ethephon slightly reduced yield. Although the differences were not statistically significant, yield gradually decreased as ethephon rate increased from 600 to 960 g/ha (Figure 1). The yield decreased after the 600 g/ha doses.

Table 3. Grain yield values of barley varieties in different ethephon applications and LSD groups.
Çizelge 3. *Farklı ethephon uygulamalarında arpa çeşitlerinin tane verimi değerleri ve LSD grupları*

Cultivar	Ethephon Doz (g h-1)	2008-2009	2009-2010	Average
Sur-93	0	2557.50 c*	2947.00 d	2752.25 d
	240	3360.50 b	4347.50 c	3854.00 c
	360	3584.75 ab	4410.75 bc	4001.75 bc
	480	3807.50 a	4734.50 ab	4271.00 a
	600	3874.50 a	4856.75 a	4365.63 a
	720	3831.75 a	4850.50 a	4341.13 a
	840	3797.50a	4836.50 a	4317.00 a
	960	3766.75 a	4807.00 a	4286.87 a
	1080	3663.50 ab	4709.00 ab	4186.25 ab
Cultivar average		**35826.9 A**	**4500.83 A**	**4041.76 A**
Local Barley	0	1887.50 f	2068.50 e	1978.00 e
	240	2337.25 e	2512.50 d	2424.88 d
	360	2521.75 de	2873.50 c	2697.63 c
	480	2632.25 de	3047.50 bc	2839.88 d
	600	2657.00 cde	3070.00 bc	2863.50 c
	720	2692.50 bcd	3185.75 bc	2939.13bc
	840	3020.25 ab	3228.75 b	3124.50 b
	960	3221.50 a	3960.50 a	3591.00 a
	1080	2988.00 abc	3784.50 a	3386.25 a
Cultivar average		**2662.00 B**	**3081.28 B**	**2871.64B**
Year average		**3122.35 B**	**3791.06 A**	

Year LSD: 9.157, Cultivar LSD: 9.157 Year x Cultivar LSD: 12.950, Cultivar x Dozage LSD:24.442, Year x Cultivar x Dozage LSD: 34.566: Within columns, means followed by same letter do not differ significantly at p=0.05 (LSD)

In regard to the interactions between barley cultivars and ethephon rates, control (untreated) plants of the local barley produced the lowest grain yield (1887.50 kg/ha) while the highest grain yield (3874.50 kg/ha) produced by Sur-93 and ethephon (600 g/ha) combination in 2008-2009 while during 2009-2010 the lowest yield (2068.50 kg/ha) was produced by local barley cultivar when untreated with ethephon and the highest yield (4856.75 kg/ha) was produced by Sur-93 and ethephon (600 g/ha) combination. Based on average yield, Sur-93 cultivar produced higher (3582.69 and 4500.83 kg/ha) yield in both years compared to the local cultivar (2662.00 and 3081.28 kg/ha). The results indicated that Sur-93 and the local cultivar responded differently to the applied rates of ethephon. Sur-93 grain yield increased proportionally as ethephon applied ethephon rates increased up to 600 g/ha while the local cultivar grain yield proportionally increased as applied ethephon concentration increased up to 960 g/ha.

Ethephon applications reduced plant height and lodging but increased grain yield Sur-93 produced the highest grain yield of 4365.63 kg/ha when treated with ethephon 600 g/ha while the local cultivar produced the highest yield of 3591.00 kg/ha. Regression analysis of Sur-93 and ethephon concentrations indicated that regression equation was as $y = 284.1 + 0.4271x - 0.0003x^2$ ($R^2 = 0.974$) (Figure 1) while regression equation of the local cultivar and ethephon concentrations was as $y = 208.8 + 0.133x$ ($R^2 = 0.929$) (Figure 2)

The barley cultivars included in this study were tall cultivars but susceptible to the lodging. Rainy seasons, irrigation and application of N fertilizers cause overly growing of already tall varieties and worsen lodging during spike development stage. Ethephon application prevent plant lodging by reducing plant height, and reduced lodging improve grain development that lead increased yield.

Previously it has been reported that ethephone application reduces plant height thus increases grain yield (Lundgaard 1984; Szirtes et al. 1986; Wiersma et al. 1986; Penckowski et al. 2009; Radamacher 2009).

Especialy local barley cultivars are susceptible to loading which is the main cause of reduced grain yield in the region. Ethephone treated plants produced greater grain yield compared to untreated plants.

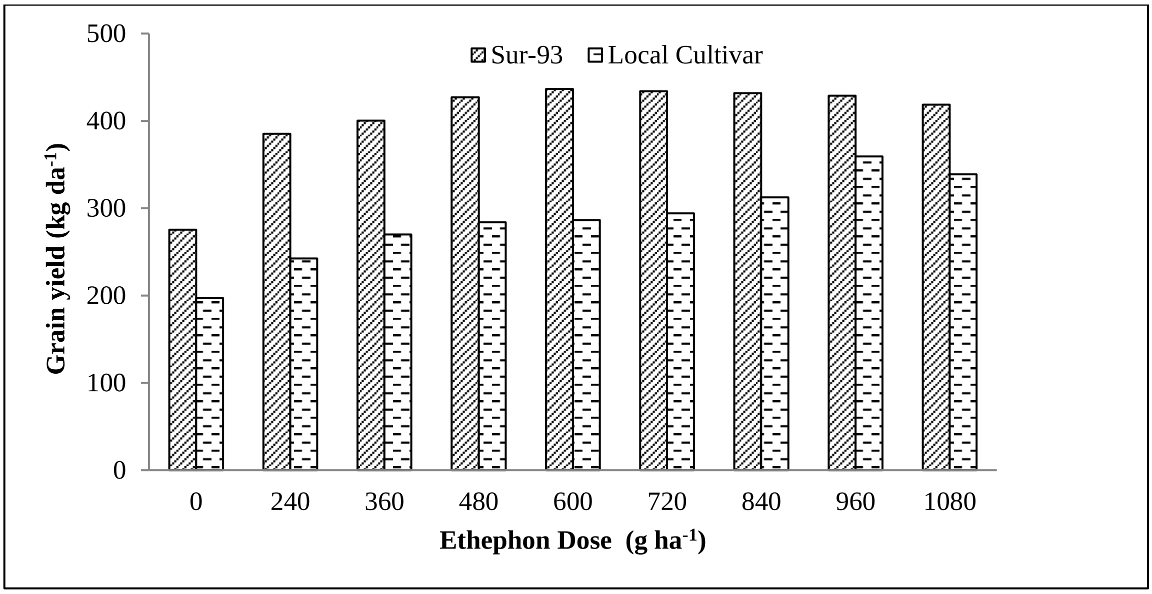

Figure 1. Barley grain yields of Sur-93 and Local Cultivar with different ethephon doses
Şekil 1. *Farklı etephon dozlarında Sur-93 ve Yerli Arpa çeşitlerinin tane verimleri*

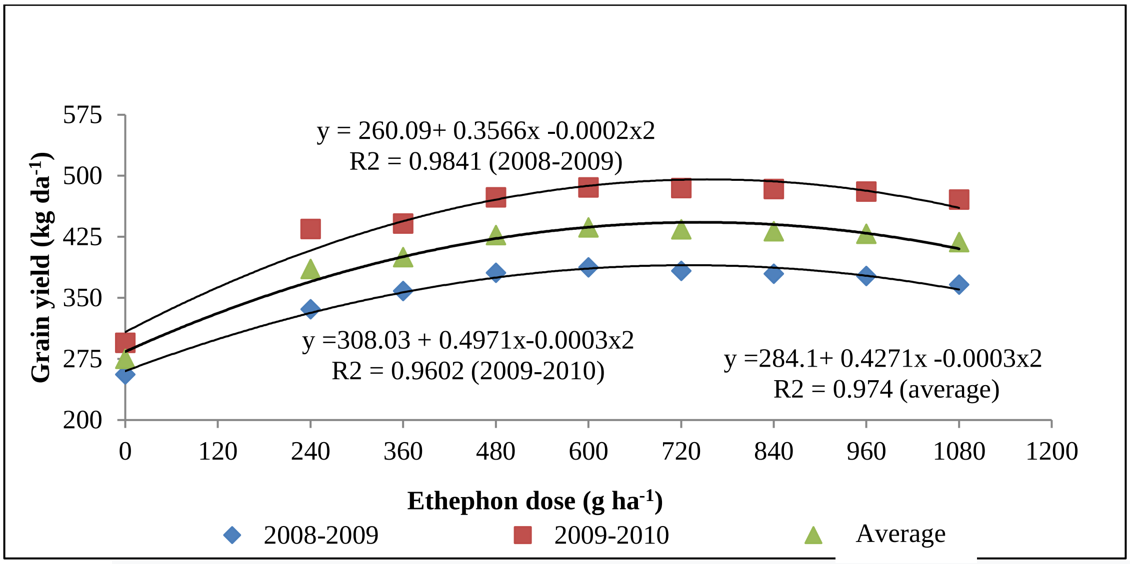

Figure 2. Regression analysis of Sur-93 barley cultivar grown in different ethephon doses in the 2008-2009, 2009-2010 growing seasons.
Şekil 2. *2008-2009, 2009-2010 yetiştirme sezonlarında farklı etephon dozlarında yetiştirilen Sur-93 arpa çeşidinin regresyon analizi*

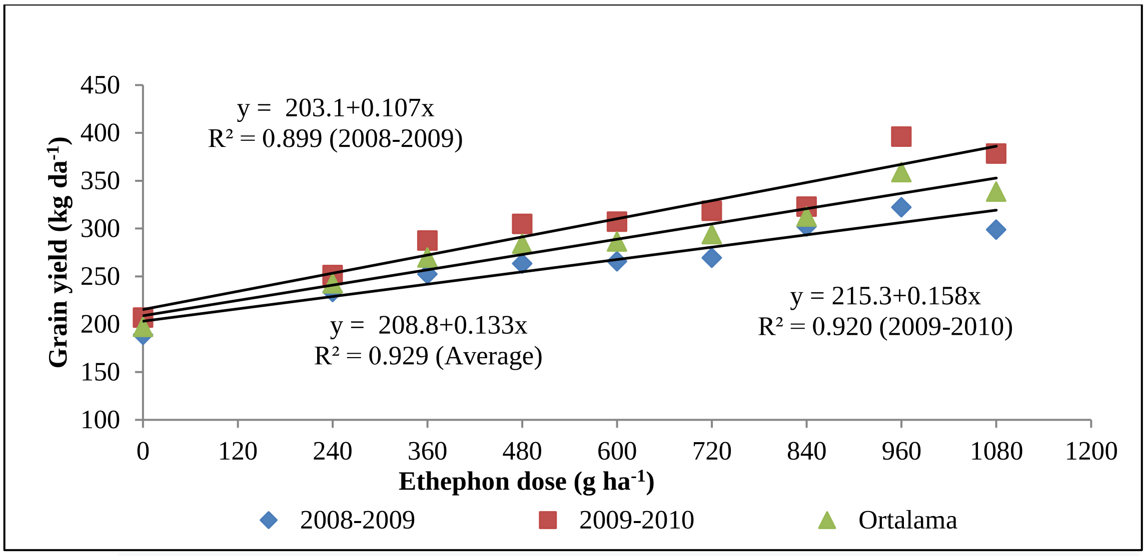

Figure 3. Regression analysis of local barley cultivars grown in different ethephon doses in the 2008-2009, 2009-2010 growing seasons.
Şekil 3. *2008-2009, 2009-2010 yetiştirme sezonlarında farklı ethephon dozlarında yetiştirilen Yerli Arpa çeşidinin regresyon analizi*

3.2. Plant Height (cm)

Height of Sur-93 was reduced proportional to ethephon concentration during the trials of in 2008-2009 and 2009-2010 seasons. During growing season of 2008-2009, average plant height of untreated Sur-93 cultivar was 102.55 cm while ethephon treated height of the cultivar was 58.3 cm. During growing season of 2009-2010, plant height of untreated and ethephone treated of Sur-93 variety was similar to the previous season (Table 4).

During the growing season of 2008-2009, ethephon application up to 840 g/ha significantly reduced plant height of the local barley variety to 62.3 cm, however, increased concentrations ethephon such as 960 and 1080 g/ha did not significantly affect plant height. During growing season of 2009-2010, results of ethephon applications were similiar to the previous season. The results showed that applied ethephon concentrations upto 840 g/ha were effective in reducing plant height (58.500 cm) while higher concentrations such as 960 and 1080 g/ha did not significantly affect plant height. During growing season of 2008-2009, in regard to barley plants and ethephon rates interaction, Sur-93 x 1080 g/ha ethephon interaction produced the lowest plant height (58.3 cm) while the highest (102.55 cm) plant height was recorded from Sur-93 and 0 g/ha ethephon interaction.

Table 4. Plant height values, lodging values of barley varieties in different ethephon applications and LSD groups.

Çizelge 4. *Farklı etephon uygulamalarında arpa çeşitlerinin bitki boyu, yatma değerleri ve LSD grupları*

		Plant height (cm)			Lodging (%)		
Cultivar	Ethephon Doz (g/ha)	2008-2009	2009-2010	Average	2008-2009	2009-2010	Average
Sur-93	0	102.550 a	98.950 a	100.550 a	61.250 a	56.250 a	58.750 a
	240	94.925 b	95.525 b	95.225 b	57.500 a	50.000 b	53.750 b
	360	92.600 b	91.225 c	91.913 c	41.250 b	31.250 c	36.250 c
	480	85.600 c	83.950 d	84.775 d	27.500 c	17.500 d	22.500 d
	600	80.050 d	79.300 e	79.675 e	25.000 c	15.000 d	20.000 d
	720	72.450 e	70.725 f	71.587 f	18.750 d	12.500 d	15.625 e
	840	64.650 f	62.575 g	63.613 g	13.750 d	6.250 e	10.000 f
	960	58.500 g	63.275 g	60.887 h	0.000e	0.000 f	0.000 g
	1080	58.300 g	58.950 h	58.625 h	0.000e	0.000 f	0.000 g
Average		**78.803**	**78.275**	**78.539 A**	**35.000 A**	**26.964 B**	**30.982 B**
Local barley	0	86.650 a	83.475 a	85.063 a	98.750 a	100.000 a	99.375 a
	240	81.000 b	77.950 b	79.475 b	76.250 b	83.750 b	80.000 b
	360	80.875 b	77.525 b	79.200 bc	62.500 c	70.000 c	66.250 c
	480	78.200 b	75.775 b	76.988 c	35.000 d	57.500 d	46.250 d
	600	69.250 c	70.500 c	69.875 d	30.000 d	50.000 e	40.000 e
	720	66.550 c	65.625 d	60.087 e	23.750 e	42.500 f	33.125 f
	840	62.300 d	58.500 e	60.400 f	20.000 e	40.000 f	30.000 f
	960	60.975 d	60.125 e	60.550 f	10.000 f	10.000 g	10.000 g
	1080	59.575 d	59.575 e	59.575 f	7.500 f *	5.000 g	6.667 g
Cultivar average		**71.708**	**69.894**	**70.801 B**	**42.353 B**	**55.152 A**	**48.657 A**
Year average		**75.256**	**74.085**			**39.032**	**42.213**

Plant Height: Çeşit LSD:1.396, Çeşit x Doz LSD:2.329, Yıl x Çeşit x Doz LSD: 3.294

Lodging: Çeşit LSD:4.297, Yıl x Çeşit LSD:6.077, Çeşit x Doz LSD:4.349, Yıl x Çeşit x Doz LSD: 6.150

*: Within columns, means followed with same letter do not differ significantly at P=0.05 (LSD).

In 2009-2010, the shortest plant height (58.95 cm) was obtained from Sur-93 and ethephon (840 g/ha) interaction and the tallest plant height (98.950 cm) was observed from Sur-93 x 0 g/ha ethephon interaction.

Average results of a 2-year study indicated that plant height of Sur-93 varied from 58.625 cm (1080 g/ha ethephon application) to 100.550 cm (0 g/ha ethephon application). Plant height was reduced as ethephon concentration increased. However, height of plants treated with either 960 or 1080 g/ha ethephon was not significantly different. The local barley cultivar height ranged from 59.575 cm (1080 g/ha ethephon application) to 85.063 cm (0 g/ha ethephon). Local barley height was not significanly differ at 840, 960 and 1080 g ha^{-1} ethephon application. In both years, local barley height decreased as ethephon concentration increased (Figure 4).

Regresssion analysis of average plant height of 2 years and ethephon application indicated that regression equation for Sur-93 cultivar was determined as y=106.9-5.675x and (R^2 = 0.985) while for local barley cultivar was determined as y=85.68-3.220x ve R^2 = 0.874 (Figure. 4).

Previous studies have indicated that barley plant height can be reduced with application of ethephon (Lunsgaard 1984 and 1986; Szirtes et al. 1986; Lloveras et al. 1990; Ege 1991; Stulova and Egorov 1991; Ma and Smith 1992; Stobbe et al. 1992; Webster et al. 1993).

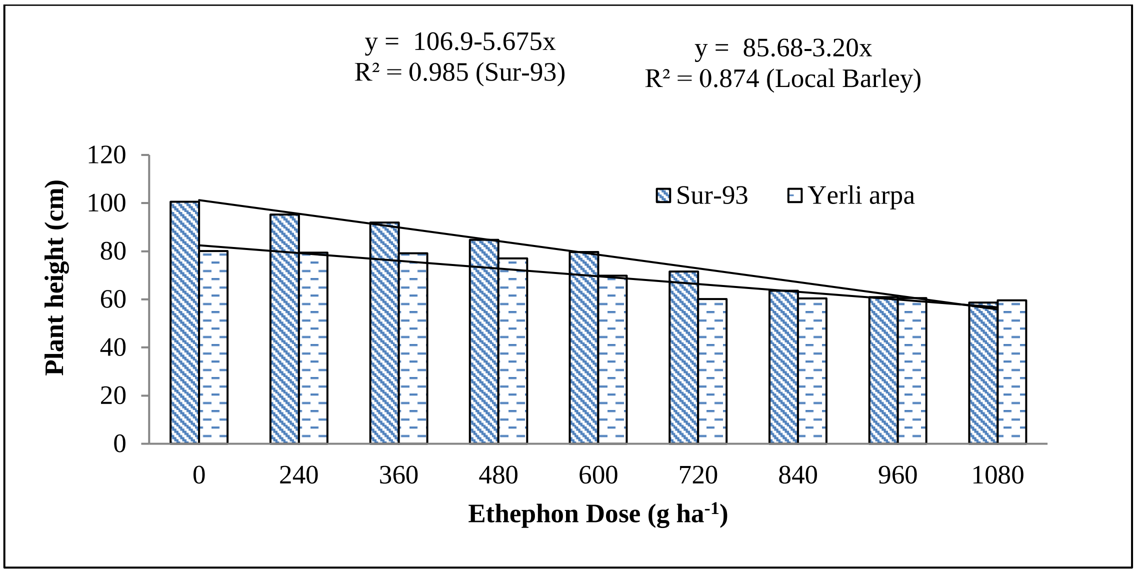

Figure 4. Barley plant height at different rates ethephon doses application during 2008-2009 and 2009-2010 growign season.

Şekil 4. 2008-2009, 2009-2010 yetiştirme sezonlarında farklı etephon dozu uygulamalarında arpa çeşitlerinin bitki boyu

3.3. Lodging

Lodging of Sur-93 barley cultivar in 2008-2009 was 61.25% when it was treated with ethephone, however, no lodging was recorded when plants treated with 960 ve 1080 g/ha ethephon. In 2009-2010, lodging of untreated plants decreased but still more than 50% of plants lodged while no lodging of treated plants was observed. In both years, reduced plant height was proportinal to the increased ethephon rates (Table 4).

In 2008-2009, lodging of local barley ranged from 7.5% (plants treated with 1080 g /ha etehephon) to 98.75% (untreated plants with ethephone). In 2009-2010, lodging of the local cultivar varied from 5% (plants treated with 1080 g /ha ethephon) to 100% (untreated plants with ethephone). Lodging of the local barley cultivar reduced as applied ethephon concentration increased.

During the growing season of 2008-2009, regarding lodging and ethephon rates, the highest (98.75%) lodging rate of the local barley cultivar was recorded at 0 g/ha ethephone application while the lowest lodging (0%) was recorded at interactions of Sur-93 treated with 960 and 1080 g/ha rates of ethephon. In 2009-2010, the lodging was like the previous growing season. The highest lodging (100%) was observed from the local barley cultivar and 0 g/ha ethephon interaction while the lowest lodging (0%) was observed from Sur-93 and 960 -1080 g/ha ethephone interactions.

Based on average of 2 years lodging value of Sur-93 varied from 0% when plants treated with 960 and 1080 g/ha to 58.75% when untreated with ethephon. Plant lodging reduced proportionally to the concentrations of ethephon, however, the highest reduction of lodging was between 480 and 600 g/ha ethephone applications while lodging reduction of 960 and 1080 g/ha was not significantly different. Height of the local barley was ranged from 59.57 cm when plants treated with 1080 g/ha ethephon to 85.06 cm when plants when plants was not treated with ethephon. Although plant height gradually reduced as ethephon rate increased the effect of ethephon rates from 840 to 1080 g/ ha ethephon was significantly different. In both years, plant height was reduced as apllied ethephon rate increased (Figure 4). Regression of lodging rate and applied ethephon rates were significant and regression between Sur-93 and ethephon rates was determined y=62.06-7.593x and (R^2 =0.940) and regression between the local variety and ethephon rates was y=101.2-11.10x and (R^2=0.959) (Figure 5).

In this study, applied ethephon rates reduced lodging by reducing plant height. Previous studies also have indicated that ethephon application would reduce lodging by reducing plant height (Szirtes et al. 1986; Ma and Simith 1992; Havazvidi 1992; Stobbe et al. 1992; Bridger et al. 1995; Rajala et al. 2001; Rajala et al. 2002; Tripathi et al. 2004; Haskins and Mcmullen. 2007; Radamacher 2009; Pavlista et al. 2010; Wiersma et al. 2011).

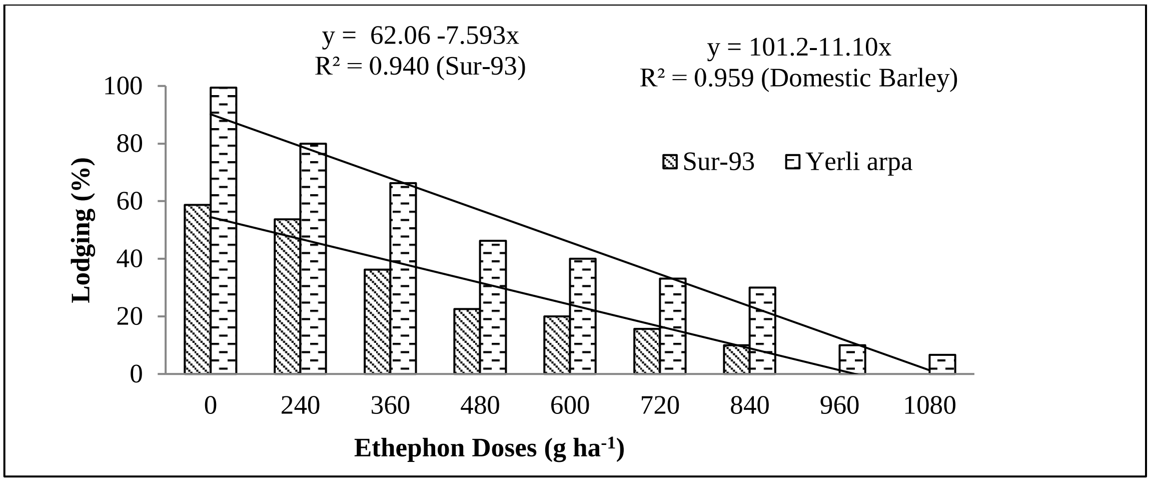

Figure 5. Percentage of lodging at different rates of ethephon application during 2008-2009 and 2009-2010 growing seasons.
Şekil 5. 2008-2009, 2009-2010 yetiştirme sezonlarında farklı etephon dozu uygulamalarında yatma yüzdeleri

Barley cultivars added to this study were susceptible to lodging. Susceptible barley cultivars when irrigated and fertilized lodging especially during spike stage become a serious problem. Kernel of lodged plants cannot develop well thus kernels become light-weighted. In this study, applied ethephon rates reduced plant height and therefore delayed spiking which helped better development of heavy kernels. These results agree with the previous studies (Dziamba 1986; Stobbe et al. 1992; Akcura 2001; Aral 2001; Tripathi et al. 2004; Rajala et al. 2002; Auskalniene 2005; Ramburan and Greenfield 2007).

4.4. Thousand Kernel Weight

Thousand-kernel weight of Sur-93 ranged from 37.30 g when treated with 240 g/ha ethephon to 47.035 g when treated with 960 g/ha ethephon during 2008-2009 (Table 5). Although 1000-kernel weight increased as applied ethephon rate increased, ethephon rates higher than 840 g/ha did not increase kernel weight significantly. Thousand-kernel weight of Sur-93 ranged from 37.942 g when treated with 0 g/ha ethephon to 45.812 g when treated with 840 g/ha ethephon during 2009-2010. The increase in ethephon rate from 840 to 1080 g ha did not cause any significant change in thousand kernel weight. Although 1000-kernel weight increased as applied ethephon rate increased, ethephon rates higher than 720 g/ha did not significantly increase the kernel weight. The difference between ethephon doses 840, 960,1080 was found insignificant.

Thousand kernel weight of the local barley cultivar ranged from 31.563 g when plants were not treated with ethephon to 40.228 g when plants treated with 1080 g/ha ethephon in 2008-2009 while in 2009-2010, 1000-kernel weight ranged from 31.928 g (untreated, control) to 44.638 g when plants treated with 1080 g/ha ethephon. Thousand kernel weight did not increase significantly when plants were treated with 960 and 1080 g/ha ethephon.

Table 5. Thousand kernel weight values of barley varieties in different ethephon applications and LSD groups.
Çizelge 5. *Farklı etephon dozu uygulamalarında arpa çeşitlerinin bin tane ağırlığı değerleri ve LSD grupları*

		Thousand kernel weight (g)		
Cultivar	Ethephon Doz (8g/ha)	2008-2009	2009-2010	Average
Sur-93	0	37.230 d	37.942 d	37.586 e
	240	37.228 d	39.200 cd	38.214 e
	360	37.718 d	39.678 c	38.698 e
	480	37.793 d	40.345 b	40.469 d
	600	40.070 c	43.415 b	41.743 c
	720	42.230 b	45.670 a	43.950 b
	840	46.705 a	45.812 a	46.259 a
	960	47.035 a	45.040 a	46.068 a
	1080	46.658 a	44.500 ab	45.579 a
Cultivar average		**41.414**	**42.711**	**42.063 A**
Local barley	0	31.563 e	31.928 e	31.745 f
	240	33.185 d	33.610 d	33.398 e
	360	33.137 cd	34.295 cd	33.806 de
	480	33.903 bcd	34.500 cd	34.201 de
	600	34.577 bcd	34.723 cd	34.650 cd
	720	34.893 bc	35.803 c	35.348 cd
	840	35.340 b	39.730 b	37.535 b
	960	39.598 a	43.305 a	41.451 a
	1080	40.228 a	44.638 a	42.433 a
Cultivar average		**35.178**	**36.948**	**36.063 B**
Year average			**38.296 B**	**39.830 A**

Year LSD:0.318, Cultivar LSD:0.318, Cultivar x Dozage LSD: 1.122, Year x Cultivar x Dozage LSD: 1.587; *: Within columns, means followed with same letter do not differ significantly at P=0.05 (LSD).

In regard to 1000-kernel weight from barley cultivars and ehtephon interaction, the lowest 1000-kernel weight was recorded from interaction of the local barley and 0 g/ha ethephon application while the highest 1000-kernel weight (47.035 g) was recorded in Sur-93 with 960 g/ha ethephon application in 2008-2009. In 2009-2010, the lowest 1000-kernel weight (31.928 g) was from the untreated local barley. The highest 1000-kernel weight (45.812 g) was from interaction of Sur-93 and 840 g/ha ethephon application (Table 5).

Average 1000-kernel weight of 2 years varied from 31.745 g (local barley x 0 g/ha ethephon) to 46.259 g (Sur-93 x 840 g/ha ethephon). Thousand-kernel weight increased as applied ethephon rate increased. Thousand-kernel weight of the local barley increased as applied rates of ethephon increased. No significant difference of 1000-kernel weight detected when the applied ethephon rate increased from 960 to 1080 g/ha (Figure 5).

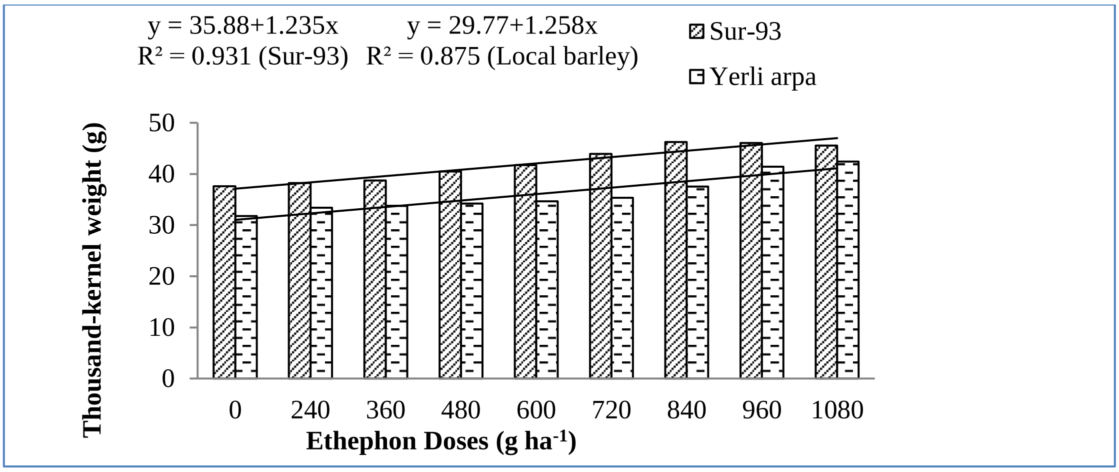

Figure 6. Thousand-kernel weight of barley cultivars treated with different rates of ethephon during the growing seasons of 2008-2009 ve 2009-2010.
Şekil 6. *2008-2009, 2009-2010 yetiştirme sezonlarında farklı etephon dozu uygulamalarında arpa çeşitlerinin bin tane ağırlığı*

Regression analysis based on average 1000-kernel weight of 2 years indicated that regresion equation between 1000-kernel weight and ethephon rates for Sur-93 barley was y=35.88+1.235x and (R^2 = 0.931) while the equation for local barley was y=29.77+1.258x and (R^2 = 0.875) (Figure 6). Lodging is a serious cause of poorly kernel development of barley cultivars. Applied ethephon rates well developed kernels thus increased 1000-kernel weight of the barley cultivars. Results of this study indicated similar results that were reported previously

(Dziamba 1986; Stobbe et al. 1992; Akçura 2001; Tripathi et al. 2004; Rajala et al. 2002; Auskalniene 2005).

4. Conclusion

Grain yield of Sur-93 and the local barley cultivars were 2752.25 kg/ha, 4365.63 kg/ha and 1970.00 kg/ha, 3591.00 kg/ha, respectively. Ethephon application up to 600 g/ha significantly increased grain yield of Sur-93 barley. The grain yield of barley did not significantly increase with 720 g/ha ethephon application and higher doses. Grain yield of the local barley significantly increased by ethephon application up to 840 g/ha. There was no statiscal difference between the dosesafter the 840 kg dose.

Ethephon application reduced plant height and numbers of kernels but caused well kernel development thus 1000-kernel weight was increased. The recorded highest grain yield due to ethephon applications was 4365.63 kg/ha for Sur-93 when treated with 600 g/ha ethephon while the recorded highest grain yield for the local barley was 3591.00 kg/ha when treated with 960 g/ha ethephon. The lodging of barley cultivars decreased with the increase in ethephon application rate. The highest lodging rate was recorded in control treatments, while the lowest lodging ratio was obtained with the highest ethephon dose.

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