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The ripening and fruit quality of 'Monroe' peaches in response to pre-harvest application gibberellic acid

Hasat öncesi gibberellik asit uygulamasının 'Monroe' şeftalisinde meyve olgunluğuna ve kalitesine etkisi

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ABSTRACT

The primary aim of this research was to prolong the harvest date and a secondary aim was to increase the quality of 'Monroe' peaches. For this purpose, different concentrations (0, 100, 200 and 300 mg L^{-1}) of GA_3 (commercial name is Falgro) were applied to 7, 21 and 30 days before commercial harvest. The effect of gibberellic acid (GA_3) were evaluated on fruit quality and harvest date of 'Monroe' peach over 2-year period in a commercial orchard. Some fruit quality parameters (fruit weight, fruit flesh firmness, soluble solids content, titratable acidity, fruit color and sugar contents), delay in harvest, ethylene production, respiration rate were assessed for per treatments. Fruit maturity was delayed about 4-6 days in GA_3 applied fruits than control group. Sequential harvest was completed in 6-7 days before the normal harvest time. The additional increase in fruit size and fruit weight was detected. GA_3 sprayed fruits were firmer than that of the control fruits. The most determined results of GA_3 treatment was occurred on color, one of the significant quality parameter in peaches and GA_3 application had positive effect on the development red color and sugar (total, invert and sucrose) accumulation in fruits. On the other hand, treatments of GA_3 decreased ethylene production and respiration rate.

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ÖZ

Bu çalışma 'Monroe' şeftali çeşidinde hasat tarihini geciktirmek ve meyvelerin kalitesini arttırmak amacıyla yürütülmüştür. Bu amaçla, GA_3'ün (ticari ismi Falgro) 3 farklı konsantrasyonu (0, 100, 200, 300 mg L^{-1}), tahmini hasat zamanından 7, 21 ve 30 gün önce şeftali meyvelerine sprey şeklinde uygulanmıştır. Meyvelerde bazı kalite özellikleri [meyve ağırlığı, meyve eti sertliği, SÇKM, titre edilebilir asitlik, meyve rengi (L*, a*, b*), şeker içeriği], hasat tarihinin gecikmesi, meyvelerin etilen üretimi ve solunum hızları her bir uygulama için incelenmiştir. GA_3 uygulamaları ile meyve olgunluğu kontrol grubuna göre 4-6 gün gecikmiş ve kademeli yapılan hasat, normal hasat periyoduna göre 6-7 gün önce tamamlanmıştır. GA_3 uygulaması 'Monroe' şeftalisinde meyve büyüklüğünü ve ağırlığını arttırmıştır. GA_3 uygulanan meyveler kontrol meyvelerine göre daha sert olmuştur. Şeftali meyvelerinde önemli kalite parametrelerinden olan renklenme üzerine tüm GA_3 uygulamalarının kırmızı rengin gelişimi üzerine olumlu etkisinin olduğu belirlenmiştir. GA_3 uygulamaları ile meyvelerde etilen üretimi ve solunum hızı azalmıştır. GA_3 uygulamalarının meyvelerde şeker içeriğini de (toplam, invert ve sakkaroz) artırdığı saptanmıştır.

1. Introduction

Peach fruit (*Prunus persica* L.) is native to China. Acreage for peach growing is increasing in Isparta, Turkey. Turkey has 545.902 tones of peach production (FAO, 2011). There is interest in extending the marketing season of late peach cultivars, which can be achieved both by delaying fruit ripening on the tree (Lurie et al. 1997). Fragile storability due to rapid softening and price fluctuation from short harvest span is a problem. Reports on effects of plant bioregulators on growth and fruit quality are numerous (Kim et al. 2004). GA_3 is effective for bud and fruit thinning (Southwick and Yeager 1995; Taylor and Taylor 1998) and fruit drop control (Stutte and Gage 1990). GA_3 is probably the most widely used plant growth regulator for manipulation of fruit development and ripening. In stone fruit it has been used to delay ripening and maintain firmness in both cherries (Lurie et al. 1997). Plant bioregulators affect the leaf mineral and chlorophyll content (Monge et al.

1994), and delay the maturity by hindering the chlorophyll decrease (Mohammmad and Khalil 1997). Plant bioregulators are also reported to be effective for keeping freshness (Kim et al. 1999).

Poor fruit quality leads to serious problems in marketing of peach fruits. And also this problem causes significant losses in peach cultivation in Turkey.

This study examined the effects of pre-harvest application of GA_3 on harvest delay, fruit size, fruit quality, ethylene production, respiration rate, sugars and some leave properties of 'Monroe' peach cultivar. This study was conducted in Isparta-Turkey, where is the most important production centers of peaches in Turkey.

2. Material and Methods

Experiments were conducted at the commercial peach orchard located in Isparta, altitude is 963 m - 971 m asl. The uniform trees, 14-years-old cv. 'Monroe' peach on *P. persica* rootstock, spaced at 6x5 m were used. Trees were trained to a vase system and pruned in late winter and standard cultural practices including, thinning, and pesticide sprays have been provided to the trees for several years. Experimental design was a randomized block, with 12 treatments and 5 replicates using single tree for per treatment. Falgro containing 100% GA_3, obtained from Sumitomo, was sprayed at 0 (water+surfactant), 100, 150, 200 mg L^{-1} plus 1% (v/v) Tween 20 as a surfactant onto fruits and leaves around the fruits until runoff. The spraying was performed with a hand pump sprayer at 7, 21 and 30 days before commercial harvest (in the first and second experiment year. Fruits were harvested at commercial stage of maturity, with a change in ground color from green to yellow-red at intervals of 3-4 days, for yield and fruit assessment. GA_3-treated fruits and untreated fruits were harvested separately and picked into specially designated bins. After each harvest pick, fruit was transported 30 km to the Postharvest Physiology Laboratory of Horticulture Department where the fruits were placed into cool storage (1°C) during the analyses.

All treatments were harvested 3 times and from 28 August to 8 September in the first experiment year and 26 August to 3 September in the second experiment year. The data used for analysis in this paper comes from the second harvest because the percentage of commercial mature fruit picked was seen in the second harvest. The fruit weight, fruit colour (colour and colour difference meter in CIE L*, a*, b* values (Model CR-300, Minolta), fruit firmness (a universal testing machine (Lloyd LF Plus Universal Test Machine), SSC [digital refractometer (Palette PR–32 Atago)] were measured. TA was measured using a digital buret (Digitrate Isolab 50 ml) by titration with 0.1 N NaOH up to pH 8.1, using 10 ml of diluted juice, and the TA was converted to malic acid. Ethylene production and respiration rate were determined for peaches of close to the jar after 1 day at room temperature (20±1 °C) (1 kg of fruit was closed in each jar and the volume of each jar was 4 litres. Ethylene production and respiratory rate was measured by using gas chromatography (Agilent GC-6890N) with a flame ionization detector (Gunes et al. 2001). To determine the total sugars (%), a modified Anthrone method (Sanz et al. 1987) was used. Reducing sugars contents (%) were determined using the dinitrophenol method. This method is a modified colorimetric method of Ross (1959). Reducing sugars were extracted by water and reacted with dinitrophenol solution. The changes in absorbance were measured at 600 nm. Moreover, some leaf analyses were made for determine the effect of GA_3 treatments. Twenty leaves showing average growth from upper, middle and lower parts of outer canopy were selected. Leaf area index (LAI) was measured by leaf area meter (AM 300 Area Meter, ADC, BioScientific Ltd.) (Ünlü 2000; Kim et al. 2004). Chlorophyll was extracted with 80% acetone, and measured by spectrophotometer (UV-1601, Shimadzu, Japan) at 645 and 663 nm. The experiment was arranged as a completely randomized design with five replications, each plot having 20 peaches. Statistical analyses were performed with General Linear Model using SPSS (V.16; Statistical software, SPSS. Inc., USA). The differences among means were analyzed by Duncan's multiple range test at $P<0.05$ of significance.

3. Results

3.1. Fruit maturity and harvesting

'Monroe' peach fruits have been harvested sequentially. GA_3 delayed the development of the background colour of 'Monroe' peach. GA_3-treated fruits were harvested later than control fruits. The control fruits constituted the first harvest [28 August (first year) – 26 August (second year)]. The second harvest was performed immediately when the GA_3-treated fruits grown enough for the harvest [3 September (first year)–30 August (second year)]. The third harvest of the trial was performed for the fruits of all applications on 8 September (second year). As a result, while the control fruits were harvested 3 times, GA_3-treated fruits were harvested twice (in the first and second year). Fruit maturity was delayed about 4-6 days in GA_3 applied fruits. Therefore; it has been proved that the application of the GA_3 before the harvest delays the maturity of the harvest and shortens the period of the harvest.

3.2. Fruit quality

In the first experiment year, the effects of GA_3 concentrations and treatment times on the fruit weight were statistically significant ($P<0.05$). The highest fruit weight (312.95 g) was found to be at 100 mg L^{-1} concentration and the fruits weights which were treated with 30 DBH (314.89 g) treatments were heavier than the other groups. In the second experiment year, the highest fruit weight was from 21 DBH-300 mg L^{-1} concentration and the interaction effects between concentrations and treatment times on the fruit weights were found statistically significant ($P<0.05$) (Table 1).

The highest fruit firmness (70.35 N) was observed 21 DBH-100 mg L^{-1} dose in the first year and the interaction effects between GA_3 doses and treatments times statistically significant ($p<0.05$). In the second experiment year, 200 mg L^{-1} GA_3 (31.86 N) applied fruits were firmer than the other groups and differences among responses of GA_3 doses were statistically significant ($P<0.05$) (Table 1). In the first experiment year, compared to control fruits, the 21 DBH treatments improved the L^* values (bright color) and were not statistically significant. In the second experiment year, the effect of GA_3 doses was determined to be statistically significant ($P<0.05$). The lowest L^* values were found at the 300 mg L^{-1} GA_3 treatment fruits (Table 2). The a^* value which refers to redness was obtained from 7 DBH-300 mg L^{-1} dose with the highest value (30.47), while the lowest (23.69) was derived from 30 DBH-200 mg L^{-1} dose treatment in the first experiment year. Hereby, time x dose interaction was statistically significant ($P<0.05$). As for the second year of the experiment, the differences among doses were significant ($P<0.05$) but the significance did not make difference among doses. The lowest values were obtained from

the control group fruits (Table 2). The effect of the treatments on b* value was not statistically significant in the first year, however in the second experiment year, it was significant among doses (P<0.05). In both experiment years, the highest b* value is related to the control fruits. In addition to this, the lowest b* value was found at the highest dose (300 mg L^{-1}) in both experiment years (Table 2).

Table 1. Fruit weight and firmness in 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations (mg L^{-1})	Fruit weight (g)		Fruit firmness (N)	
		First Year	Second Year	First Year	Second Year
30 d	0	284.29	188.04d	36.72b	15.64
	100	291.11	273.55b	39.40b	24.85
	200	352.05	235.92bc	56.99a	32.19
	300	332.09	261.90bc	57.30ab	30.09
21 d	0	268.79	177.36d	23.27c	13.47
	100	315.87	223.67b-d	60.35a	31.71
	200	291.32	264.15bc	43.31b	36.68
	300	240.90	362.78a	55.19ab	26.40
7 d	0	253.12	171.45d	38.82b	12.40
	100	331.88	249.4bc	39.95ab	27.96
	200	261.93	280.65b	33.20b	26.70
	300	244.92	264.94bc	34.90b	33.49
Main effects (Means)					
Time					
30		314.89a	249.56	47.60	25.69
21		279.22ab	272.00	45.53	27.07
7		272.96b	264.13	36.72	25.14
GA_3 Concentration					
0		268.73b	178.95	32.94	13.84b
100		312.95a	248.90	46.57	28.18a
200		301.77ab	260.24	44.50	31.86a
300		272.64b	296.54	49.13	29.99a
P values					
Time (T)		0.034	0.645	0.551	0.888
Concentration (C)		0.022	0.020	0.041	0.001
T x C		0.008	0.001	0.002	0.062

[1]: days before harvest (DBH). a-d: Values in a same column for each effect followed by different letters are significantly different (Duncan, P<0.05).

Table 2. Fruit colour (L*, a*, b*) in 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations (mg L^{-1})	L*		a*		b*	
		First Year	Second Year	First Year	Second Year	First Year	Second Year
30 d	0	45.21	49.54	27.36ab	23.41	25.82	30.07
	100	47.13	40.58	28.68ab	27.59	28.34	23.81
	200	49.80	39.46	23.69b	28.71	31.06	22.35
	300	47.40	38.95	30.15a	30.20	29.76	22.52
21 d	0	51.16	61.66	26.21ab	12.78	32.63	42.16
	100	45.55	40.72	24.30ab	26.45	27.21	23.40
	200	48.28	40.55	29.46a	30.67	29.92	24.36
	300	46.88	37.79	28.18ab	30.24	26.95	21.83
7 d	0	49.21	44.75	27.95ab	24.54	30.95	28.89
	100	43.28	43.20	27.58ab	27.37	25.05	26.29
	200	46.10	37.45	29.63a	29.65	28.55	20.64
	300	44.97	38.08	30.47a	30.50	26.29	22.61
Main effects (Means)							
Time							
30							
21							
7							
GA_3 Concentration							
0		48.53	51.98a	27.17	20.24b	29.80	33.71a
100		45.32	41.50b	26.85	27.14a	26.87	24.50b
200		48.06	39.15b	27.59	29.67a	29.84	22.45b
300		46.42	38.27b	29.60	30.31a	27.67	22.32b
P values							
Time (T)		0.078	0.898	0.455	0.112	0.245	0.178
Concentration (C)		0.965	0.010	0.258	0.444	0.169	0.021
T x C		0.762	0.551	0.041	0.062	0.165	0.642

[1]: days before harvest (DBH). a-b: Values in a same column for each effect followed by different letters are significantly different (Duncan, P<0.05).

In the first experiment year, the effects of GA_3 treatments on SSC were not statistically significant. The highest SSC was derived from 30 DBH-200 mg L^{-1} treatment with 10.92% value, whereas the lowest SSC was obtained from 7 DBH-control fruits. The difference between dose groups in the second experiment year was found to be statistically significant (P<0.05). The highest SSC, 13.99%, was recorded at the 200 mg L^{-1}-treatment (Table 3). In both experiment years, the effect of the treatments on titratable acidity was found to be statistically significant among dose groups (P<0.05). In the first year, the maximum amount of titratable acidity at all times (0.71%) was derived from 100 mg L^{-1} dose, as for the second year the maximum amount (0.73%) was obtained from 300 mg L^{-1} dose treatment (Table 3).

3.3. Ethylene production and respiration rates

In the first experiment year, ethylene production decreased compared to that of the control groups and the lowest average ethylene amount was 0.22 µL kg^{-1} h^{-1} retained from 200 mg L^{-1} dose treatment. Difference among dose groups were statistically significant (P<0.05). As for the second experiment year, difference among doses and treatment times were found statistically significant (P<0.05). The highest ethylene production at all times was obtained at the fruits treated with 21 DBH-200 mg L^{-1} dose (0.21 µL kg^{-1} h^{-1}) (Table 4). In the first experiment year, the lowest value of respiration rate (5.31 mL CO_2 kg^{-1} h^{-1}) was retained from 21 DBH-100 mg L^{-1} dose treatment, while the highest respiration rate (8.36 mL CO_2 kg^{-1} h^{-1}) was found at the fruits treated with 7 DBH-200 mg L^{-1} dose. In the second experiment year, difference among dose groups on the fruit respiration rates was obtained statistically significant (P<0.05). While the lowest respiration rate (7.53 mL CO_2 kg^{-1} h^{-1}) was observed at 100 mg L^{-1} dose treatment, the highest respiration rate (8.36 mL CO_2 kg^{-1} h^{-1}) was derived from the control fruits in second year (Table 4).

3.4. Total sugar, invert sugar and sucrose

While the difference among dose groups for the effect of the treatments on total sugar content in the first experiment year was found statistically significant, difference among dose groups and treatment times was observed significant in the second year (P<0.05) (Table 5). The lowest total sugar content had from control group fruits, whereas the highest total sugar content was recorded in the first and second year of the experiment for 100 mg L^{-1} dose and 300 mg L^{-1} dose treatments, respectively. As seen on Table 5, there was no statistically significant difference in the effect of GA_3 treatments on invert sugar content in the first year, however, difference between dose groups and treatment times were found significant in the second experiment year (P<0.05). In the second year of the experiment, the treatment which had the highest invert sugar content was 300 mg L^{-1} dose, and the highest treatment time was found as 7 DBH (Table 5). 100 mg L^{-1} and 300 mg L^{-1} doses had the highest value in the first year in terms of the sucrose content of the treatments while in the second experiment year the highest amount was observed at 100 mg L^{-1} and 200 mg L^{-1} doses. In the second experiment year solely the difference among doses on account of sugar content was statistically significant (P<0.05) (Table 5).

Table 3. Total soluble solids (SSC) and titratable acidity (TA) in 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations (mg L^{-1})	Total soluble solids (%)		Titratable acidity (%)	
		First Year	Second Year	First Year	Second Year
30 d	0	9.96	12.04	0.61	0.52
	100	10.28	12.85	0.73	0.69
	200	10.92	14.24	0.69	0.79
	300	10.23	13.52	0.68	0.77
21 d	0	9.78	11.98	0.62	0.50
	100	9.82	14.65	0.71	0.71
	200	9.76	14.20	0.69	0.65
	300	10.26	13.26	0.68	0.73
7 d	0	9.26	11.95	0.63	0.57
	100	10.70	14.30	0.69	0.63
	200	10.22	13.52	0.68	0.64
	300	10.83	13.36	0.68	0.68
Main effects (Means)					
Time					
30		10.35	13.16	0.69	0.69
21		9.91	13.52	0.68	0.65
7		10.25	13.28	0.67	0.63
GA_3 Concentration					
0		9.67	11.99b	0.62b	0.53b
100		10.27	13.93a	0.71a	0.68a
200		10.30	13.99a	0.69a	0.69a
300		10.44	13.38a	0.68a	0.73a
P values					
Time (T)		0.771	0.115	0.211	0.441
Concentration (C)		0.654	0.046	0.020	0.012
T x C		0.542	0.132	0.084	0.265

[1]: days before harvest (DBH). a-b: Values in a same column for each effect followed by different letters are significantly different (Duncan, P<0.05).

Table 4. Ethylene production and respiration rate in 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations (mg L^{-1})	Ethylene production (µL kg^{-1} h^{-1})		Respiration rate (mL.$C0_2$ kg^{-1} h^{-1})	
		First Year	Second Year	First Year	Second Year
30 d	0	0.76	1.09	5.06	13.62
	100	0.37	0.50	7.38	10.80
	200	0.24	0.36	6.90	8.51
	300	0.30	0.53	6.29	10.20
21 d	0	0.79	0.64	8.12	15.47
	100	0.43	0.33	5.31	8.41
	200	0.21	0.12	5.93	8.28
	300	0.30	0.28	7.14	11.20
7 d	0	0.59	0.87	8.10	20.50
	100	0.34	0.21	5.55	7.84
	200	0.22	0.15	8.36	5.79
	300	0.29	0.21	7.34	7.77
Main effects (Means)					
Time					
30		0.42	0.62a	6.41	10.78
21		0.43	0.34b	6.63	10.84
7		0.36	0.36b	7.34	10.47
GA_3 Concentration					
0		0.71a	0.87a	7.09	16.53a
100		0.38b	0.35b	6.08	9.01b
200		0.22c	0.21b	7.06	7.53b
300		0.30b	0.34b	6.92	9.73b
P values					
Time (T)		0.245	0.321	0.458	0.225
Concentration (C)		0.001	0.001	0.215	0.025
T x C		0.111	0.856	0.126	0.114

[1]: days before harvest (DBH). a-b: Values in a same column for each effect followed by different letters are significantly different (Duncan, $P<0.05$).

Table 5. Total sugar, reducing sugar and sucrose in 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations mg L^{-1}	Total sugar (%)		Reducing sugar (%)		Sucrose (%)	
		First Year	Second Year	First Year	Second Year	First Year	Second Year
30 d	0	5.14	6.31	2.57	3.30	2.49	2.92
	100	8.26	8.77	2.81	3.23	5.29	5.37
	200	7.34	5.69	2.88	2.70	4.32	2.90
	300	8.23	9.81	3.53	7.56	4.56	2.17
21 d	0	5.18	5.21	2.53	2.76	2.58	2.39
	100	7.78	5.45	3.00	2.43	4.63	2.93
	200	7.50	6.07	3.05	1.85	4.31	4.10
	300	8.28	3.79	3.27	1.32	4.86	2.40
7 d	0	5.44	7.36	2.53	4.07	2.82	3.20
	100	7.62	6.51	2.95	4.45	4.53	2.00
	200	7.29	8.17	2.67	5.00	4.49	3.07
	300	7.99	8.06	2.57	4.67	5.26	3.29
Main effects (Means)							
Time							
30		7.24	7.64a	2.95	4.20a	4.17	3.34
21		7.19	5.13b	2.96	2.09b	4.10	2.96
7		7.09	7.52a	2.68	4.55a	4.28	2.89
GA_3 Concentration							
0		5.25c	6.30b	2.54	3.38b	2.63c	2.83ab
100		7.89a	6.91ab	2.92	3.37b	4.82a	3.43a
200		7.38b	6.64ab	2.87	3.18b	4.37b	3.36a
300		8.17a	7.22a	3.12	4.52a	4.89a	2.62b
P values							
Time (T)		0.144	0.032	0.532	0.001	0.475	0.588
Conc. (C)		0.011	0.001	0.488	0.001	0.025	0.021
T x C		0.878	0.555	0.245	0.863	0.252	0.114

[1]:days before harvest (DBH). a-c: Values in a same column for each effect followed by different letters are significantly different (Duncan, $P<0.05$).

3.5. *Leaf area index (LAI) and total chlorophyll, chlorophyll a, chlorophyll b in leafs*

Having observed the leaf area index, time x dose interaction is statistically significant in both experiment years (P<0.05) (Table 6). In the first and second experiment year, the maximum result of leaf area index was found at 30 DBH-300 mg L^{-1} and 21 DBH-100 mg L^{-1} dose treatments, respectively.

While the effect of GA_3 applications on total chlorophyll was not statistically significant in the first experiment year, doses and treatment times had the significance level of 0.05 in the second experiment year. 200 mg L^{-1} dose treatment reached the highest amount of total chlorophyll with 2.01 mg/g in the second experiment year. The lowest amount was detected in 100 mg L^{-1} dose treatment (Table 7). The effect of GA_3 treatments on chlorophyll a in leaves among dose groups was significant solely in the second experiment year (P<0.05). It was observed the control group and 200 mg L^{-1} dose group contained the same amount of chlorophyll a, while the other dose treatments decreased the amount of chlorophyll a in comparison with the control group fruits (Table 7). Although chlorophyll b content indicated an overall increase in the first experiment year, no statistically significant difference was found between control groups and GA_3 treatments in terms of GA_3 treatments effect on chlorophyll b content. As for the second experiment year, the difference between dose groups and treatment times are statistically significant (P<0.05). The application which had the highest Chlorophyll b content was recorded as 200 mg L^{-1} dose and 7 DBH treatments (Table 7).

4. Discussion and Conclusion

While the control fruits were harvested gradually 3 times in a harvest period of 11-12 days, the harvest of GA_3 treatments were picked 2 times in a harvest period of 6-8 days. We think that of reducing the harvest expenses, which are a great portion of cultivation cost, are quite considerable.

Table 6. Leaf area index (LAI) in leaf of 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations mg L^{-1}	Leaf Area Index (LAI)	
		First Year	Second Year
30 d	0	1.62bc	1.57c
	100	1.05d	1.73bc
	200	1.74bc	1.49cd
	300	2.25a	1.35cd
21 d	0	1.12cd	1.41cd
	100	1.99b	2.03a
	200	0.80d	1.57c
	300	1.63bc	1.72bc
7 d	0	1.25cd	1.20d
	100	1.43c	1.39cd
	200	1.61bc	1.70bc
	300	1.81b	1.27d
Main effects (Means)			
Time			
30		1.66	1.53
21		1.39	1.69
7		1.52	1.39
GA_3 Concentration			
0		1.33	1.39
100		1.49	1.72
200		1.38	1.59
300		1.90	1.45
P values			
Time (T)		0.001	0.002
Concentration (C)		0.001	0.010
T x C		0.000	0.000

[1]: days before harvest (DBH). a-d: Values in a same column for each effect followed by different letters are significantly different (Duncan, P<0.05).

Table 7. Total chlorophyll, chlorophyll a and chlorophyll b in leaf of 'Monroe' peaches at harvest as affected by treatment date and GA_3 concentration.

Application time (d^1)	GA_3 concentrations (mg L^{-1})	Total chlorophyll (mg g^{-1})		Chlorophyll a (mg g^{-1})		Chlorophyll b (mg g^{-1})	
		First Year	Second Year	First Year	Second Year	First Year	Second Year
30 d	0	1.07	1.83	0.79	1.26	0.28	0.57
	100	1.64	1.50	1.19	1.29	0.45	0.21
	200	1.15	1.61	0.85	1.18	0.30	0.44
	300	1.32	1.25	0.92	0.98	0.41	0.27
21 d	0	1.47	1.74	1.04	1.27	0.42	0.46
	100	2.04	1.45	1.40	1.19	0.65	0.26
	200	1.34	2.26	0.95	1.48	0.39	0.78
	300	1.45	1.58	1.02	1.21	0.43	0.37
7 d	0	1.51	2.24	0.99	1.48	0.52	0.77
	100	1.52	1.31	1.04	0.99	0.47	0.32
	200	1.69	2.15	1.17	1.36	0.52	0.79
	300	2.02	1.94	1.43	1.23	0.60	0.71
Main effects (Means)							
Time							
30		1.30	1.55c	0.94	1.18	0.36	0.37c
21		1.58	1.75b	1.10	1.29	0.47	0.47b
7		1.69	1.91a	1.16	1.27	0.53	0.65a
GA_3 Concentration							
0		1.35	1.94ab	0.94	1.34a	0.41	0.60a
100		1.73	1.42b	1.21	1.16b	0.52	0.26c
200		1.39	2.01a	0.99	1.34a	0.40	0.67a
300		1.60	1.59ab	1.12	1.14b	0.48	0.45b
P values							
Time (T)		0.068	0.029	0.144	0.111	0.154	0.042
Concentration (C)		0.112	0.001	0.158	0.041	0.064	0.030
T x C		0.085	0.085	0.889	0.099	0.126	0.100

[1]: days before harvest (DBH). a-c: Values in a same column for each effect followed by different letters are significantly different (Duncan, P<0.05).

Additionally, it was exposed that GA_3 applications were postponed the harvest date for approximately 4- 6 days and shortened the harvest period for 3-6 days. The results were coincided with the literature in this area (Facteau et al. 1985; Lurie et al. 1997; Mohammmad and Khaili 1997; Amarante et al. 2005; Ju et al. 1999).

We are of the opinion that these results are important for reducing the harvest expenses, which have could bring great benefits for the marketing of peaches. It was stated that the plant growth regulators which were used in the treatments favorably affected the fruit yield of 'Monroe' peaches. The average yield (kg/tree) of 'Monroe' peach fruits was increased by 60-173 % with the GA_3 treatments compared to the average yield of the control fruits. To, our findings this is the first on the effect of GA_3 on 'Monroe' peach fruit yield. While the best results for fruit weight in the first year were retained from 30 DBH-200 mg L^{-1} and 7 DBH-100 mg L^{-1} dose treatments, in the second year the best results were observed at 21 DBH-300 mg L^{-1} and 7 DBH-200 mg L^{-1} dose treatments. Overall, the fruit weights were decreased by GA_3 treatments. Amaranteet al (2005) was found similar results with our results. 100 mg L^{-1} GA_3 dose which had been applied 3 and 6 weeks before the harvest time enhanced the fruit size. In this study, the higher dosages more than 100 mg L^{-1} was found like us 100 mg L^{-1} dosage on fruit weight. Therefore, the used of GAs in lower dosages could be decrease profitability, because its high cost. In addition to, using lower dosages of GAs chemical reserves can be reduced, too. Likewise, Dagar et al (2012) indicated that the fruit quality of peach fruits treated with 60 mg L^{-1} GA_3 was found to best result.GA_3 treatments favorably affected fruit firmness. In the first experiment year, the best treatment was found as 21 DBH-100 mg L^{-1} while in the second year 200 mg L^{-1} dose treatment gave the best result in both harvests. Our results were in agreement with previous reports on GA_3 treatments (Özgüven, 1994; Lurie et al. 1997; Southwick and Yeager 1995). However, Weksler et al (2012) stated that 25 and 50 mg L^{-1} GA_3 which had been treated on 'Sun Snow' (nectarine) and 'Swelling' (peach) cultivars 12 and 24 days before harvest caused the fruits lost their firmness less than the control fruits after 3 days at 20°C. Accordingly,GA3's lower doses (25 and 50 mg L^{-1}, etc.) should be considered a positive effect on the quality of the fruit. The effect of GA_3 applications on outer layer of fruit color showed similar results in both experiment years. It was observed that the L* value which refers to brightness and the b* value referring to yellowness were lower in the control groups, while the a* value which represents redness was higher in all treatment times and doses. Thus, it was claimed that GA_3 applications had a favorable effect on fruit color of outer layer, particularly on red color. Correlatively, the decrease in the yellow color of the fruits treated with GA_3 was shown in the studies of Lurie et al (1997) and Mohammmad and Khalil (1997). They proved that red color value of fruit outer layer was increased in the fruits by GA_3 application. In both experiment years, GA3 application increased the SSC in the 'Monroe' peach. Addressing the GA_3 applications in a broad manner, the amount of SSC changed between %8.83 (control-I. experiment year) and %14.61 (300 mg L^{-1} second experiment year), the amount of titratable acidity varied from %0.53 (Control-first experiment year) to %0.94 (100 mg L^{-1}-second experiment year) compatible with the SSC (%10) and TA (%0.6) values of the optimum peach found by Kader et al(1999). In both experiment years, having observed the GA_3 treatments decreased the amount of ethylene production, GA_3 doses were found to be more effective in the first year while the application times had no effects on the ethylene production. As for the second year, neither the doses nor the treatment times were found to be effective. No study reported the decreasing effect of gibberellic acid on ethylene production of fruits. However, it is concluded that GA_3 has a reducing effect on ethylene production in peaches. However, this result should be strengthened with new researches. Overall, it was detected GA_3 increases the amount of sugar content. Chapman and Horvat (1990) expressed that after the full flowering time the sucrose content of 'Monroe' peaches had increased on day 95th, and 109th, the second increase has been occurred between day 123th and 137th. Those increases might have resulted from active cell growth. In our experiment, the increase in sugar content of fruits after the full flowering time on 105th (30 DBH) and 128th (7 DBH) day strengthen the conviction of GA_3's contribution to the cell growth. The impact of all the treatments on total chlorophyll, chlorophyll a, and chlorophyll b contents was found insignificant in the first experiment year. But in the second experiment year , the increasing effect of 200 mg L^{-1} dose at all times was identified on the amounts of total chlorophyll, chlorophyll a, and chlorophyll b.

As a result, regarding effects on color, weight and firmness as the time of application in terms at the 7 or 21DBH+100 mg L^{-1} AVG dose for 'Monroe' peach varieties can be recommended. However, doses higher than 100 mg L^{-1} has not been evaluated more effective, because of this reason; further studies should be planned by using dosages lower than 100 mg L^{-1}.

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