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Effects Of Ba+Ga $_{4+7}$ Treatments On Fruit Quality In 'Fuji' Apple Variety

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Abstract

The study was carried out in order to determine the effects of BA+GA $_{4+7}$ applications on fruit quality in 'Fuji' grafted on M9 rootstock in Isparta conditions. When fruitlets reached 10 mm diameter, trees were applied with BA+GA$_{4+7}$ at 0, 100 and 150 ppm (1.8 BA+1,8%GA$_{4+7}$; Perlan) two times at one-week intervals. BA+GA$_{4+7}$ were most effective on fruit quality, which increased fruit weight, fruit diameter, fruit length and fruit shape (L/D ratio) and fruit ratio >65 mm (%) (first class fruit) compared to control. However it did not affect flesh firmness, soluble solute content (SSC), titrable acidity and a*(redness), and it did not influence fruit thinning ratio.

Keywords: *Malus x domestica*, growth regulators, fruit size, shape

Introduction

Quality of fruit which is determined by size, firmness, skin color, shape, as well as by other features such as internal quality (eg. sugar contents) and eating quality (e.g. crispness, juiciness) is affected by environmental, cultural, physiological, and genetic factors, and by the microenvironment within the canopy (Sams, 1999).

In apples, the appearance which is characterized by size, shape, form and color is primary criteria in making purchasing decisions. In general, red apples with bright color are preferred. Also, shape and size are important factors in distinguishing between individual cultivars (Kays, 1999). Increasing appearance and quality of fruit requires appropriate plant management such as thinning, growth regulator use, and cultivar. One of the techniques in apple growing practice to improve fruit size and shape is Benzyladenine (BA) alone or in combination with Gibberellin (GA$_{4+7}$) applications. BA is also used as an effective thinning compound for apples (Green *et al.* 1990). BA is described as a natural purine cytokinin with N6-substituted adenines having the ability to stimulate cell division in the presence of an adequate auxin supply (Bubán, 2000). BA had influenced fruit size and weight (in the year of treatment) by reducing crop load as well as increasing the number of cells per fruit through the stimulation of cell division (Turk and Stopar, 2010). It is not toxic or has low toxicity to other species (Bubán, 2000). It is also friendly chemical to environment.

'Fuji' is one of the popular and commercially important apple cultivar in world. It is typically red striped, round and medium to large size, firm, crisp, very sweet and very juicy. It is harvested at the early or mid-November and can be stored long time. Recently 'Fuji' gained popularity in Turkey. This study was conducted to evaluate the effects of BA+GA$_{4+7}$ applications on fruit quality in 'Fuji' apple variety grafted on M9 rootstock in Isparta conditions.

Materials and Methods

The study was conducted in 2013 on nine-year-old apple trees. The research was conducted at the experimental orchard of Agricultural Research Farms of Suleyman Demirel University, Isparta, Turkey. Trees were freestanding, trained as a central leader, and planted at 1.0 x 3.0 m apart. Experimental design was a randomized complete block with three replications and each replication contained 3 trees. Trees having similar growth vigor and fruit density were selected.

When fruitlets were 10 mm diameter, trees were applied with BA+GA $_{4+7}$ at 0, 100 and 150 ppm (1.8 BA+1,8%GA 4+7; Perlan) two times at one-week interval with a hydraulic, handgun sprayer. Fruit thinning ratio was determined after June drop. At the harvest time, all fruits on the tree were harvested and weighed. Thirty apples were randomly selected from each tree for analyses. The fruit weight, length (L) and diameter (D) were measured in sample fruits and L:D ratio (shape) was

calculated. Color parameters of fruit skin were determined with colorimetric CIE LAB method using a chroma meter (Konica Minolta, CR-400/410). L* is a measure of lightness, where values range from completely opaque (0) to completely transparent (100), a* is a measure of redness (or −a* of greenness) and b* of yellowness (or −b*of blueness) on the hue-circle (Pedisić et al. 2009). Flesh firmness was determined with a hand penetrometer (tip diameter 11 mm) on two sides of each fruit. The soluble solids content (SSC) was determined with a hand refractometer. The pH was determined using a pH meter. Titrable acidity (as malic acid) was determined on the juice sample by titration with 0.1 mol/L NaOH to a pH of 8.1.

All data were analyzed by analysis of variance using MİNİTAB software. Mean differences were determined by Tukey test ($P \leq 0.05$)

Table 1. Effect of BA+GA_{4+7} on fruit thinning ratio, yield and fruit size and shape

Dozes	Fruit thinning ratio (%)	Yield (kg/tree)	Fruit weight (g)	Fruit diameter (D) (mm)	Fruit length (L) (mm)	Fruit shape (L/D)	Fruit ratio >65 mm (%)
0 (Control)	77.49	17.51	99.09 **b**	59.27 **b**	51.08 **b**	0.86**b**	13
100 ppm BA+GA_{4+7}	76.15	25.09	157.63 **a**	69.00 **a**	61.24 **a**	0.89 **a**	73
150 ppm BA+GA_{4+7}	69.91	18.51	139.70 **ab**	66.93 **a**	58.90 **a**	0.88 **ab**	72
Lsd	11.95	9.582	45.47	7.204	7.634	0.02397	

Table 2. Effect of BA+GA_{4+7} on fruit flash firmness, SSC, pH and titrable acidity

Dozes	Flesh firmness (lb)	SSC (%)	pH	Titrable acidity (%)
0 (Control)	18.82	12.89	3.76 **b**	0.24
100 ppm BA+GA_{4+7}	17.21	12.61	3.84 **b**	0.25
150 ppm BA+GA_{4+7}	17.32	12.39	4.00 **a**	0.24
Lsd	1.922	2.62	0.1525	0.06596

Results and Discussion

The analyses results of the effects of BA+GA_{4+7} applications on fruit thinning ratio, yield, fruit weight, fruit diameter, fruit length, fruit shape and fruit ratio >65 mm are presented in Table 1. According to Table 1, BA+GA_{4+7} did not influence fruit thinning ratio. Some researchers suggested that BA alone or combination with other chemical thinners may be used as effective chemical thinner on apples (Green and Autio, 1990; Elfving and Cline, 1993; Yuan and Green 2000; Yıldırım *et al.,* 2007; Turk and Stopar, 2010). However, the thinning effect of BA with combination of GA_{4+7} (Perlan, Promalin) has been inconsistent (Williams and Fallahi, 1999). When 200 ppm BA+GA_{4+7} applied in bloom to apple trees it was reported to cause increased fruit set (Byers and Carbaugh, 1991), however Leite *et al.* (2006) reported time of application of GA_{4+7}+BA had effect on fruit set reduction. It can be expressed that the response on thinning of BA+GA_{4+7} may vary by cultivar, location, application time and dose. In the present study, BA+GA_{4+7} did not have any significant influence on the yield (kg/tree). Yield is a result of fruit number on tree. In our study, BA+GA_{4+7} did not reduce fruit number and also greatly increased fruit ratio >65 mm (first class fruit). Fruit size is determined by both cell size and cell number. Especially, fruit size is determined as the number of cell in fruit cortex rather than cell size (Byers, 2003). It was reported that BA had stimulating effects on cell division in cortex of 'Empire' (Wismer *et al.,* 1995). Gibberellins which are one of components of Perlan elongate cells, rather than increase cell division (Williams and Fallahi, 1999). The combination of BA+GA_{4+7} is highly effective on fruit size when applied before cell division completed. In the study, BA+GA_{4+7} were significantly increased the fruit weight compared to the control. It also increased fruit diameter, fruit length and fruit shape (Figure 1). Especially, the application of 100 ppm BA+ GA_{4+7} was significantly increased fruit weight by 37 % more than control and improved the fruit shape.

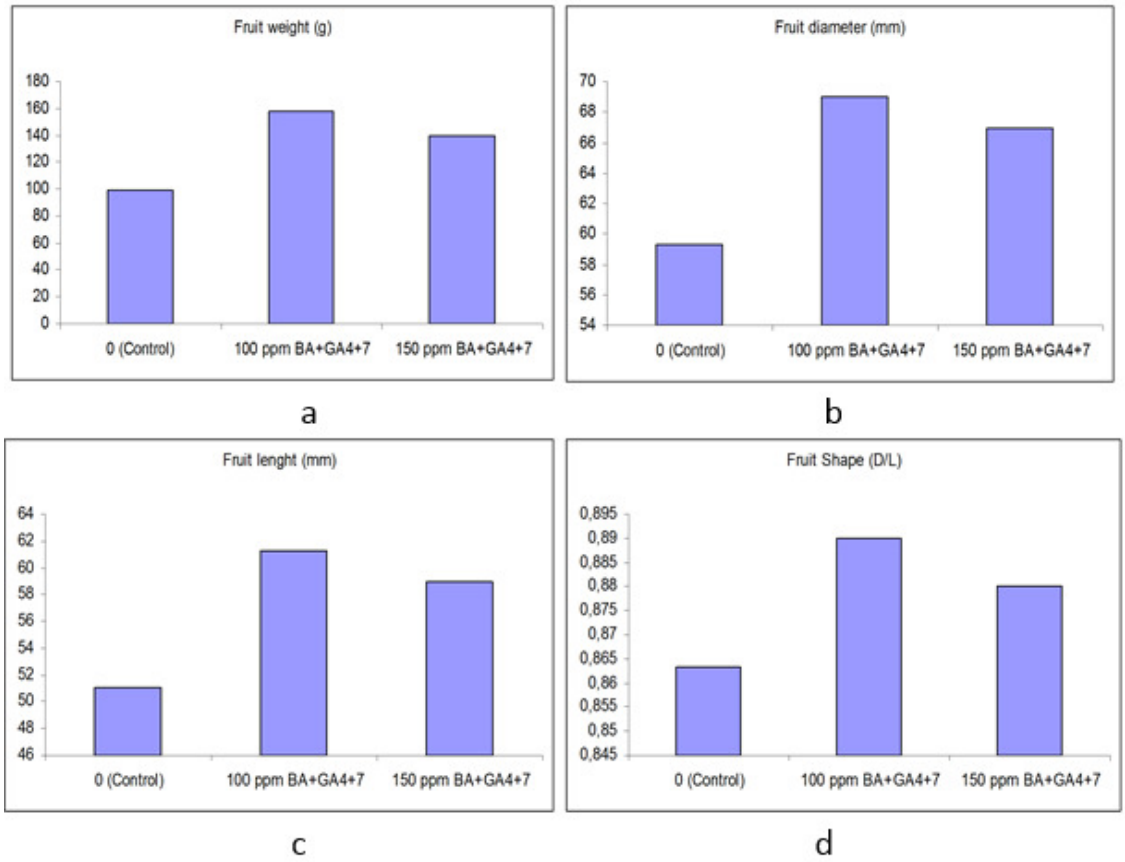

Figure 1. Effect of BA+GA$_{4+7}$ on fruit weight (a), fruit diameter (b), fruit length (c) and fruit shape (d)

These results are in agreement with the reported studies (Kumar *et al.,*2003; Youn *et al.,* 2004; Leite *et al*., 2006; DongHoon *et al*., 2010; Sepahvand *et al*., 2012). Burak and Büyükyılmaz (1998) reported that the high doses of BA+GA$_{4+7}$ had adverse effect on fruit shape while low doses increased fruit size, fruit length and fruit diameter. Also it was stated that the 25 ppm 6-BA+GA$_{4+7}$ applied 14 days after full bloom greatly increased fruit size without causing any deformation in pear (Stern *et al*., 2007).

Table 3. Effect of BA+GA$_{4+7}$ on L*, a*, b* values in fruit skin

Dozes	L*	a*	b*
0 (Control)	48.963	30.480	14.297 **b**
100 ppm BA+GA$_{4+7}$	47.500	29.053	16.020 **a**
150 ppm BA+GA$_{4+7}$	48.603	30.720	16.777 **a**
Lsd	3.711	4.625	1.359

The results of the effects of BA+GA$_{4+7}$ applications on flesh firmness, SSC, pH and titrable acidity are presented in Table 2. We determined that 150 ppm BA+GA$_{4+7}$ increased the pH value of fruit juice. The SSC and titrable acidity were not significantly affected by BA+GA$_{4+7}$ applications compare to the control. Although the flesh firmness was not significantly affected by all applications, the highest flesh firmness was obtained from the control (mean 18,82 lb), which had small fruit size. Generally, fruit size is negatively correlated to firmness, especially in apples (Dell *et al*., 1999). These results did support the findings of a previous report (DongHoon *et al*., 2010). Also, Youn *et al*. (2004) reported that flesh firmness was decreased by promalin (BA+GA$_{4+7}$). L*, a*, b* values were obtained from BA+GA$_{4+7}$ applications presented in Table 3. While L* (Lightness) and a* (redness) in color of fruit skin was not affected by applications, b*(yellowness) values were significantly increased by BA+GA$_{4+7}$ applications.

In conclusion, it was demonstrated that BA+GA$_{4+7}$ (especially 100 ppm) application can be useful for improving fruit size and shape when applied fruitlets 10 mm diameters two times at one-week intervals in 'Fuji' apple.

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