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PRE-HARVEST APPLICATION OF ABSCISIC ACID IMPROVES THE FRUIT QUALITY OF FLAME SEEDLESS GRAPES (*VITIS VINIFERA* L.)

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ABSTRACT

The present investigations were conducted to study the combined effect of various levels of crop load and growth regulators application on fruit quality of grape cv. Flame Seedless. The grapevines were subjected to application of three levels of abscisic acid (50, 100 and 150 ppm at veraison stage) compounded with three crop loads (50, 75 and 100 per cent). Results showed that the application of 100 ppm ABA combined with 50 per cent crop load, improved bunch length (24.0 cm) and berry size (1.72 cm x 1.71 cm). Reduced crop load (50 %) along with 100 ppm ABA application also significantly improved TSS (19.15 %), TSS/acid ratio (43.91 %), fruit firmness (230.25 g force^{-1}) and also berries registered with lowest acidity (0.44 %). Vines retained with 50 per cent crop load + 150 ppm ABA application, significantly improved peel colour of berries with higher colour index of red grapes (CIRG = 5.89) as compared to control (CIRG = 4.82). In conclusion, reducing crop load and pre harvest application of ABA at veraison stage can be used for improving peel colour and fruit quality of Flame Seedless grapes.

INTRODUCTION

Grapes (*Vitis vinifera* L.) is an important fruit plant being grown on a vast geographical area extending over tropical, sub-tropical and temperate regions across the world. It is third most widely cultivated fruit after citrus and banana in the world (Anonymous, 2014). The major producers of grapes in world are China, Italy, USA, Spain, France, Turkey and Argentina. India is at rank ninth with 3.31 per cent (26.02 lakh MT) of world grapes production from an area of 1.2 lakh ha (Anonymous, 2014). The short duration spur bearing varieties like Perlette, Flame Seedless, Beauty Seedless and Pusa Navrang can be grown successfully in subtropical condition of northern India. Recently, Punjab Agricultural University (PAU), Ludhiana recommended coloured grape variety 'Flame Seedless' for table purpose to the growers. This variety has an edge over already commercial grape variety Perlette as it has crimson red colour, seedless berries, relatively higher yield, better TSS/acid ratio but bunch is medium and well filled. It ripens a week later than Perlette and ease out the market glut due to Perlette. Although 'Flame Seedless' cultivar of grapes has many advantages over 'Perlette' but uneven colour development in berries is a major production constraint under subtropical conditions. The uneven development of berry colour in Flame Seedless grapes may be attributed to high temperature at time of harvesting that inhibits anthocyanin accumulation in grape berry skin (Spayed *et al.,* 2002).

Previously, various workers had tried to improve quality and colour by reducing crop load and application of ethephon. However, ethephon releases ethylene which exerts negative impact on important fruit quality characters such as reduced berry firmness, shelf life and increased berry shattering (Peppi *et al.*, 2006). Recent findings indicated that, ABA can enhance physico-chemical properties of grape berries such as average berry weight and volume (El-Sayed, 2013), fruit firmness, colour, total anthocyanin and TSS (Amiri *et al.*, 2009), titrable acidity (Peppi *et al.*, 2006), Total sugars (Giribaldi *et al.*, 2011).

Need for improvement in berry colour was felt which could enhance the marketability of the crop that fetches premium prices in the market and contributes in raising the grower's income. Therefore, considering the positive effects of ABA on fruit quality, the objectives of present work was to study the effects of crop load and pre-harvest treatments of ABA on fruit quality (bunch and berry size, TSS, TSS/ Acid ratio, acidity, fruit firmness and berry colour) of grapes cv. Flame Seedless.

MATERIALS AND METHODS

The study was conducted on 11-year-old vines of Flame Seedless grapes having uniform growth and trained on bower's training system in the vineyard at Fruit Research Farm, The Department of Fruit Science, Punjab Agricultural University, Ludhiana, Punjab, India, during cropping seasons of 2013. The own-rooted vines planted at 3 m X 3 m distance and managed under uniform cultural practices were selected for studies. The vines were retained with three levels of crop load, thinned at pea stage *viz*., 50 per cent (50-65 bunches/vine), 75 per cent (80-90 bunches/vine) and 100 per cent (110-120 bunches/tree). These treatments were compounded with three concentrations of ABA (50, 100 and 150 ppm) applied as foliar sprays at veraison stage. An additional treatment of the recommended and prevalent regional practice (75% crop load + 400 ppm ethephon) was also included in the study for comparison.

For preparing the aqueous solutions of ABA, commercial grade ABA (S-ABA 10 % *a.i.*) was used. The required concentration was worked out based on the per cent active ingredient and dissolved in small amount of alcohol, prior to making final volume with water. Tween 20® (Sigma Aldrich Co., USA) at the rate of 0.1 per cent was added to obtain better retention and penetration of ABA solution. The prepared solutions were sprayed directly to the clusters of vines (5 L per vine) at veraison (10 per cent of the berries of 50 per cent of the clusters are at colour break). Average cluster size was recorded from the twenty randomly selected bunches from each vine and calculating the length and breadth of each bunch.

The average berry size was worked out from the length and breadth of 100 berries taken from 20 bunches at random from each vine. Berry firmness was measured using a Texture Analyzer (TA + HDi® Stable Micro Systems, UK) equipped with a HDP/90 platform and 5 kg load cell. The measurement was made on the equatorial position of the berry with 4 mm probe at a test speed of 1 mm/s to a constant compression distance of 1 mm (Rolle *et al*., 2011). For analysis of other chemical parameters, 50 berries from each replicate were squeezed and the juice obtained was filtered through a cheese cloth. Total soluble solids were recorded by digital hand refractometer (Atago, Japan) and expressed in °Brix. The fruit acid content was determined by titrating juice against 0.1 N sodium hydroxide, using phenolphthalein as an indicator and sugars content by the methods of AOAC (2000) and TSS/Acidity ratio was calculated by dividing the values of TSS by TA. The peel colour of berries was measured by using Hunter lab colour difference meter (ColorFlex® EZ, USA). The values of L*, a*, b* were recorded and the hue angle (ho) arc tan (b*/a*) and chroma (C*) [(a*) 2 + (b*) 2] ½ were calculated. From these data colour index of red grapes (CIRG) was calculated as described by Carreno *et al*. (1995) i.e., CIRG = (180 – ho/ (C* + L*).

Experimental design and analysis

The experiment was laid out as randomized block design with three replications. The details of the treatments are as follows:

The data were analyzed for variance by using SAS (V 9.3, SAS Institute Inc., USA). The treatment means were subjected to mean separation by Least Significant Difference (LSD, $p \leq 0.05$) by using the methods of Singh *et al*. (1998).

RESULTS AND DISCUSSION

The vines with reduced crop load and ABA treatment produces longer bunches as compared to bunches obtained from control vines (Table-1). The maximum bunch length (24.0 cm) was recorded in treatment T_{11} (50 per cent crop load + 100 ppm ABA) which were significantly higher than control (19.5 cm). Among the crop load treatment, it was observed that the bunch size (both bunch length and breadth) increased with the decrease in crop load and this effect was further enhanced with the application of ABA. Similarly, higher average bunch breadth (19.0 cm) was recorded in the treatment with retention of 50 per cent crop load and sprayed with 150 ppm ABA. However, mean minimum bunch breadth (13.20 cm) was observed in vines left untreated. The positive effect of the treatments observed in the study may be attributed to the regulation of number of clusters on the treated vines and thus remaining bunches might have got better chances for their development. The results are in conformity with the findings of Mor *et al*. (1986) who reported that cluster and berry thinning effectively improve bunch size.

Berry size (length and breadth) were prominently higher in clusters of 50 per cent crop load vines which were treated with 100 ppm of ABA on the contrary to control (Table -1). Evidently, grapes treated with either 100 or 150 ppm of ABA produced less compact bunches alongside and larger berries in comparison to control. Beneficial effects of ABA on these parameters might account for improved cluster and berry physical properties thereby improving its marketability. The treatment 75 per cent crop load compounded with 400 ppm ethephon also significantly improved berry length. Likewise, El-Sayed (2013) found that the vines of grapes cv. Crimson

Table 1: Effect of crop load and ABA/ethephon application on bunch size and berry size of 'Flame Seedless' grapes

S. No.	Treatment	Bunch length (cm)	Bunch breadth (cm)	Berry length (cm)	Berry breadth (cm)
T_1	Crop load (100 %) – Control	19.5^{e}	13.20^{g}	1.38^{f}	1.35^{f}
T_2	Crop load (75 %)	19.90^{de}	13.80^{fg}	1.48^{def}	1.44^{ef}
T_3	Crop load (50 %)	21.30^{cde}	14.0^{fg}	1.62^{abc}	1.58^{bc}
T_4	Crop load (100 %) + 50 ppm ABA	19.60^{e}	14.30^{efg}	1.46^{ef}	1.43^{ef}
T_5	Crop load (100 %) + 100 ppm ABA	21.10^{cde}	15.10^{def}	1.59^{bcd}	1.53^{bcde}
T_6	Crop load (100 %) + 150 ppm ABA	22.10^{bc}	15.90^{cde}	1.5^{cdef}	1.48^{cde}
T_7	Crop load (75 %) + 50 ppm ABA	20.00^{de}	15.14^{def}	1.51^{cde}	1.45^{def}
T_8	Crop load (75 %) + 100 ppm ABA	22.20^{abc}	15.90^{cde}	1.60^{abcd}	1.58^{bc}
T_9	Crop load (75 %) + 150 ppm ABA	23.20^{ab}	15.30^{def}	1.62^{abc}	1.57^{bcd}
T_{10}	Crop load (50 %) + 50 ppm ABA	21.50^{bcd}	16.10^{bcd}	1.68^{ab}	1.64^{ab}
T_{11}	Crop load (50 %) + 100 ppm ABA	24.0^{a}	17.60^{ab}	1.72^{a}	1.71^{a}
T_{12}	Crop load (50 %) + 150 ppm ABA	22.60^{abc}	19.0^{a}	1.70^{ab}	1.62^{ab}
T_{13}	Crop load (75 %) + 400 ppm ethephon	22.20^{abc}	17.10^{bc}	1.66^{ab}	1.58^{bc}
	LSD ($p \leq 0.05$)	1.81	1.63	0.123	0.120

Mean followed by same letter are not significantly differ at $p \leq 0.05$.

Table 2: Effect of crop load and ABA/ethephon application on berry peel colour of 'Flame Seedless' grapes.

S. No.	Treatment	Berrycolour (l)	Berry colour (a)	Berry colour (b)	Colour index (CIRG)
T_1	Crop load (100 %) – Control	25.11[a]	2.72[d]	3.57[d]	4.30[h]
T_2	Crop load (75 %)	24.21[ab]	2.77[d]	3.64[cd]	4.43[gh]
T_3	Crop load (50 %)	21.65[bcd]	3.46[b]	4.10[abcd]	4.82[fg]
T_4	Crop load (100 %) + 50 ppm ABA	23.10[abc]	2.71[d]	3.60[d]	4.60[fgh]
T_5	Crop load (100 %) + 100 ppm ABA	22.57[abcd]	3.18[bc]	3.73[cd]	4.75[fg]
T_6	Crop load (100 %) + 150 ppm ABA	24.18[ab]	3.11[bcd]	3.84[bcd]	4.43[gh]
T_7	Crop load (75 %) + 50 ppm ABA	22.24[bcd]	4.18[a]	4.82[a]	4.58[fgh]
T_8	Crop load (75 %) + 100 ppm ABA	20.75[cde]	4.22[a]	3.77[cd]	5.24[cde]
T_9	Crop load (75 %) + 150 ppm ABA	20.17[de]	4.35[a]	4.80[ab]	4.96[def]
T_{10}	Crop load (50 %) + 50 ppm ABA	18.16[ef]	5.13[a]	4.22[abcd]	5.59[bc]
T_{11}	Crop load (50 %) + 100 ppm ABA	18.65[fe]	4.37[a]	4.60[abc]	5.35[cd]
T_{12}	Crop load (50 %) + 150 ppm ABA	17.21[f]	4.50[a]	4.15[abcd]	5.89[ab]
T_{13}	Crop load (75 %) + 400 ppm ethephon	16.70[f]	4.54[a]	4.14[abcd]	6.03[a]
	LSD ($p \leq 0.05$)	2.72	0.42	0.97	0.40

Mean followed by same letter are not significantly differ at $p \leq 0.05$.

Seedless sprayed with S-ABA (Pro-Tone) showed an increase in average berry volume. Patel *et al.* (2014) found that fruit size (length and breadth) was increased by all the thinning treatments in peach cv. Flordasun in comparison to control. Maximum fruit length (45.21mm) and breadth (44.76 mm) found in when maintaining 30: 1 leaf to fruit ratio. Raj *et al.* (2016) observed that the most fruit length (6.62 cm) takes place in chilli (*Capsicum annuum* L.) plants as compared to untreated plants (6.08 cm) when 300 ppm Ethrel applied as foliar spray.

As Flame Seedless berries mature, their colour changes from a relatively pure green to yellow and eventually to red. Fruit colour development was enhanced with ABA (150 ppm) and ethephon (400 ppm) application compared to control fruits. The treatments T_{13} and T_{12} significantly affected peel colour of grape berries in which, higher colour index of red grapes (CIRG= 6.03) and lower luminosity L^* value (16.70) along with higher a^* value (4.54) was observed. The berries treated with 400 ppm ethephon + 75 % crop load (T_{13}) and followed by the treatment T_{12} (150 ppm ABA + 50 per cent crop load) which registered the values to the tune CIRG = 5.89, L* = 17.21 and a* = 5.50. The treatment T_7 (75 per cent crop load + 50 ppm ABA) produced the berries with maximum value of b* (4.84) (Table -2). These results are in accordance with the findings of Lombard *et al.* (2004) which reported that the best results over the three seasons regarding export-quality berry colour, were obtained with ethephon applied at two weeks after acid maximum (30 to 40% colour development). Similarly, Roberto *et al.* (2013) found that ABA improves the colour of grapes, especially when applied twice (7 days after veraison + 15 days before harvest) at the concentration of 400 mg L^{-1} in 'Rubi' table grapes.

All the treatments irrespective of the intensity of crop load and spray concentration improved the fruit quality of grapes in terms of TSS, acidity, TSS/acid ratio and fruit firmness (Table 3). The highest mean TSS (19.15 per cent) was recorded in treatment T_{11} (crop load 50 per cent+ 100 ppm ABA). The treatment T_{11} was found to be statistically at par with treatments T_8, T_{12} and T_{13} which produced berries with TSS value of 18.86, 18.60 and 17.28 per cent, respectively. In case of untreated vines, the least percentage of total soluble solids 15.22 % was recorded which was significantly lower than all treatments. These results are in conformity with the findings of Amiri *et al.* (2009) which showed that application of ABA at veraision stage was more effective than ethephon for enhancing the soluble solids concentrations of fruits than the control in Beidaneh Ghermez grape cultivar. Patel *et al.* (2014) found that maintaining 30:1 leaf to fruit ratio (LFR) by fruit and leaf thinning was most effective to improve the TSS (13.16 Brix) content in peach cv. Flordasun.

The average acidity in grapes decreased with the reduction in crop load with 100 ppm ABA application (Table-3). The lowest mean acidity value of 0.44 per cent and 0.46 per cent was recorded in treatment T_{11} (crop load 50 per cent + ABA 100 ppm) and followed by T_8 (crop load 75% + ABA 100 ppm), respectively. The reduction in acidity might be due to the conversion of organic acid to sugar. The highest mean TSS/acid ratio (43.91 per cent) was recorded in treatment T_{11} i.e. crop load (50 per cent) + 100 ppm of ABA application at veraison stage. The treatments T_8, T_{11} and T_{12} were found to be statistically at par with each other with respect to TSS/acid ratio. The mean TSS/acid ratio was lowest (25.49 per cent) in control. Peppi *et al.* (2006) reported that treatment with ABA reduced titratable acidity in 'Flame Seedless' grapes. Patel *et al.* (2014) found that all the thinning treatments in peach cv. Flordasun, reduced the acidity in comparison with control, however, 30 leaves per fruit were found to be highest in reducing titratable acidity (0.65%).

Maximum fruit firmness (230.25 g $force^{-1}$) was recorded in T_{11} (50 per cent crop load + 100 ppm), followed by treatment T_{12} (50 per cent crop load + 150 ppm ABA) which had fruit firmness (215.0 g $force^{-1}$) (Table 3). However, the treatments T_9 (75 per cent crop load + 150 ppm ABA), T_{11} (50 per cent crop load + 100 ppm ABA) and T_{12} (50 per cent crop load + 150 ppm) showed statistically at par among themselves. Treatment T_1, *i.e.* crop load 100 per cent had registered lowest fruit firmness (145.60 g $force^{-1}$) as compared to other treatments. In general, the data revealed that berry firmness declined with high crop load. Grapes lose their firmness by loss of water and changes in their structure/composition. ABA prevents fruit softening and maintains high berry firmness. Likewise, Amiri *et al.* (2009) found that the grape berries receiving ethephon are fewer firms, but they had better berry quality (appearance) than those with no treatment (control).

The present study suggested that the reducing crop load and preharvest application of abscisic acid ABA/ethephon at veraison stage can be used for improving peel colour and fruit quality of Flame Seedless grapes which ultimately enhances the commercial value and fetch higher returns to the grower's.

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