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Original Research Article

Minimizing Shot Berries Level and Improving Quality of Superior Seedless Table Grapes Using Boron and GA_3

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Abstract

Two separated field experiments were carried out through four successive seasons. The aim of the two experiments was to examine the effect of boron foliar spray and GA_3 bunch dipping on reducing shot berries and improving the quality of Superior Seedless grapes. In the first experiment, grapevines were sprayed with boron at 150 cm/200 liter of water /fed at 5, 50 and 80% blooming. In the second experiment, vines were sprayed with boron at 150 cm/200 liter of water at 50% blooming (the most effective treatment from the first experiment) then bunches were dipped in GA_3 solution at 0, 10, 20 and 30 mg/l at 7-8 mm berry diameter. The obtained results markedly reveal that number of shot berries /bunch, were significantly reduced with boron and GA_3 treatments. Berry dimensions and berry shape index were significantly affected with GA_3 treatments in both seasons. Total soluble solids percentage (TSS%) and TSS/acid ratio were significantly increased as a result of boron spraying treatments. It could be recommended that spraying boron at 50% blooming and dipping bunches in GA_3 solution at 20 mg/l were the optimum treatments for reducing shot berries incidence and improving berry quality of Superior Seedless table grape.

Keywords

Berry quality

Boron

GA_3

Shot berries

Superior Seedless grapes

Yield

Introduction

Grape (*Vitis vinifera* L.) is considered one of the most important and popular fruit crops in the world, while it ranks fourth after citrus, mango and olive in Egypt (FAO, 2012). Recently, the cultivated grapes area increased year after year. Seedless table grapes are a commercially attractive fruit with high consumer demand. Generally, one of the main problems in the production of seedless table grapes, is producing small berries naturally known as shot berries. Such small berries are a limiting factor for their suitability for production and exportation.

Superior seedless is a white seedless variety of table grapes. It has several positive characteristics such as, early ripening, good appearance, excellent flavor and crispy texture with high Brix ratio at harvest and reach marketable quality during May in Egypt according to the used agriculture practices. One of the main limiting factor that prevent its spread and increasing the cultivated area is the formation of small to medium sized seedless berries called shot berries, which varied from year to another. This berries never enlarge or ripe and retain to the harvest time so, it reduce the percentage of exportable bunches. Marketing value of Superior table grapes depends on its homogeneity of berry size and shape.

The formation of shot berries in grape clusters is related with stress resulted from unsuitable conditions at the time of fertilization. The exogenous treatment of various plant hormones cleared its important role in fruit development and improving quality characteristics (Srivastava and Handa, 2005).

Gibberellins (GA_3) are widely used to increase bunch and berry weight and size, as well as yield / vine in seedless grape cvs (Ezzahouani et al., 1985; Orth, 1990a). In addition, the use of GA_3 for thinning and /or berry enlargement may affect budburst and bud fertility negatively in the following year (Orth, 1990b). According to different investigators, GA_3 generally, cause a reduction in flower set due to causing flowers fall (Orth, 1990a).

Boron is essential micronutrient for all plants growth, it is important to be available for the new reproductive development tissues and vegetative growth (Marschner, 1995). Deficiency of boron in grapevines has many symptoms include shot berries incidence, dieback of the shoot tip, yellow parts of the vines (Marschner, 1986). During flowering time, boron deficiencies can result in poor set, since it plays a main role in early season shoot growth and pollen growth and tube generation which is needed for fertilization processand berry set (Nyomora et al., 2000; Jayaprakash and Sarla, 2001; Mengel and Kirkby, 2001; Marschner, 2012). Vines that suffer from boron deficient will have clusters that set large numbers of shot berries and low boron supply inhibit flowering and seed development (Peacock and Christensen, 2005). Generally, boron foliar application timing was found to affect fruit set, fruit quality and fruit development in many fruit trees (Hanson, 1991; Nyomora et al., 1999).

Boron foliar spraying was found to be an effective method to increase boron level in reproductive and vegetative tissues rapidly. Applying boron must be done carefully because the available range between deficiency and toxicity is narrow (Peacock and Christensen, 2005). Reproductive tissues of grapevines are the most sensitive parts to boron deficiency, which lead to reduce fruit set, formation small berries (shot berries) and causing negative effect on fruit quality and fruit yield. In addition, the over dose of boron can lead to plant phytotoxicity (Christensen, 2000).

The purpose of this study is to determine the best blooming time for spraying boron to grape clusters and the best GA_3 concentration for reducing shot berries incidence and improving berry quality.

Materials and methods

The present investigation contains two experiments were carried out during four successive seasons on Superior Seedless grapevine. The first experiment was carried out during 2011, 2012 seasons to determine the role of boron in reducing shot berries in grape clusters. The second experiment was conducted after the first one during 2013 and 2014 seasons. In the second experiment, the final recommended result obtained from the first one (boron at 150 cm/200 liter of water at 50% blooming) was used as a general agricultural practice in the second one.

The experimental Superior Seedless vines were 8-year-old at the beginning of this study, grown in a private vineyard at Bilbees district, Sharkia Governorate, Egypt. The experimental vines were selected to be healthy, nearly similar in growth vigor and size and received the normal horticultural practices. The vineyard was planted at 1.5 m between vines in the row and 2.5 m between rows in sandy soil under drip irrigation system and trellised on Spanish Paron system. Superior Seedless vines were trained according to the cane pruning system and pruned at winter of each season leaving around 120 buds/vine, i.e., 12 fruit canes ×10 buds/cane.

After fruit set, all experimental vines were adjusted to 15 clusters/vine. In the first experiment, the selected vines (4 treatments × 3 replicates) were sprayed by boron solution (boron soluble in water 13.3% w/v) at 150 cm/200 liter of water /fed (the recommend rate of the producing company) at different stages of blooming (calyptras fall) to determine the suitable flowering stage of application. The following boron foliar spraying treatments were applied on the whole vine as follows:

1. Control treatment (vines were sprayed with water only).
2. Spraying with boron at the begining of blooming (approximately 0-5 % calyptras fall) directly when the flowers of the cluster start to open.
3. Spraying with boron at approximately 50% blooming.
4. Spraying with boron at full bloom (approximately 80-100% calyptras fall).

In the second experiment, bunches of the selected vines were dipped in GA_3 solutions in 2013 and 2014 seasons, mainly because Superior Seedless is very sensitive to GA_3 treatments which sharply reduce bud fertility and budburst (Orth, 1990b). GA_3 treatments were applied after fruit set at approximately 5-6 mm berry diameter to determine the suitable concentration for bunches dipping in the prepared GA_3 solutions to avoid the negative effect of GA_3 on budburst and bud fertility in the following year (Orth, 1990b). The GA_3 treatments were as follows:

1. Control treatment (vines were sprayed with water only).
2. GA_3 at 10 mg/l.
3. GA_3 at 20 mg/l.
4. GA_3 at 30 mg/l.

At harvest time, bunches of each vine were picked and the yield /vine (kg) was recorded. Five bunches per each replicate were randomly taken and the following parameters were estimated: bunch weight, total number of berries/bunch, number of normal berries/bunch and number of shot berries/bunch. The shot berries percentage was then calculated.

In addition, berry physical characteristics: 100 berries were randomly picked from each bunch sample (5 bunches of each replicate) and the 100 berry weight was estimated. The berry polar diameter (cm) and berry length (cm) were estimated, random 30 berries sample per each replicate using Vernier caliper. The berry shape index, i.e. length/width was calculated.

Moreover, the berry chemical constituents were determined in berry juice after being extracted from 100 berries representing each replicate as follows: the total soluble solids percentage (TSS%) of berry juice was determined using a hand refractometer. The juice acidity was determined by titration against sodium hydroxide (0.1 N) in the presence of phenolphythalyne as indicator. The total juice acidity was expressed as g tartaric acid per 100 ml of juice. The TSS/acid ratio of each juice sample was then calculated (AOAC, 2006).

Statistical analysis

This experiment was set in a completely randomized block design with 4 treatments; each treatment was applied on three vines (three replicates). The obtained data were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1982) using SPSS program. The individual comparisons between the obtained means were carried out using LSD at 5% level.

Results and discussion

The first experiment

Yield and bunch component: The boron tested treatments at all stages of blooming affect the number of normal berries /bunch and significantly, reduced number of shot berries/bunch in both seasons (Table 1). The uppermost number of shot berries/bunch was recorded for control treatment in both seasons. On the other hand, the lowermost value of shot berries and the highest number of normal berries resulted from spraying boron at 50% flowering in the two seasons. Generally, all boron treatments reduced shot berries, and increased number of normal berries in both seasons. This result is in line with those of Wojcik and Wojcik (2003) and Nikkhah et al. (2013). The percentage of reduction in shot berries in grape clusters differed among treatments (flowering stages) and ranged between7.8 - 15.1% in the first season and 8.3- 14.4% in the second one compared with control treatment (Table 1). Boron treatment at 50% blooming recorded the smallest number of shot berries/bunch in both seasons. This result may be as a direct effect of boron in increasing fruit set by improving pollen germination and growth of pollen tube (Mengel and Kirkby, 2001; Wojcik and Wojcik, 2003; Wójcik et al., 2008).

Data in Table 1 clearly showed that boron treatments significantly increased yield/vine, bunch weight and weight of 100 berries in both seasons. The highest yield /vine was recorded for boron spraying at 50%

blooming stage. Also, boron treatments at all blooming stages increased bunch weight and weight of 100 berry in both seasons. This result is in harmony with those of Ahmedullah et al. (1987). Boron treatments at 5 and 50% blooming recorded the most significant increase in both seasons. This result is in line with those reported by Yamdagni et al. (1979) and Sindhu et al. (1999). The obtained increments in yield/vine, bunch weight and weight of 100 berries may be a direct effect of decreasing number of shot berries in the bunches of vines treated with those treatments. In addition, boron plays a main role in correlation with accumulation process of more photosynthetic products (Shukha, 2011).

Table 1. Effect of boron foliar application at different stages of blooming on total number of berries/bunch, number of normal berries/bunch, number of shot berries/bunch, percentage of shot berries/bunch, yield/vine, bunch weight and weight of 100 berries of Superior Seedless table grapes in 2011 and 2012 seasons.

Treatments	Total number of berries/bunch		Number of normal berries/bunch		Number of shot berries/bunch		Percentage of shot berries/bunch		Yield/vine (kg)		Bunch weight (g)		weight of 100 berry (g)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Blooming level														
Control (sprayed with water only)	136.1	125.4	101.1	106.7	35.0	29.1	25.7	23.2	4.28	4.37	281.8	287.2	206.1	226.3
5% blooming	129.7	134.2	111.4	103.0	18.3	17.0	14.1	12.7	4.54	4.20	299.4	279.3	229.3	207.6
50% blooming	133.3	126.0	119.2	110.0	14.1	11.1	10.6	8.80	4.77	4.46	314.6	293.1	237.8	231.0
80% blooming	127.8	131.6	104.9	120.0	22.9	19.6	17.9	14.9	4.40	4.81	289.9	315.7	226.8	238.2
LSD 0.05	7.65	6.81	11.85	11.60	7.04	6.49	8.08	3.55	0.41	0.37	20.56	24.05	13.64	11.64

Chemical berry characteristics: Data in Table 2 is clear that boron spraying at all stages of blooming significantly increased TSS percentage and TSS/acid ratio in both tested seasons. This result may be attributed to boron treatment which increases the movement and accumulation of phloem carbohydrates and sugars which increases fruit soluble solids content Abdollahi et al. (2010) and Nikkhah et al. (2013). On the other hand, boron treatments at all stages of blooming significantly decreased acidity percentage in both seasons compared with control treatment.

Table 2. Effect of boron foliar spraying at different stages of blooming on TSS, acidity, TSS/acid ratio, berry length, berry diameter, berry shape index of Superior Seedless table grapes in 2011 and 2012 seasons.

Treatments	TSS		Acidity		TSS acid ratio		Berry length		Berry diameter		Berry shape index	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Blooming level												
Control (without any spray)	14.0	14.4	0.70	0.71	20.0	20.4	1.33	1.37	1.16	1.24	1.16	1.11
5% blooming	16.2	16.6	0.65	0.66	25.0	25.2	1.60	1.57	1.30	1.29	1.23	1.23
50% blooming	16.5	16.8	0.61	0.63	27.1	26.8	1.69	1.71	1.38	1.34	1.25	1.28
80 % blooming	16.0	16.1	0.67	0.68	24.0	23.7	1.52	1.50	1.26	1.22	1.21	1.25
LSD 0.05	0.85	1.02	0.06	0.05	2.39	2.89	0.23	0.18	0.13	0.08	0.08	0.14

Data in Table 2 also shows that boron treatments at all stages of blooming affect berry physical characteristics in both seasons. This obvious effect was significant in berry length and diameter as well as berry shape index because boron has an important role and effect on cell wall structure and cell elongation (Abdollahi et al., 2010) and improve cell number or cell size. The obtained findings are in line with those reported by Singram and Prabhu (2001), Abdollahiet al. (2010) and Ashoori et al. (2013).

The second experiment

The tested GA_3 treatments affected the number of normal and shot berries/bunch in both seasons (Table 3). GA_3 treatments at 10 and 20 mg/l significantly reduced number of shot berries/bunch in both seasons. This result is in harmony with that of Zabdal and Dittmer (2000). On the other hand, the uppermost number of shot berries/bunch was recorded for control treatment and GA_3 treatment at 30 mg/l in the two seasons. The obtained result is in line with those reported by Lynn and Jensen (1966) and Dokoozlian and Peacock (2001). The lowermost value of shot berries and the highest number of normal berries resulted from dipping bunches in GA_3 solution at 20 mg/l in the two seasons. GA_3 treatments at 10 and 20 mg/l reduced shot berries to reach 5.23 and 2.08% against 11.1% for control treatment in the first season, and 6.01 and 2.50% against 10.5% for control treatment in the second one. These results are in agreement with those of Hassan et al. (1988), Usha et al. (2005) and Josan et al. (2011).

Table 3. Effect of GA_3 dipping on total number of berries /bunch, number of normal berries /bunch, number of shot berries / bunch, percentage of shot berries /bunch, yield/vine, bunch weight and weight of 100 berries of Superior Seedless table grapes in 2013 and 2014 seasons.

Treatments	Total number of berries/bunch		Number of normal berries/bunch		Number of shot berries/bunch		Percentage of shot berries/bunch		Yield/vine (kg)		Bunch weight (g)		Weight of 100 berry (g)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
GA_3 concentration														
0 mg/l (Control)	141.0	134.7	125.4	126.6	15.6	14.3	11.1	10.5	5.04	4.87	331.7	344.5	232.2	254.8
10 mg/l	136.1	141.0	129.0	137.5	7.10	8.10	5.23	6.01	5.32	5.13	350.2	397.1	256.3	280.6
20 mg/l	143.9	136.2	140.9	121.9	3.00	3.53	2.08	2.50	6.20	6.00	406.6	320.9	281.9	233.6
30 mg/l	138.4	131.8	120.8	111.6	17.6	20.2	12.6	15.3	5.90	5.51	389.3	362.3	277.3	271.9
LSD 0.05	5.87	6.79	6.98	6.22	6.72	3.87	4.53	2.84	1.06	1.11	48.55	44.97	15.88	17.36

The positive effect of GA_3 treatments at 10 and 20 mg/l on percentage of shot berries/bunch differed significantly among treatments. It ranged between 5.87-9.02% in the first season and 4.49-8.00% in the second one (Table 3). Dipping bunches in GA_3 solution at 20 mg/l recorded the smallest number of shot berries/bunch in both seasons, whereas the highest number of shot berries/bunch was recorded for GA_3 at 30 mg/l in both seasons. This result was in harmony with those found by Weaver and McCune (1961), Khajuria and Bakhshi (1985), El-Ghany (2000) and Dokoozlian and Peacock (2001). This result may be due mainly to genetic sensitive of some grape varieties for GA_3 treatment (Zabdal et al. 1997; Dokoozlian and Peacock, 2001). Data in Table 3 shows that GA_3 treatments increased yield/vine, bunch weight and weight of 100 berries in both seasons. The uppermost increase was recorded for GA_3 at 20 mg/l. This result is in agreement with those stated by El-Hammady et al. (1998), Ferree et al. (2003), Casanova et al. (2009) and Gonzaga and Ribeiro (2009) and may be attributed to the least number of shot berries /bunch (Zabdal and Dittmer, 2000).

Table 4. Effect of GA_3 dipping on TSS, acidity, TSS acid ratio, berry length, berry diameter and berry shape index of Superior Seedless table grapes in 2013 and 2014 seasons.

Treatments	TSS		Acidity		TSS acid ratio		Berry length		Berry diameter		Berry shape index	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
GA_3 concentration												
0 mg/l (Control)	16.5	16.3	0.62	0.60	26.6	27.2	1.65	1.59	1.36	1.40	1.21	1.14
10 mg/l	15.7	15.5	0.63	0.64	25.0	24.7	1.82	1.80	1.70	1.67	1.15	1.09
20 mg/l	15.2	15.0	0.65	0.66	23.4	22.8	1.89	1.91	1.92	1.95	1.06	1.13
30 mg/l	13.4	13.5	0.73	0.71	18.4	19.1	1.91	1.95	2.03	2.10	1.18	1.24
LSD 0.05	1.68	2.05	0.06	0.05	3.01	4.43	0.25	0.19	0.21	0.21	0.08	0.10

Data in Table 4 clearly shows that GA_3 treatments generally reduced TSS percentage and TSS acid ratio in berry juice, especially GA_3 at 30 mg/l which recorded the lowermost percentages in both seasons. GA_3 treatments increased acidity percentage in berry juice in the two seasons, especially GA_3 at 30 mg/l which gained the highest percentage compared with control treatment. All GA_3 treatments significantly improved berry dimensions (diameter and length) in both seasons. This result is in line with that observed by Josan et al. (2011). In general, the obtained data from the two experiments revealed a sharp decrease in the occurrence of shot berries in Superior Seedless bunches as a direct effect of boron foliar spray at 50% blooming and dipping bunches in GA_3 solution at 20 mg/l.

The decrement in shot berries incidence may result either by preventing its formation or dropping the formed ones. GA_3 at 20 mg/l enhanced yield and quality of superior grapes by improving weight of 100 berry, bunch weight, yield/vine, berry dimensions. These results are in harmony with those of Marzouk and Kassem (2011). While GA_3 at 30 mg/l significantly increased shot berries in the two seasons and deformed the shape of the main and lateral bunch rachis. These results are in agreement with those of Weaver et al. (1959) and (1961), and Dokoozlian and Peacock (2001).

Conclusion

Generally, it could be concluded that boron spraying at 150 cm/200 L at 50% flowering reduce shot berries incidence by 58.8 -62.1% compared with control treatment in both seasons. The direct contact with boron sprays may enhance and improve fruit set as compared to after and pre-blooming sprays (Christensen et al., 2006). Dipping bunches in GA_3 solution at 20 mg/l reduced shot berries by 72.1–85.9 % compared with control treatment in both seasons.The combination of the previous two treatments together (boron spraying at 50% flowering and dipping bunches in GA_3 solution at 20mg/l reduced shot berries in Superior Seedless bunches by 89.2–91.8% compared to control treatment in both seasons.

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