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Effect of Streptomycin and GA3 Application on Seedlessness, Yield and Fruit Quality of 'Balady' Mandarin

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THE EFFECTIVENESS of repeated applications of GA3 and streptomycin (SM) to stimulate seedless fruit development or reducing seed number per fruit of mandarin (Citrus recticulata Blanco cv Balady) were evaluated under field conditions at Motobus district, Kafr El-Sheikh governorate during 2014 and 2015 seasons. Trees were sprayed with GA3 at 25 ppm, SM at 250 ppm, SM at 500 ppm, SM at 250 ppm + GA3 at 25 ppm and SM at 500 ppm + GA3 at 25 ppm, while the control trees were sprayed with tap water. Results indicated that GA3 at 25 ppm recorded the highest fruit weight and acidity in both seasons. SM 500 + GA3 reduced seed number per fruit with about 76.66 and 77.46 % reduction in both seasons, respectively compared to the control. Meanwhile, high yield and fruit characteristics, firmness, vitamin C, brix and SSC/Acid ratio, were maintained under this treatment. The addition of GA3 to SM increased its efficacy in this respect.

Keywords: Seedlessness, GA3, Streptomycin, Mandarin, Fruit quality.

Introduction

Citrus are one of the most widely cultivated and economically important fruit crops in the world and a major export product of Egypt. Mandarins represent around 25.35% of total Egyptian citrus production (Arab Agricultural Statistics Yearbook, 2011). Among the important cultivated varieties in Egypt is 'Balady' mandarin. The fruits of this variety have quite big number of seeds, which is disadvantage, since consumers prefer seedless fruit or that with less seed number.

Production of triploids by crossing is one of the most effective ways for producing seedless fruits (Grosser & Chandler, 2004 and Reforgiato et al., 2005). However, desirable autotetraploid that can be used in such crosses are still limited. A citrus cultivar can be considered seedless if it is able to produce normal fruit containing no seeds, aborted seeds, or a significantly reduced number of seeds (Vardi et al., 2008).

Endogenous gibberellic acid levels increased in the parthenocarpic Fino Clementine, pear and grape cultivars (Coombe, 1960, Garcia-Papi & Garcia-Martinez, 1984 and Gil et al., 1972). Gibberellic acid (GA3) is widely used to induce seedlessness in seeded varieties in grapes (Fukunaga & Kurooka, 1988, Ogasawara, 1985, Ogasawara and Hirata, 1985, Fellman et al., 1991, Shiba, 1980, Kazunori et al., 2001 and Cheng et al., 2013), cherry (Beppu et al., 2001 and 2005), loquat (Mesejo et al., 2010) and other fruits (Pharis and King, 1985).

Streptomycin (SM) is a human antibiotic drug which also is used as a pesticide, to control bacterial and fungal diseases of certain plants including fruit crops. The use of streptomycin to control fire blight on apples and pears accounts for 58% of its total use (U.S. Environmental Protection Agency. 1992). SM has been used to induce seedlessness in different grape varieties such as Kyoho (Fukunaga & Kurooka, 1988, Ogasawara, 1985 and Shiba, 1980) and Muscat Bailey A (Ogasawara and Hitra, 1985).

GA3 failed to induce seedlessness in many cases (Motomura and Hori, 1978), thus cultivars need to be evaluated individually for this characteristic.

The objective of this study was to

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investigate whether GA3 and SM would be efficient in reducing seed number per fruit or producing seedless 'Balady' mandarin fruits.

Materials and Methods

The experiment was carried out at a private orchard located in Motobus area, Kafr El-Sheikh governorate, Egypt during 2014 and 2015 seasons. The experimental site is clay soil. Soil chemical and physical analysis is shown in Table 1.

Plant material and treatments

Eighteen years old healthy and uniform mandarin (Citrus reticulata Blanco cv Balady) trees budded on sour orange and planted at 5 m apart were used in this study. Trees were subjected to six foliar spray treatments as follows:

- Control (tap water)
- GA3 at 25 ppm
- Streptomycin at 250 ppm
- Streptomycin at 500 ppm
- Streptomycin at 250 ppm + GA3 at 25 ppm
- Streptomycin at 500 ppm + GA3 at 25 ppm

Trees were sprayed three times, at the beginning of flowering, 50% of full bloom and at full bloom. Each treatment was represented with three trees.

TABLE 1. Some chemical and physical properties of the experimental soil.

Physical			Chemical		Soluble Cations (meq.l^{-1})				Soluble Anions (meq.l^{-1})		
Sand %	Silt %	Clay %	pH	Ec (dS.m^{-1})	Na+	Ca++	Mg++	K+	HCO3-	Cl-	SO4-
10.33	38.31	51.36	8.2	1.68	9.5	3.71	2.94	0.15	2.0	9.0	5.3

Yield and fruit quality properties determination:

Fruits were harvested when SSC/acid ratio reached to 8-12, then yield was calculated based on fruit number and average fruit weight per tree. Fruit physical and chemical properties were estimated. Fruit firmness was measured by using LFRA texture analyzer. Juice SSC was determined by a handy refractometer. Titratable acidity expressed as citric acid (%) was estimated with titration with NaOH (0.01 N) with presence of Ph Ph indicator according to AOAC (1995), then SSC/acid ratio was calculated. Ascorbic acid content (V.C) was determined using 2, 6 dichlorophenol indophenol according to Jacobs (1951). Seed number per fruit was also counted using 100 fruit per replicate.

Statistical analysis

The experiment was laid out in a randomized complete block design with three replicates. Data were statically analyzed using CoStat 6.303, CoHort Software, 798 Lighthouse Ave. PMB 320, Monterey, CA, 93940, USA.

Results

Data in Table 2 show that application of GA3 significantly increased fruit weight recording the highest values in both seasons followed by control and SM at 500 ppm + GA3 in the first season and both concentrations of SM+ GA3 in the second season with no significant difference. However, total fruit number and yield per tree was obtained at SM 500 ppm + GA3 in both seasons.

TABLE 2. Effect of GA_3 and streptomycin (SM) application on fruit weight, fruit number per tree, yield and firmness in 'Balady' mandarin.

Treatments	Fruit Weight (g)		Fruit No./tree		Yield (kg/tree)		Fruit Firmness g.mm^{-2}	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	140.18b	138.93b	604.00e	617.00e	84.60d	85.73c	31.40e	34.38e
GA3 (25 ppm)	146.94a	150.73a	615.00d	611.00e	90.38b	92.09b	38.91d	40.02d
SM (250 ppm)	128.49e	132.07d	674.67b	660.00c	86.69cd	87.17c	42.36cd	44.08c
SM (500 ppm)	131.63de	133.49cd	647.00c	643.67d	85.16d	85.93c	45.19c	43.35c
SM (250) + GA3 (25)	134.07cd	137.49bc	671.67b	670.67b	89.88bc	92.22b	53.85b	51.59b
SM (500) + GA3(25)	137.47bc	138.32bc	701.67a	708.33a	96.46a	97.98a	61.19a	57.51a

Means followed by the same letter are not significantly different at 5% level by DMRT.

A clear reduction in seed number per fruit was observed under all treatments compared to the control (Fig.1). The most effective treatment was SM 500 + GA_3 with about 76.66 and 77.46 % reduction in both seasons, respectively. The addition of GA_3 to SM increased its efficacy in this respect.

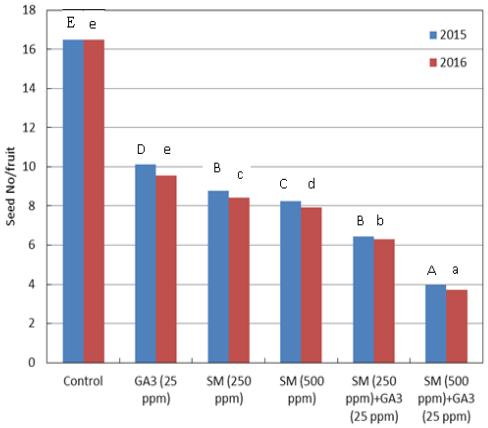

Fig.1. Effect of GA_3 and streptomycin (SM) application on seed number per fruit in 'Balady' mandarin.

Fruit firmness was significantly higher in all treatments compared to control. SM+ GA3 treatments had the highest values followed by SM treatments alone, GA3 and control respectively.

Fruit chemical characters were improved by all treatments as compared to the control (Table 3). Soluble solids content (SCC) showed a significant increase recording the highest value at SM+GA3 with no significant difference between the two used concentrations in both seasons, while the lowest Brix value was found under control.

Titratable acidity of the juice increased as a result of GA3 application and reduced significantly at SM and SM+ GA_3 treatments, consequently SSC/Acid ratio was increased with the highest ratio at SM500+ GA_3 in the first season and both SM concentrations+ GA3 in the second season. The lowest ratio recorded at control and GA_3 alone treatments.

Vitamin C is one of the most important nutritional quality factors in many horticultural crops and has many biological activities in the human body. The content of vitamin C was enhanced as a result to SM treatments either alone or accompanied with GA_3compared to the control. The highest content was recorded at SM at 250 and 500 ppm +GA_3 with no significant difference among these two treatments and the lowest content was found under control treatment, while the other treatments showed intermediate value of vitamin C.

Discussion

Among the major goals of improvement of fruit crops are large fruit size as well as reduced seed number and size (Varoquaux et al., 2000). Exogenous GA_3 application is one of the strategies used to induce seedlessness in seeded grape varieties and so SM has been used for the same purpose (Fukunaga & Kurooka, 1988, Ogasawara, 1985, Ogasawara & Hirata, 1985 and Shiba, 1980).

GA3 application increased fruit weight significantly as compared to the control (Table 2). These findings are in agreement with the reports of Rokaya et al. (2016) and Pal et al. (1977) in mandarin, Singh et al. (2003) in pear, and Kaur et al. (2008) in plum. The increment in fruit weight may be due to hormone directed to transportation and accumulation of phytosynthates which resulted in better fruit development and also acceleration of cell division, elongation, and enlargement. Lu et al. (1997) found that seedless

TABLE 3. Effect of GA_3 and streptomycin (SM) application on vitamin C content, SSC, acidity and SSC/Acid ratio of 'Balady' mandarin fruits.

Treatments	Vitamin C (mg/100 ml)		SCC % °Brix		Acidity %		SSC/Acid ratio	
	2015	2016	2015	2016	2015	2016	2015	2016
Control	38.01d	37.63d	8.37c	8.73d	0.96b	0.94b	8.75cd	9.33d
GA3 (25 ppm)	39.18cd	39.77c	8.40c	8.80d	0.99a	0.97a	8.49d	9.21d
SM (250 ppm)	40.21bc	39.88c	8.40c	9.43c	0.91c	0.91c	9.26c	10.37c
SM (500 ppm)	41.32b	41.10b	9.47b	9.73b	0.88c	0.86d	11.01b	11.31b
SM (250) + GA3 (25)	42.91a	43.53a	9.80a	10.57a	0.85d	0.82e	11.54b	12.98a
SM (500) + GA3(25)	43.45a	44.26a	10.07a	10.73a	0.82d	0.80f	12.23a	13.45a

Means followed by the same letter are not significantly different at 5% level by DMRT.

berries in clusters of 'Triumph' grape treated with GA3 were characterized by smaller size. However, seeded berries under the same treatment weighed significantly more compared to nontreated vines.

Fruit firmness is one of the fruit quality characters. Fruit firmness was significantly higher in all treatments compared to control and it seems that the addition of GA3 to SM solution apparently increased fruit firmness (Table 2). These results are in conformity with the findings of Rokaya et al. (2016) and Ladaniya (1997) on mandarin and Abo El-Enien (2012) and Zahgloul (2004) on Navel orange, who stated that GA3 treated fruits had higher peel firmness.

The average number of seeds per fruit was significantly reduced as a result of either single or combined application of GA3 and SM (Fig.1). The combined treatment (SM at 500ppm+GA3 at 25ppm) reduced seed number per fruit by about 77% with increased fruit yield compared to the control. Eshghi et al. (2010) found that streptomycin was effective in inducing seedlessness in the naturally seeded table grape 'Rotabi Seyah' with high total soluble solids and decreased bunch weight compared with control.

Application of GA3 before anthesis was found to accelerate embryo sacs degeneration after anthesis, whereas the GA-biosynthesis inhibitor, paclobutrazol (PBZ) increases their longevity (Beppu et al., 2001). Early degeneration of embryo sacs by GA3 treatments before anthesis also has been observed in 'Muscat Bailey A' (Takagi, 1980) and 'Kyoho' (Komatsu, 1987) grapes.

Mesejo et al. (2008) concluded that application of GA3 the days around anthesis impairs fertilization by either enhancing ovule abortion or reducing pollen tube growth, in `Clemenules' flowers under cross-pollination conditions. The intensity of the response depends on the physiological flower state at the moment of treatment.

The GA3 -induced increase in cell damage may be caused by reactive oxygen species, a decrease in antioxidant enzymatic activities, and an alteration of the expression of genes related to seed development (Cheng et al., 2013).

Concerning the induction of seedlessness by SM, Ogasawara (1985) suggested that principal action of SM should be to cause ovule abnormality and thus some different mechanism to cause seedlessness by GA based on the fact that SM carries sterilizing power against bacteria (inhibitory action of protein synthesis) and this may result in an inhibitory effect for ovary growth, cell division and enlargement in ovary wall tissue. Moreover, Fukunaga and Kurooka (1988) suggested that the increase in seedless berry set by addition of SM to GA solution would probably be due to the inhibitory effect of SM to seed growth and development.

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تأثير الإستربتوميسين والجبريلين على إنتاج ثمار لا بذريه والمحصول وجودة الثمار فى اليوسفى البلدى

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أجريت هذه الدراسة تحت ظروف الحقل بمنطقة مطوبس – محافظة كفر الشيخ خلال موسمى ٢٠١٤ و ٢٠١٥ وذلك لدراسة تأثير الرش بالجبرلين والإستربتوميسين على انتاج ثمار لا بذريه او قليلة البذور والمحصول وجودة ثمار اليوسفى البلدي. وكانت المعاملات عبارة عن الرش بالجبرلين بمعدل ٢٥ جزء فى المليون منفردا والإستربتوميسين بمعدلات ٢٥٠ و ٥٠٠ جزء فى المليون منفردا أو بإضافة الجبرلين بمعدل ٢٥ جزء فى المليون إلى معاملات الإستربتوميسين السابقة. أشارت النتائج إلى أن معاملة الجبرلين بمعدل ٢٥ جزء فى المليون سجلت أعلى وزن ونسبة الحموضة لثمار اليوسفى في كلا الموسمين .خفضت معاملة الإستربتوميسين بمعدل ٥٠٠ جزء فى المليون + الجبرلين بمعدل ٢٥ جزء في المليون من عدد بذور/ثمرة بنسبة ٦٦و٦٧٪ و ٤٦و٧٧٪ خلال الموسمين على التوالى مقارنة بالكنترول، كما حققت هذه المعامله أعلى محصول وصفات جوده للثمار من صلابة وفيتامين س ونسبة المواد الصلبة الذائبة الكلية ونسبة المواد الصلبة الذائبة /الحموضة .