Study on the Induction of Seedless Loquat

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Abstract

An experiment was conducted to induce seedless fruit in loquat by applying gibberellic acid (GA_3) at 150, 200, 250, 300 mg L^{-1} when one third of single flower cluster was flowering and $CuSO_4.5H_2O$ at 25, 50 mg L^{-1} at full bloom. The application of 250 and 300 mg L^{-1} GA_3 induced seedless fruit. The seedless loquats were longer and narrower as compared with the untreated seeded fruits. The total soluble solids contents at harvest were similar with seeded fruits. When 50 mg L^{-1} of $CuSO_4.5H_2O$ was applied reduced the number of seeds per fruit. Finally trees treated with 250 mg L^{-1} GA_3 induced parthenocarpy in loquat.

Keywords: copper, *Eriobotrya japonica*, fruit quality, gibberellic acid, parthenocarpy

Introduction

Loquat tree (*Eriobotrya japonica* Lindl.) belongs to the family Rosaceae, Maloideae is a subtropical evergreen fruit tree(Lin et al., 1999; Sharafi et al., 2011). That blooms in fall and early winter and fruits are harvested 152-189 days after full bloom (Lin et al., 1999). The center of origin of *Eriobotrya japonica* has been accepted as the middle and lower valley of the Daduhe River in China (Zhang et al., 1993) and now it is commercially grown in many countries, including China, Japan, Italy, Brazil, Spain, Northern India (Chen et al., 2009). Loquat is one of the most perspective trees with tasty fruits suitable for commercial production in Iran (Sharafi et al., 2011). Loquats are consumed mainly as fresh fruit, which contain nearly all of the essential nutrients, particularly minerals and carotenoides (vitamin A) (Ding et al., 2001). A pome fruit has several proportionately small seeds and sigmoid pattern of fruit growth, while a stone fruit has proportionately large seed and generally a double sigmoid growth curve. The loquat has relatively large seed, as do the subfamily Amygdaloideae but has multiple seeds as do the subfamilies Rosoideae and Maloideae (Blumenfeld, 1980; Lin et al., 1999). The ovary of loquat flower contains 5 carpels with 2 ovules in each. Under open pollination condition the fruit bears among 1-5 seeds. Seeds are relatively large and occupy 20-30% of fruit volume (Sadamatsu et al., 2004). Two weeks before color breaks; flesh exceeds seed in weight and becomes the main contributor to fruit weight, both fresh and dry weight (Agustí et al., 2011). These multiple large seeds reduce the edible portion of loquats as well as their appeal to the consumer and also decrease the quality of the fruits. Seedless fruit is a desirable trait that has been achieved in many plant cultivars, such as grape and citrus. Production of seedless loquat is commercial importance and represents a valuable horticultural objective (Goubran and El-zeftawi, 1986; Mesejo et al., 2010). Several groups of scientists having applied GA to induce seedless fruits (Kumar, 1976; Muranishi, 1983; Goubran and El-zeftawi, 1986; Takagi et al., 1994; Kimura et al., 1996; Matsui et al., 2004; Gowda et al., 2006; Polat, 2007; Guo et al., 2011; Liang et al., 2011; Yahata et al., 2006). The objective of this study was to evaluate the effectiveness of GA_3 and $CuSO_4.5H_2O$ in inducing parthenocarpy in loquat.

Materials and Methods

Plant Material

Experiments were carried out in orchards of adult (10- year-old) loquat trees and located in Shiraz Eram garden (29º 38´ 10" N, 52º 31´31" E). The trees were planted 4m × 3m and received standard horticultural practice and disease and insect control.

Treatments

To determine the optimum concentration of GA_3 inducing parthenocarpy 150, 200, 250, 300 mg L^{-1} were sprayed by hand gun at 12 l/ tree on entire trees when one third of a single flower cluster was flowering and in a separated experiment, $CuSO_4.5H_2O$ at 25, 50 mg L^{-1} were sprayed on entire trees at the full bloom. Control trees were sprayed with water. The experiment was carried out during the years 2009 and 2010.

Measurements

The loquat fruit were harvested at commercial maturity and 25 fruit samples were randomly picked from each treatment and each replication. Each fruit was then weighed and average fruit weight per part was estimated. The width and length values of each fruit were measured by a digital compass. The ratio was estimated by dividing fruit width by fruit length. After measurements of fruit weight, seeds were removed from fruit pulps by halving the fruits. Seeds were weighed by a precision scale of ±0.01 g. Seed counts were also made. Fruit juice was obtained by blending the above halved fruit pulps without seeds. A few drops of fruit juice were analysed by a hand refractometer (N.O.W. (Nippon Optical Works Co. Ltd Tokyo/Japan) model no. 507-I (Brix 0-32%) and Titratable acidity (TA) was determined by titration with 0.1 *N*, NaOH, using phenol-phthalein as indicator. Its volume was measured by the water displacement method (Akar and Aydin, 2005). For this purpose, a loquat fruit was submerged into a known volume of water, and the volume of water displacement was measured.

Statistical Analysis

All experiments were conducted in 4 replicates using a randomized complete block design. The statistical analyses were performed using MSTATC. Duncan's multiple range tests was used to determine the significance of differences among the compared mean values at a level of confidence of 0.05.

Results and Discussion

GA_3 significantly reduced the number of seeds per fruits and the magnitude of the response depended on the concentration applied. Application of 250 and 300 mg $L^{-1}$of GA_3 significantly reduced the number of seeds in comparison with the control and two lower concentration of GA_3 (Table 1). Conversely, control trees and 150 mg $L^{-1}$of GA_3 in average fruit weight were highest (14.77, 14.82 g), (Table 1). Differences in fruit weight between seedless and seeded fruits became significant ($P<0.05$). Development of loquat fruit during the period studied was divided in two distinct phases. The phases before the turning point were a growth phase characterized by growth of seed, next came a phase of maturation. Termination of the seed growth was followed by a rapid growth of pulp tissue, and fresh weight of the whole fruit increased

Table 1 Effects of GA_3 concentration on seed number, fruit weight, length, width, width/length index and fruit volume of loquat.

Treatment	Seed number	Fruit weight	Fruit length	Fruit width	Width/ length index	Fruit volume
(GA3 mg L^{-1})		(g)	(---------- mm ---------)			(cm^3)
control	4.87a	14.77a	27.12 b	28.99a	1.06a	13.25a
150	4.47a	14.82a	27.67b	29.02a	1.04a	13.25a
200	3.23b	10.48b	28.31b	22.91b	0.8b	7.25b
250	0.05c	7.87c	28.7b	22.12b	0.77b	6.5b
300	0c	7.16c	33.2 a	21.86b	0.65c	6.25b

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

in a sigmoid fashion (Hirai, 1980). Although the greatest fruit length (33.2 mm) occurred when 300 mg L^{-1} GA_3 was applied (Table 1). No significant differences were found in fruit length between control and 150, 200, 250 mg L^{-1} GA_3 (Table 1). Moreover, increasing concentration up to 200 mg L^{-1} GA_3 did not significantly improve the fruit width. The highest fruit width was found in control trees and 150 mg L^{-1} GA_3 (28.99, 29.02 mm) (Table1). The highest fruit width/length index was found in control trees (1.06) and 150 mg $L^{-1}GA_3$ (1.04) although the lowest fruit width/length index (0.65) occurred when 300 mg L^{-1} GA_3 was applied (Table 1). No significant differences were found in fruit volume between control and 150 mg L^{-1} GA_3 (13.25 cm^2) and the lowest fruit volume were found in 300, 250, 200 mg L^{-1} GA_3 (6.25 cm^2), (Table 1). Our results are in accordance with several groups of scientists having applied GA to induce seedless fruits (Kumar, 1976; Muranishi, 1983; Goubran and El-zeftawi, 1986; Takagi et al., 1994; Kimura et al., 1996; Matsui et al., 2004; Gowda et al., 2006; Polat, 2007; Guo et al., 2011; Liang et al., 2011). To establish a useful agronomical technique for reducing the number of seeds per fruit in orchards $CuSO_4.5H_2O$ was applied to entire adult trees. The application of 50 mg L^{-1} $CuSO_4.5H_2O$ reduced the average number of seeds per fruit, whereas, control fruits with up to four seeds (Table 2). Although the greatest fruit weight (14.67 g) occurred when water was applied, but also showed no significant difference with 25 mg L^{-1} $CuSO_4.5H_2O$ (Table 2). The lowest fruit weight was found in 50 mg L^{-1} $CuSO_4.5H_2O$ (10.51 g). No significant differences were found in fruit length, width and fruit width/length index and fruit volume between all of the treatments (Table 2). One of the most important factors affecting loquat fruit quality is seed number per fruit, as low seed number positively influences fruit quality (Durgac et al., 2006). Our results are in accordance with Uchino et al. (1994) and Agustí et al. (2011) that the factor affecting fruit weight is the seed weight rather than seed number. Mesejo et al. (2008) reported that 25 mg L^{-1} $CuSO_4.5H_2O$, applied as a foliar spray at full bloom, can be used for citrus to reduce the number of seeded fruit of "fortune" mandarin. They demonstrated that appearance of callose has been linked to ovule degeneration of citrus. Fresh and dry weight of fleshes and seeds were significantly higher than those of seedless fruit. Average dry seed of control and 150 mg L^{-1} GA_3 were highest (0.82, 0.8 g) but the lowest fresh and dry weight seeds were notice in application 250 and 300 mg L^{-1}(Table 3). Moreover, the lowest fresh and dry weight seeds (2.17, 0.35 g) occurred when 50 mg L^{-1} $CuSO_4.5H_2O$ was used but the greatest fresh and dry weight seeds occurred in 25 mg L^{-1} $CuSO_4.5H_2O$ and untreated tree (Table 4). When 250, 300 mg L^{-1} GA_3 and 50 mg L^{-1} $CuSO_4.5H_2O$

Table 2 Effects of $CuSO_4.5H_2O$ concentration on seed number, fruit weight, length, width, Width/ length index and fruit volume of loquat.

Treatment ($CuSO_4.5H_2O$ mg L^{-1})	Seed number	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Width/ length index	Fruit volume (cm^3)
control	4.57a	14.67a	30.14a	29.09a	0.96a	13.35a
25	4.35a	14.35a	29.36a	28.86a	0.98a	13a
50	2.81b	10.51b	29.48a	28.54a	0.96a	12.78a

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

Table 3 Effects of GA_3 concentration on fresh/ dry fleshes and seeds of loquat.

Treatment (GA3 mg L^{-1})	Fresh flesh	Dry flesh	Fresh seed	Dry seed
	(g)			
control	10.43a	1.78a	3.91a	0.82a
150	10.37a	1.69a	3.86a	0.8a
200	9.54a	1.15b	1.97b	0.53b
250	8.25b	0.86b	0.02c	0c
300	8.17b	0.75b	0.01c	0c

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

Table 4 Effects of $CuSO_4.5H_2OF$ concentration on fresh/dry fleshes and seeds of loquat.

Treatment ($CuSO_4.5H_2O$ mg L^{-1})	Fresh flesh	Dry flesh	Fresh seed	Dry seed
	(---------- g ----------)			
control	10.45a	1.71a	3.89a	0.82a
25	10.33a	1.42a	3.81a	0.76 a
50	9.06b	1.02b	2.17b	0.35b

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

was applied also reduced seeds length and width. The differences in average seeds length, width and fruit width/length index were significant $P<0.05$. No significant differences were found in TSS concentration and TA between all of the treatments GA_3 and $CuSO_4.5H_2O$ (Tables 5 and 6). Seedless loquats were more elongated and narrower than seeded ones. Although seeded fruit was heavier than seedless fruit, both in fresh and dry weight. Therefore, lower fruit weight of seedless fruit, compared to seeded fruit and are due to seed absence (Mesejo et al., 2010) which is the source of hormonal stimulation for growth. Seed weight was the most influential factor affecting fruit weight. Therefore, seedless loquats need a further treatment to increase fruit size. As reported by Mesejo et al. (2010) the mechanism of GA_3 in inducing parthenocarpy has been studied in grape (Kimura et al., 1996), sweet cherry (Stösser and Anvari,1982) and citrus (Mesejo et al., 2008) but, how it works in loquat remains unknown. Mesejo et al. (2008) reported that it depends critically on floral growth stage, being preferably accomplished prior to anthesis, suggesting that GA_3 may operate on ovule development prior to fertilization, in similar manner to that observed in citrus.

Conclusions

250 mg L^{-1} GA_3 applied at the suitable time when one third of a single flower cluster was flowering induced parthenocarpy in loquat trees, 50 mg L^{-1} $CuSO_4.5H_2O$ applied as a foliar spray at full bloom, can be used for loquat to reduce the number of seeded fruit per tree. But it seems that higher concentrations of $CuSO_4.5H_2O$ are necessary for inducing parthenocarpy in loquat.

Acknowledgments

We thank the cooperative of Shiraz Eram garden for providing the experimental farm and department of horticultural science, college of agriculture, Shiraz University, Iran for their support.

References

Agustí, M., C. Reig, C. Mesejo, A. Martínez-Fuentes, N. Gariglio. 2011. Physiology of growth and development in loquat fruit. Acta Hort. 887: 179-183.

Akar, R., C. Aydin. 2005. Some physical properties of Gumbo fruit varieties. J. Food. Eng. 66: 387-393.

Blumenfeld, A. 1980. Fruit growth of loquat. J. Amer. Soc. Hort. Sci. 105: 747-750.

Chen, F.X., X.H. Liu, L.S. Chen. 2009. Developmental changes in pulp organic acid concentration and activities of acid-metabolising enzymes during the fruit development of two loquat (*Eriobotyra japonica* Lindl.) cultivars differing in fruit acidity. Food Chem. 114: 657-664.

Durgac, C., A. Polat, O. Kamiloglu. 2006. Determining performances of some loquat (*Eriobotrya japonica*) cultivars under Mediterranean coastal conditions in Hatay, Turkey. New Zealand. J. Crop. Hort. Sci. 34: 225-230.

Ding, C., K. Chachin, Y. Ueda, Y. Imahori, and Y. Wang. 2001. Metabolism of phenolic compounds during loquat fruit development. J. Agric. Food. Chem. 49: 2883-2888.

Goubran, F.H. and B.M. El-zeftawi. 1986. Induction of seedless loquat. Acta Hort. 179: 381-384.

Gowda, V.N., S. Shyamalamma, R.B. Kannolli. 2006. Influence of GA_3 on growth and development of "Thompson seedless" grapes. Acta Hort. 727: 239-242.

Guo, Q.G., Q. He, K. Ji, Q. Wu, C. Zhang, W.X. Wang, X.L. Li and G.L. Liang. 2011. Analysis on the anther and pollen morphology of triploid loquat. Acta Hort. 887: 265-270.

Hirai, M. 1980. Sugar accumulation and development of loquat fruit. J. Japan. Soc. Hort. Sci. 49: 347-353.

Kimura, P.H., G. Okamoto and K. Hirano. 1996. Effects of gibberellic acid and streptomycin on the pollen germination and ovule and seed development in Muscat Bailey. Amer. J. Enol. Vitic. 47: 152-156.

Table 5 Effects of GA_3 concentration on seed length, width, TSS and TA of loquat.

Treatment ($GA3$ mg L^{-1})	Seed length	Seed width	TSS	TA
	(---------- mm ----------)		(---------- % ----------)	
control	16.07a	14.09a	10.25a	1.51a
150	15.81a	14.04a	9.87a	1.52a
200	7.58b	5.33b	10a	1.52a
250	0c	0c	10.25a	1.48a
300	0c	0c	9.87a	1.51a

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

Table 6 Effects of $CuSO_4.5H_2O$ concentration on seed length, width, TSS and TA of loquat.

Treatment ($CuSO_4.5H_2O$ mg L^{-1})	Seed length	Seed width	TSS	TA
	(---------- mm ----------)		(---------- % ----------)	
control	15.88a	13.79a	10a	1.53a
25	15.02ab	13.47a	10a	1.49a
50	11.80b	8.07b	10.25a	1.5a

Values followed by the same letter are not significantly different according to Duncan's multiple range test at $P<0.05$.

Kumar, R. 1976. Induction of seedlessness in loquat. Indian. J. Hort. 33:26-32.

Lin, S., R.H. Sharpe, J. Janick. 1999. Loquat, botany and horticulture. Horticultural Reviews 23: 233-276.

Liang, G.L., W.X. Wang, X.L. Li, Q.G. Guo, S.Q. Xiang and Q. He. 2011. Selection of large- fruited triploid plants of loquat. Acta Hort. 887: 95-100.

Matsui, H., S. Yahata, S. Sato, H. Ohara, K. Ohokawa, M. Miwa. 2004. Production of seedless loquat fruits. Regul. Plant Growth Dev. 39: 106-113.

Mesejo, C., A. Martínez-fuentes, C. Reig, M. Agustí. 2008. Gibberellic acid impairs fertilization in Clementine mandarin under cross pollination conditions. Plant Sci. 175: 267-271.

Mesejo, C., C. Reig, A. Martínez-fuentes, M. Agustí. 2010. Parthenocarpic fruit production in loquat (*Eriobotrya japonica* Lindl.) by using gibberellic acid. Scientia Horticulturea 126: 37-41.

Muranishi, S. 1983. Effect of gibberellic acid on the seedless fruiting of artificial polyploids in loquat (*Eriobotrya japonica* Lind. L.). Acta Hort. 137: 343-348.

Polat, A.A. 2007. Selection studies on loquat growth in bakras, Turkey. Acta Hort. 750: 169-174.

Sadamatsu, M., V. Keawladdagorn, H. Ohara, K. Ohkawa and H. Matsui. 2004. Induction of partenocarpic fruit growth with endogenous gibberellins of loquat. Acta Hort. 653: 67-70.

Sharafi, Y., A.R. Motallebbi-Azar and A. Bahmani. 2011. *In vitro* pollen germination, pollen tube growth and longevity in some genotypes of loquat (*Eriobotria japonica* Lindl.). Afri. J. Biotech. 10: 8064-8069.

Stösser, R. and S.F. Anvari. 1982. On the senescence of ovules in cherries. Sci. Hort. 16: 29-30.

Takagi, T., H. Mukai, R. Ikeda and T. Suzuki. 1994. Effect of application of GA and KT on the enlargement of frost-induced seedless fruit of loquat. J. Japan Soc. Hort. Sci. 62: 733-738.

Uchino, K., A. Kono, Y. Tatsuda and K. Sakoda. 1994. Some factors affecting fruit weight of loquat (*Eriobotyra japonica* Lindl.). Japan J. Trop. Agric. 4: 286-292.

Yahata, S., M. Miwa, H. Ohara, K. Ohkawa and H. Matsui. 2006. Effect of application of gibberellins in combination with forchlorfenuron (cppu) on induction of seedless fruit set and growth in triploid loquat. Acta Hort. 727: 263-268.

Zhang, H.Z., S.A. Peng, L.H. Cai and D.Q. Fang. 1993. The germplasm resources of the genus *Eriobotrya* with special reference on the origin of *E. japonica* Lindl. Plant breeding Abstracts 63: 772.

Manuscript received 24 March 2013, accepted 18 June 2013