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Influence of different degrees and stages of summer pruning on the vine characteristics, fruit yield and quality of kiwifruit cv. Hayward

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ABSTRACT

The present experiment was conducted in the mid hills of Ziro, Arunachal Pradesh, which is located at 93^0 5′ to 940 2 ′ E longitude 270 5 ′ to 270 75 ′ N latitude at an elevation of 1,564 amsl. During summer pruning, the shoots were pruned back to different pruning degrees *viz*., pruning at 25 cm after the last fruit (D_1), pruning 50 cm after the last fruit (D_2) and pruning at 100 cm after the last fruit (D_3) of the bearing shoot. All the summer pruning treatments were performed on 3 different stages *i.e*., at complete petal fall (S_1), 15 days after petal fall (S_2) and 30 days after petal fall (S_3). It was revealed that the summer pruning done by heading back of the bearing shoots at 1 m after the last fruit at complete petal fall stage (D_3S_1) resulted in higher yield with more proportion of 'A' and 'B' grade fruits in comparison to control and other treatments. D_3S_1 exhibited the highest fruit weight, fruit size, photosynthetic rate, sugars, TSS and sugar: acid ratio. Correlation studies showed the positive relation among many growth, yield and chemical parameters. Summer pruning done by heading back of the bearing shoots at 100 cm after the last fruit at complete petal fall stage (D_3S_1) might be recommended for added profit in kiwifruit cultivation in the region.

Key words: Kiwi fruit, summer pruning, yield, chemical attributes, correlation.

INTRODUCTION

Kiwifruit (*Actinidia deliciosa* Chev.) nonetheless of being introduced late, is gaining popularity in the mid-hill parts of Arunachal Pradesh. It is already grown in commercial basis in other parts of the country like Himachal Pradesh, J&K, Nagaland, etc. A warm sub-temperate climate with an annual precipitation of 100-150 cm is said to be required for establishment of kiwifruit vines. Kiwifruit was introduced very recently in the year 2000 in this part of the state. The crop being new to the area is luring the attention of farmers owing to its high returns per unit area, easy management and is a hardy fruit crop susceptible to very less number of pests and diseases. Increase in production and quality of the fruit is the main issue among the growers in this region. In kiwifruit, the fruiting occurs only on current growth which arises from a bud developed in the previous season. A judicious pruning is required every year to regulate vegetative growth and fruiting. Summer pruning which involves the removal of current year's growth is an essential management practice because it affects the vegetative growth of a plant and modifies leaf to fruit ratio, bud number and the microclimate within the canopy. It has been reported that summer pruning influences several aspects of tree physiology, such as hormonal balance, branch vigour, apical dominance, competition between vegetative growth and crop load for nutrient and carbohydrate content (Chouliaras *et al*., *3*). Besides, it also improves light penetration and air movement in the canopy which facilitates pest and disease control (Matta *et al*., 10). The main aim of summer pruning is to ameliorate source-sink relationship by allowing a better light penetration in the canopy. Water sprouts are generally completely removed because of their long internodal length, low bud break, poor ability to produce good bearing shoot (Costa, 4). Keeping it in view, the following study was carried out.

MATERIALS AND METHODS

The investigation was carried out on 8-year-old vines of kiwifruit cv. Hayward, planted at a spacing of 4 m × 6 m and trained on T-bar trellis system during 2007-2008. The experiment was laid out in Randomized Block Design with three different degrees (levels) of summer pruning at three different stages. Each treatment was replicated thrice with one vine as a unit. Dormant/ winter pruning was done commonly to all the experimental vines irrespective of treatments during the months of December-January. Summer pruning was done by heading back of bearing shoots to different levels at different times depending on the treatment. During summer pruning, the shoots were pruned back to different pruning degrees *viz*., pruning at 25 cm after the last fruit (D_1), pruning 50 cm after the last fruit (D_2) and pruning at 1 m after the last fruit (D_3) of the bearing shoot. All the summer pruning treatments were performed on 3 different stages, *i.e*., at complete petal fall (S_1), 15 days after petal fall (S_2)

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and 30 days after petal fall (S_3). Treatment details were as pruning at 25 cm after the last fruit (D_1) at complete petal fall stage (S_1): D_1 S_1, Pruning at 25 cm after the last fruit (D_1) at 15 days after petal fall stage (S_2): D_1 S_2, Pruning at 25 cm after the last fruit (D_1) at 30 days after petal fall stage (S_3): D_1 S_3, Pruning at 50 cm after the last fruit (D_2) at complete petal fall stage (S_1): D_2 S_1, Pruning at 50 cm after the last fruit (D_2) at 15 days after petal fall stage (S_2): D_2 S_2, Pruning at 50 cm after the last fruit (D_2) at 30 days after petal fall stage (S_3): D_2 S_3, Pruning at 100 cm after the last fruit (D_3) at complete petal fall stage (S_1): D_3 S_1, Pruning at 100 cm after the last fruit (D_3) at 15 days after petal fall stage (S_2): D_3 S_2, Pruning at 100 cm after the last fruit (D_3) at 30 days after petal fall stage (S_3): D_3 S_3, Control (No summer).

Observation on various growth and yield parameters like number of leaves, leaf area, photosynthetic rate, carbohydrate content, No. of fruits and leaf to fruit ratio were recorded. Twenty canes were randomly selected from all over the vine periphery and number of leaves and fruits were counted in these canes before harvesting. Leaf to fruit ratio was computed by dividing the number of leaves by number of fruits. The harvested fruits were categorized into different grades on the basis of fruit diameter and expressed in percent basis. Ten fruits per each replication were taken randomly and analyzed for physical characteristics *viz*., fruit length, fruit diameter and fruit weight. Chemical parameters like TSS, ascorbic acid, acidity and sugars were also analyzed as per procedure given by Ranganna (13). All the treatments were executed on Randomized Block Design (RBD) in three replications. The data obtained were subjected to statistical analysis, using AGRES software. Correlation studies have been under taken to know the relation among growth and yield attributes.

RESULTS AND DISCUSSION

Vine growth and fruiting characteristics are presented in table 1. The number of leaves per bearing shoot was significantly influenced by different degrees and time of summer pruning. The highest number of leaves (11.72) per bearing shoot was recorded in the vines which were unpruned (control) and the lowest leaf number (8.58) per bearing shoot was recorded in the vines which were under D_1S_3 treatment (Table 1). The number of the leaves per bearing shoot was observed to decrease with increase in the severity of degree of summer pruning. The heavy summer pruning reduced the number of vegetative buds, which are likely to develop into new shoots, thereby, reducing the number of leaves in the heavily pruned shoots. Leaf area was found to increase with the decrease in the degree of summer pruning treatments. The highest leaf area (132.83 cm^2) was recorded in the vines pruned by D_3 S_1 treatment, whereas, the lowest leaf area (102.92 cm^2) was recorded in the vines which were severely pruned (D_1 S_3). Summer pruning done in the mid-growing season or later is not followed by any regrowth, hence area of the foliage was reduced, thus severe the degree of summer pruning greater is the reduction in leaf area. Both dormant and summer pruning influence leaf area which have the direct and indirect effects on photosynthesis. Heavy dormant pruning results in decreased foliage area at the beginning of growing, but later, due to rapid growth

Table 1. Effect of time and level of summer pruning on the number of leaves, number of fruits and leaf to fruit ratio per bearing shoot of kiwifruit cv. Hayward.

Treatment	No. of leaves	Leaf area (cm^2)	Photo-synthetic rate (μ mol/S/cm^2)	Carbo-hydrate content (%)	No. of fruits	Leaf to fruit ratio	Fruit yield (kg/vine)			
							'A' grade	'B' grade	'C' grade	Total yield
D_1 S_1	10.46	127.55	19.74	3.38	6.20	1.67	16.68	14.87	9.40	40.95
D_1 S_2	9.77	112.96	19.06	3.70	5.32	1.84	16.22	15.58	6.63	38.43
D_1 S_3	8.58	102.92	18.46	3.97	4.64	1.85	10.71	11.20	7.40	29.31
D_2 S_1	10.20	120.14	21.35	4.22	6.11	1.69	19.45	17.90	6.53	43.88
D_2 S_2	10.02	112.69	18.48	4.60	5.4	1.85	15.89	19.61	7.43	42.93
D_2 S_3	8.95	104.43	18.66	3.97	4.46	2.01	14.87	12.65	9.43	36.95
D_3 S_1	10.99	132.83	24.71	4.18	5.44	2.02	23.25	22.92	7.03	53.20
D_3 S_2	10.67	123.06	23.73	4.69	4.74	2.26	19.46	19.15	7.83	46.44
D_3 S_3	10.54	109.03	23.46	3.65	4.81	2.20	18.17	12.12	8.23	38.52
Control	11.72	120.01	19.33	3.90	4.73	2.49	17.34	13.44	6.10	36.88
$CD_{0.05}$	0.08	0.16	0.02	0.003	0.15	0.07	0.12	0.01	0.04	0.006

of shoots, the foliage areas is restored and is often equal to or greater than that of unpruned trees. When summer pruning is done early in the season, leaf area removed by pruning is partially compensated by leaves on subsequent growth, therefore, early summer pruning is compensated by later re growth, though the extent of re growth varies depending on the pruning degrees (Taylor and Ferree, 15). Photosynthesis is a function of leaf area and light exposure to the canopy of plants. The highest photosynthetic rate (24.71 µmol/S/cm^2) was recorded in the vine, pruned lightly (D_3S_1). The investigation revealed that summer pruning increased the photosynthetic rate, but severe summer pruning influenced the photosynthetic rate negatively. These findings are in conformity with Marini and Barden (9) who suggested that the higher net photosynthetic rate after summer pruning treatment is due to many factors, which included light adaptation, source-sink modification and hormone induced rejuvenation. *Meirowska et al.* (11) recorded significant recovery of net photosynthesis in the interior spur leaves of apple due to exposure of high light intensity following summer pruning. It is well known that a growing shoot apex is a strong acceptor of assimilates. The higher rate of photosynthesis in pruned shoots has been reported to be associated with greater chlorophyll content, mesophyll cell enlargement, lower starch and alteration in the activity of cytokinin like substances (Taylor and Ferree, 15).

The highest carbohydrate content (4.69%) was recorded in the shoots of the vines which were pruned by D_3S_2 treatment. The increase in carbohydrate content of the bearing shoot may be related to the fact that the increased leaf area and light penetration into the canopy of the vines might have enhanced the rate of photosynthesis in the leaves and hence increasing the carbohydrate accumulation. The findings of the present investigation are in agreement with Taylor and Ferree (15). The highest number of fruits (6.20) per bearing shoot was recorded in the vines which were subjected to D_1S_1 treatment. The lowest number of fruits (4.46) was however, recorded in the vines which were pruned to D_2S_3. The present investigation revealed that the time of summer pruning seemed to have more pronounced effect on the number of fruits per bearing shoot, whereas, the level of pruning exhibited less consistent results. Number of fruits per bearing shoot was significantly influenced by the early time of summer pruning which may be justified by the fact that early pruning performed at complete petal fall caused early sink removal and enhanced the mobilization of photo-assimilates and hormones towards fruits during the critical period of fruit growth and development, *i.e*. 28 to 34 days after fruit-set (Lawes *et al.*, 6). The highest leaf fruit ratio (2.49) was observed in the vines which were unpruned (control) and the lowest (1.67) was recorded in the vines which were severely pruned under D_1S_1 treatment. The severity and stage of pruning has been reported to affect vegetative and reproductive activity of the plant to a great extent and modify leaf to fruit ratio, bud number and microclimate within canopy. The response may vary according to the growth rate of specific plant part. Thus, understanding the growth dynamics of fruit and shoot is necessary for knowing the plant response to summer pruning (Mika, 1986). Different summer pruning treatments exerted a significant influence on the fruit yield of kiwifruit. The highest fruit yield (53.20 kg/vine) was recorded from the treatment D3 S1., and this treatment yielded highest percentage of "A" grade fruits (43.79 per cent). However, the lowest yield (29.31 kg/vine) was recorded from D_1S_3 treatment. The increase in fruit yield of vines, pruned at different degrees and stages may be attributed to the increased leaf to fruit ratio and decreased competition for food reserves after sink removal. These findings are in agreement with Chouliaras *et al.* (3) who also reported an increase in fruit yield as a result of increased fruit size with summer pruning. The early pruning in kiwifruit caused early sink removal and made the carbohydrates, photo assimilates and hormones available for the fruits during the critical period of fruit development, *i.e.*, 28-34 days after fruit set. Volz *et al* (16) who found a positive correlation between yield and cane length, reported that yield per vine increased as the severity of pruning decreased in Kiwifruit. A reduction in kiwifruit yield due to heavy summer pruning performed early as well as late has also been reported by Galliano et al., (5).

Physico-chemical characteristics of the fruits are presented in Table 2. The highest fruit size (71.90 mm, 45.40 mm, length and diameter, respectively) and weight (86.73 g) were recorded in the fruits harvested from the vines which were light pruned by D_3S_1 treatment (Table 2). Further, it is inferred from these findings that fruit size and weight were reduced by increased severity of summer pruning. The increment in size and weight of the fruit may be attributed to the higher leaf to fruit ratio, which provided higher quantities of photosynthates and nutrients for the development of the fruits. Mann and Singh (8) also reported that severe pruning resulted in reduced fruit weight and size. Biasi *et al.* (1) also reported that summer pruning increased size and weight of Hayward Kiwifruit. Galliano *et al*. (5) reported that heavy pruning of the kiwifruit vines affects the fruit size and weight negatively. The leaf to fruit ratio affects the size and the weight of the fruit. Better sized fruits were obtained in the vines having higher leaf to fruit ratio. Chouliaras *et al*. (3) reported that fruits of the kiwi vines that received summer pruning within 2 days of petal fall exhibited

Table 2. Effect of stage and intensity of summer pruning on the fruit size, fruit weight and fruit firmness of kiwifruit cv. Hayward.

Treatment	Fruit size (mm)		Fruit wt. (g)	Fruit firmness (N)	TSS content (%)	Total sugars (%)	Reducing sugars (%)	Ascorbic acid (mg/100 g)	Acidity (%)	Sugar to acid ratio
	Length	Diameter								
D_1 S_1	66.14	45.26	75.63	88.77	8.81	6.26	4.51	74.49	1.47	5.26
D_1 S_2	66.20	45.36	74.00	94.84	8.41	6.06	4.38	72.33	1.48	5.06
D_1 S_3	62.54	43.30	69.30	110.87	8.07	5.86	4.24	71.19	1.41	5.18
D_2 S_1	68.20	46.20	82.57	81.83	9.64	6.93	4.97	76.17	1.50	5.66
D_2 S_2	67.57	46.26	81.17	95.82	9.56	6.76	4.86	75.13	1.47	5.67
D_2 S_3	65.67	45.40	80.37	95.78	9.47	6.46	4.67	74.25	1.49	5.36
D_3 S_1	71.90	45.40	86.73	99.71	9.94	7.16	5.15	75.75	1.49	5.88
D_3 S_2	69.04	47.96	85.50	97.89	9.78	6.83	4.90	78.60	1.52	5.50
D_3 S_3	66.80	46.36	84.60	96.33	9.70	6.76	4.86	73.28	1.48	5.63
Control	66.20	44.73	71.70	80.05	8.61	6.26	4.52	72.31	1.48	5.23
$CD_{0.05}$	0.06	0.02	0.08	0.07	0.01	0.04	0.001	0.06	0.00	0.00

the highest growth rate of the fruits in comparison to pruning performed during the fruit development. The earlier removal of the competing sink facilitates the utilization of stored carbohydrates by the fruits during crucial period of the development, *i.e*. 28-34 days after full bloom (Lawes *et al*., 6). Lack of carbohydrates during this period may cause early termination of cell division which will severely restrict fruit size that can be achieved. The highest fruit firmness (110.87 N) was recorded in the fruits harvested from the vines pruned to severe degree under D_1 S_3 treatment and the lowest fruit firmness (80.05 N) was recorded in the vines under control (Table 4). These results are in line with the findings of Volz *et al.* (16) who reported that summer pruning increase the fruit firmness by increasing the calcium availability to the fruits. It has been reported that reduction in the leaf to fruit ratio might have decreased the translocation of calcium through xylem and enhanced the translocation via phloem as (Stow, 14; Mac Rae and Redgewell, 7). They had further reported that calcium cross-links pectic substances, which decreased pectin solubulization, exhibiting in higher firmness of fruits. Chouliaras *et al*. (3) have also reported that kiwifruit vines pruned within 2 days of petal fall produced fruits with highest firmness.

The TSS and sugar contents decreased with the increase in severity of summer pruning (Table 2). The highest TSS (9.94%, at harvest) and sugars content (7.16%) were recorded in the D_3S_1 treatment. The higher TSS and sugars as a result of summer pruning may be attributed to the higher leaf to fruit ratio and increased photosynthetic rate. Severe summer pruning decreased the foliage area and production of photo-assimilates, it usually decreases the soluble solids content in fruits. Mann and Singh (8) reported that TSS and sugars content of grapes decreased with the increase in summer pruning severity. Galliano *et al.* (5) have also reported that light summer pruning by pinching the terminal portion of the bearing shoot resulted in highest TSS content, and they further reported that TSS decreased with the increase in severity of summer pruning. Chandel *et al*. (2) reported higher TSS and sugars content as a result of higher leaf to fruit ratio, which was obtained by heavy dormant pruning of reproductive buds. Titratable acidity decreased with the increase in severity of summer pruning. The lowest value of titratable acidity (1.41%) was reported in the fruits harvested from the vines pruned at 25 cm after the last fruit (D_1) at 30 days after petal fall stage (S_3 (D_1 S_3). However, the highest fruit acidity (1.52%) was reported in the fruits harvested from the vines pruned D_3 S_2 treatment. The increase in titratable acid content of the fruits may be attributed to the high leaf to fruit ratio and more photosynthetic rate which might have resulted in higher organic acid accumulation. Galliano *et al.* (5) reported that heavy pruning reduced the fruit acidity at harvest in kiwifruit. The highest ascorbic acid content (78.60 mg/100 g) was recorded in the fruits which were harvested from the vines pruned at 1 m after the last fruit (D_3) at 15 days after petal fall stage (S_2) (D_3S_2). Galliano *et al.* (5) reported that ascorbic acid content of kiwifruit decreased with the increase in severity of summer pruning. They explained this increase in ascorbic acid content of the fruits on the basis of higher leaf to fruit

Table 3. Correlation studies on different growth and yield affecting parameters of kiwifruit.

	No. of leaves	LA	PR	C	No. of fruits	L: F ratio	Yield	FL	FD	FW	F	TSS	TS	RS	AA
LA	0.74*														
PR	0.65*	0.66*													
C	0.81**	0.80**	0.53												
No of fruits	0.54	0.58	0.85**	0.66*											
L:F ratio	0.71*	0.22	0.34	0.27	0.70*										
Yield	0.64*	0.80**	0.71*	0.63*	0.83**	0.98**									
FL	0.37	0.76**	0.76**	0.44	0.32	0.61*	0.98*								
FD	0.53	0.61	0.66*	0.51	0.11	0.79**	0.62*	0.61*							
FW	0.62*	0.57	0.78**	0.46	0.12	0.18	0.79*	0.83**	0.78**						
F	0.33	0.39	0.23	0.25	0.43	0.77**	0.18	-0.20	-0.22	-0.07					
TSS	0.45	0.35	0.69*	0.11	0.11	0.86**	0.77*	0.79**	0.76**	0.98**	0.56				
TS	0.44	0.50	0.75**	0.53	0.24	0.85**	0.85**	0.89**	0.69*	0.94**	-0.35	0.96**			
RS	0.52	0.52	0.74*	0.52	0.23	0.79**	0.87**	0.89**	0.68*	0.92**	-0.15	0.92**	0.94**		
AA	0.64*	0.56	0.59	0.44	0.27	0.70*	0.79**	0.74*	0.84**	0.79**	-0.23	0.79*	0.77**	0.76**	
Acidity	0.53	0.52	0.55	0.34	0.13	0.79**	0.70*	0.73*	0.83**	0.71*	-0.51	0.71*	0.68*	0.68*	0.77**

LA = Leaf area, PR = Photosynthetic rate, C = Carbohydrate content, L: F ratio = Leaf: fruit ratio, FL: Fruit Length, FW = Fruit weight, F = Firmness, TSS = Total soluble solids, TS = Total sugars, RS = Reducing sugar, AA = Ascorbic acid.

*,**Significant at 5 and 1% levels.

ratio and more photosynthetic rate which resulted in higher organic acid accumulation. The highest sugar to acid ratio (5.88) was recorded in the fruits which were harvested from the vines under D_3S_1 treatment (Table 2). The lowest sugar to acid ratio (5.06) was recorded in the vines subjected to summer pruning under D_1S_2 treatment. The vines pinched at petal fall had the highest leaf to fruit ratio, which might have accumulated more carbohydrates leading to the higher sugar to acid ratio.

Correlation studies (Table 3) clearly revealed that different parameters significantly affect the vine characteristics of kiwifruit. No. of leaves emerged after pruning recorded the positive relation with leaf area, carbohydrate content, leaf to fruit ratio, and yield. Photosynthetic rate significantly affected the number of fruits and yield. In addition, other growth parameters were also positively affected by the photosynthetic rate. Yield of the vine was significantly affected by the leaf area, photosynthetic rate, carbohydrate content and number of fruit. Besides, most of the chemical attributes were showed the significant positive relation with most of the growth and yield parameters. Fruit weight, fruit diameter and fruit length expressed the positive relationship among each other. Contrary, firmness of the fruits showed negative relationship with other chemical attributes nonetheless of its non significant.

REFERENCES

1. Biasi, R., Costa, G. and Succi, F. 1986. Influence of pruning length on bud fertility and vegetative fruiting performance of kiwifruit cv. Hayward. *HortSci*. **21**: 149.

2. Chandel, J.S., Bharti, O.A. and Rana, R.K.. 2004. Effect of pruning severity on growth, yield and fruit quality of kiwifruit (*Actinidia deliciosa* Chev.). *Indian J. Hort*. **61**: 114-17.

3. Chouliaras, V., Gerasopolous, D. and Lionakis S. 1995. The effect of summer pruning and shading on the yield and quality of 'Hayward' kiwifruit. *J. Hort. Sci.* **70**: 975-80.

4. Costa, G. 1990. Kiwi orchard establishment: main factors in planning and management. *Acta Hort.* **282**: 88-96.

5. Galliano, A., Youssef, J., Tonutti, P. and Giulivo, C. 1990. Effect of summer pruning of kiwifruit on yield (I). *Acta Hort*. **282**: 127-32.

6. Lawes, G.S., Woolley, D.J. and Lai, R. 1990. Seeds and other factors affecting fruit size in kiwifruit. *Acta Hort*. **282**: 257-64.

7. MacRae, E. and Redgewell, R. 1992. Softening in kiwifruit. *Postharvest News Information*, **3**: 49-52.

8. Mann, S.S. and Singh, K. 1985. Effect of summer pruning on yield and quality of Perlette grapes. *Acta Hort.* **158**: 133-38.

9. Marini, R.P. and Barden, J.A. 1982. Yield, fruit size and quality of three apple cultivars as influenced by summer or dormant pruning. *J. Amer. Soc. Hort. Sci.* **107**: 474-79.

10. Matta, F.B., Rasberry, F. and Little, S. 1987. Pruning high density orchards: influence cultivars and topping date or return bloom and regrowth of trees. *Research Report*, *Mississippi Agricultural and Forestry Experiment Station*, No. 12.

11. Mierowska, A., Keutgen, N., Huysamer, M. and Smith, V. 2002. Photosynthetic assimilation of apple spur leaves to summer pruning. *Scientia Hort.* **92**: 9-27.

12. Mika, A. 1986. Physiological responses of fruit trees to pruning. **In**: J. Janick (ed.). *Horticultural Reviews*, AVI Publishing, Westport, pp. 337-69.

13. Ranganna, S. 2002. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products* (2nd edn.), Tata McGraw Hill Publication, Co. Ltd., New Delhi.

14. Stow, J. 1989. The involvement of calcium ions in maintenance of apple fruit tissue structure. *J. Exp. Bot.* **40**: 1053-57.

15. Taylor, R.H. and Ferree, D.C. 1986. The influence of summer pruning and fruit cropping on the carbohydrate, nitrogen, and nutrient composition of apple trees. *J. American Soc. Hort. Sci.* **111**: 342-46.

16. Volz, R.K., Gibbs, H.M. and Lupton. G.B. 1991. Variation in fruitfulness among kiwifruit replacement canes. *Acta Hort.* **297**: 443-49.

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