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Induction of stimulative parthenocarpy in *Vitis vinifera* L.¹⁾

by

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Introduction

The possibility of induction of STOUT's (10) "stimulative parthenocarpy" has been studied by WEAVER and POOL (14), ZULUAGA and LUMELLI (18). These last authors define two physiological factors necessary for such induction:

1. to obtain a response to the stimulus of the anticipated parthenocarpic development of the berry,
2. to inhibit abscission of the calyptra.

Considering that cleistogamy does not occur in grapes, the berries necessarily have to be seedless. The response to auxins and gibberellin-like substances to stimulate parthenocarpic, stenospermic, and seeded development of berries has been proved in numerous experiments by WEAVER and WILLIAMS (16), WEAVER and McCUNE (12), WEAVER and POOL (14), WEAVER and OVERBEEK (13).

The effect of auxins in the delay or inhibition of the abscission has been studied by BIGGS and LEOPOLD (2) in the distal and proximal ends of explants of trifoliated *Phaseolus* leaves, where concentrations of NAA higher than 10^{-4} M inhibited abscission. RUBINSTEIN and LEOPOLD (9) showed that the action of the aminoacids alanine, glycine and others accelerated abscission, but with NAA, its effect disappeared when the inhibitory action of the auxin began. This shows that the auxin in concentrations above 20 ppm can inhibit the action of other endogenous substances in abscission.

LIU and CARNS (5) as well as ADDICOTT, CARNS and LYON (1) have undertaken studies related with two abscisins and showed that the same have also an inhibitory action on growth. The presence of abscisins in flowers of *V. vinifera* has not yet been detected.

Materials and Methods

Auxins and gibberellin-like substances were applied at the pre-bloom stage (3, 7 and 15 days before beginning of bloom), bloom stage (beginning and full bloom) and at the post-bloom stage (7, 15 and 30 days after full bloom). Single or combined treatments with auxins and gibberellin-like substances such as KGA₃, 4CPA and NAA were used at concentrations of 10, 20, 30, 40, 60 and 80 ppm. The kinin BA (benzyladenine) (6, 7) produced by Shell Development Company in 1% isopropyl-alcoholic solution, was used singly or in combination with auxins and gibberellin-like substances at concentrations ranging from 200 to 1500 ppm. In agreement with the observations of WEAVER and OVERBEEK (13) concerning the solubility of this auxin the solution was kept in a heater at temperatures ranging from 15° C through 25, 35 up to 45° C before being used.

Eight varieties of *V. vinifera* were sprayed: Regina de la Malvasia, Criolla grande (local variety), Flame Tokay, Muscat of Alexandria, Rose Muscat (local variety),

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Table 1
Pre-bloom treatment on Flame Tokay, 3 days before bloom¹⁾

Treatment	Percentage of different types of berries per cluster		
	Seeded	Seedless	Undeveloped
4CPA 30 ppm	0.91	91.77	7.32
KGA ₃ 30 ppm	0.83	80.89	18.28
KGA ₃ 30 ppm + 4CPA 30 ppm	—	97.26	2.74
Control	33.65	3.81	62.54

¹⁾ Average of 20 samples (flower clusters).

Semillón, Thompson Seedless and Black Corinth. Concrete results were obtained with Flame Tokay and Rose Muscat. Induction of parthenocarpy was attained in both of them.

Results

Flame Tokay

Meteorological data: day of treatment 15. 11. 1966; temperature: mean 14.7° C, maximum 19.5° C, minimum 7.2° C, relative humidity 57%. Average of the first 10 days following treatment: temperature: mean 22.7° C, maximum 33.3° C, minimum 6.0° C, relative humidity 47.5%. Pre-bloom stage treatments were conducted 3 days before beginning of bloom. Due to the double effect of growth regulators, auxins and gibberellins produced an anticipated parthenocarpic development of the berry and inhibition of abscission of the calyptra.

According to the data of Table 1 it can be seen that the best results were obtained with the combination of KGA₃ 30 ppm plus 4CPA 30 ppm, which induced a substantial parthenocarpic development of the berry and an inhibition of the proximal abscission of the calyptra. KGA₃ 30 ppm gave less pronounced results, since a number of berries did not develop, but the proximal abscission of the calyptra was inhibited. 4CPA produced a high percentage of parthenocarpic berries, but the growth of parthenocarpic berries was reduced. NAA 30 ppm although inhibiting proximal and distal abscission of the calyptra, inhibited also the growth of a high percentage of berries. When NAA was combined with KGA₃ 30 ppm or 4CPA the inhibition on growth of berries was reduced.

Table 2
Pre-bloom treatment on Flame Tokay, dipped 3 days before bloom

Treatment	Characteristics of the cluster			Percentage of different type of berries per cluster			Length cm	Soluble sugar %
	Weight kg	Ber- ries n	Weight of stalk kg	Seed- less	Seeded	Abnor- mal		
4CPA 30 ppm +								
KGA ₃ 30 ppm + BA 400 ppm	0.685	516	0.064	93.41	0.39	6.20	1.37	240
KGA ₃ 30 ppm + BA 400 ppm	0.438	402	0.031	81.84	1.49	16.67	1.65	240
Control	0.640	208	0.09	6.25	61.54	32.21	2.20	207
L.S.D. P = 5%	0.098	105					0.41	

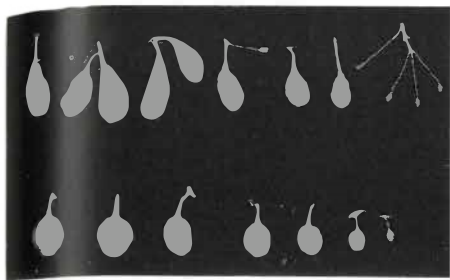


Fig. 1: Selection of berry-size from a cluster (Flame Tokay), treated with KGA_3 30 ppm, 3 days before bloom (Nov. 15th, 1966). Up-per row: parthenocarpic berries, below: control (photographed on Dec. 15th, 1966).

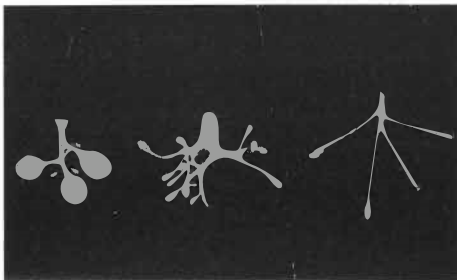


Fig. 2: Growth of berries of Flame Tokay after application of growth regulators 15 days before bloom. Left: control, middle: NAA 30 ppm + 4 CPA 30 ppm, right: KGA_3 50 ppm (photographed on Dec. 18th, 1966).

The induction of stimulative parthenocarpy can be seen in Table 2. In Flame Tokay 4CPA generally induced parthenocarpy but the berries were of smaller size and of different shape. Total parthenocarpy was produced by KGA_3 , and in this case the berries were bigger and elongated, however, growth of a great number of berries was inhibited.

When BA (6, 7) was applied in combined treatments with 4CPA or KGA_3 the number of parthenocarpic berries increased considerably. When BA was kept for 1 hour before application at 35° C, the best results were obtained. NAA alone inhibited the development of almost all berries; when combined with KGA_3 or 4CPA this effect mostly disappeared, but the size of the berries did not increase.

A pre-bloom treatment 7 and 15 days before beginning of bloom resulted in this variety, like in the others studied, in the inhibition of growth of a larger number of

Table 3

Post-bloom treatment on induced parthenocarpic berries of Flame Tokay obtained by pre-bloom treatment (4CPA 30 ppm + KGA_3 30 ppm)

Treatment 1) 2)	Characteristics of the cluster			Percentage of different type of berries per cluster			Length cm	Soluble solids ‰
	Weight kg	Ber- ries n	Weight of stalk kg	Seed- less	Seeded	Abnor- mal		
BA 1500 ppm								
— KGA_3 80 ppm	1.205	233	0.026	90.56	—	9.44	2.40	235
BA 1500 ppm								
— 4CPA 30 ppm	1.042	309	0.029	85.44	—	14.56	2.10	260
Girdled								
— BA 800 ppm	0.886	264	0.030	77.47	—	22.53	2.35	198
Control	0.750	185	0.008	6.49	78.38	15.13	2.18	201
L.S.D. P = 5%	0.390	23						

1) The post-bloom treatment was carried out by means of spraying 7 days bloom time.

2) BA was used at 35° C.

berries (pelletgrains), as can be seen in Fig. 1. The inhibition of berry growth was in correspondence with berries originated from flowers with less evolution at the time they were treated. In this case there exists in the action of auxins and gibberellin-like substances a local polarity: in the case of KGA_3 , towards the pedicel and of NAA towards the pedicel, lateral branches and rachis of the cluster (Fig. 2). By simple linear correlation, it has been shown that the application of KGA_3 , 50 ppm decreases the diameter of the berries and prolongs the pedicel ($r = +0.76$, highly significant), when applied 15 days before beginning of bloom.

Post-bloom stage treatments: Clusters with parthenocarpic berries induced by pre-bloom stage treatments were sprayed on November 26th, 1966 (meteorological data: mean daily temperature 24.3° C, maximum 28.9° C, minimum 13.3° C and relative humidity 65%; average of the first 10 days following treatment: temperature: mean 20.9° C, maximum 33.7° C, minimum 12.6° C, relative humidity 63.6%, precipitation 67 mm).

Satisfactory results were obtained when the application of gibberellin-like substances and auxins was carried out during the first 7 days after bloom stage. As the size of berries increased, the effect of growth regulators diminished. The best results were obtained with the application of BA, as a 1% isopropyl alcoholic solution and using Tween 20 as wetting agent, in combination with KGA_3 or 4CPA.

BA in a concentration of 1500 ppm and KGA_3 of 80 ppm seem to have the best effect in parthenocarpic berries. When BA at the same dosis is combined with 4CPA, the most suitable concentration for the latter seems to be 30 ppm (Table 3).

Satisfactory results were also obtained with combined treatments of 4CPA 30 ppm + KGA_3 30 ppm. Berries of larger size were obtained with dosis of KGA_3 higher than 80 ppm.

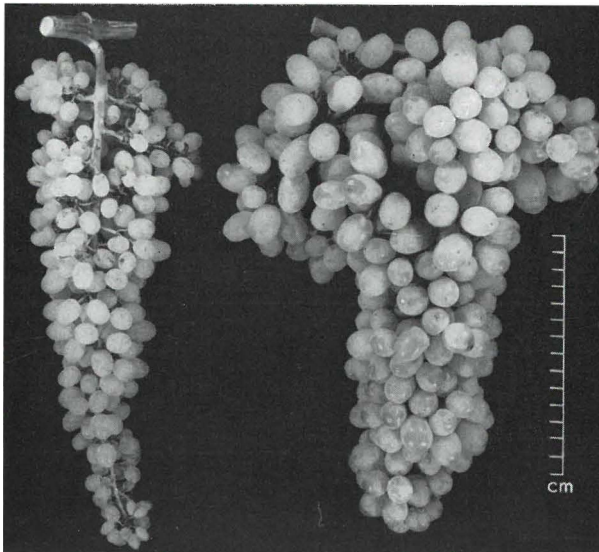


Fig. 3: Clusters of Thompson Seedless after application of BA 800 ppm + KGA_3 80 ppm 3 days after bloom (right); left: control.

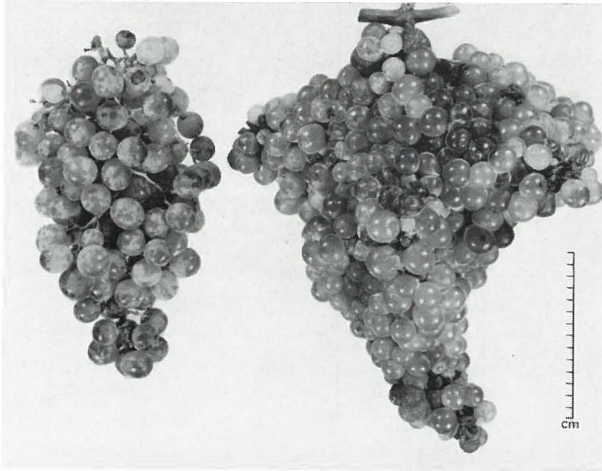


Fig. 4: Effect of application of gibberellin-like substances on cluster growth of Rose Muscat. Left: control; right: treated at beginning of bloom with BA 800 ppm + KGA₃ 80 ppm (photographed on March 28th, 1967).

Thompson Seedless and Black Corinth

Meteorological data: day of treatment 15. 11. 1966; temperature: mean 22.78° C, maximum 29.6° C, minimum 12.5° C, relative humidity 61%. Average of the first 10 days following treatment: temperature: mean 23.78° C, maximum 33.3° C, minimum 6.0° C, relative humidity 52.7%.

Table 4

The effects of BA and KGA₃ on Thompson Seedless and Black Corinth

Variety	Time of treatment	Treatment	Characteristics of the cluster			Characteristics of the berry		
			Weight kg	Berries n	Weight of stalk kg	Seedless n	Length cm	Soluble solids ‰
Thompson Seedless								
	Post-bloom 3 d after full-bloom	BA 800 ppm + KGA ₃ 80 ppm	1.073	404	0.012	404	1.67	170
	full-bloom	BA 800 ppm + KGA ₃ 80 ppm	1.021	384	0.022	384	1.58	168
	Control		0.261	201	0.008	201	1.15	195
L.S.D. P = 5%			0.149	155			N. S.	
Black Corinth								
	Bloom time	BA 80 ppm + KGA ₃ 80 ppm	0.098	250	0.004	204	0.70	261
	Control		0.036	185	0.002	185	0.30	292
L.S.D. P = 5%			0.022	37			0.10	N.S

Table 5
The effects of BA and KGA₃ on Rose Muscat

Time	Treatment	Characteristics of the cluster			Percentage of berries per cluster			Length cm	Soluble solids %
		Weight kg	Berries n	Weight of stalk kg	Seedless	Seeds	Abnor- mal		
Pre-bloom, 15 d before beginning of bloom stage	BA 800 ppm + KGA ₃ 80 ppm (dipped)	0.218	514	0.032	62.65	—	37.35	1.30	212
Beginning of bloom stage	BA 800 ppm + KGA ₃ 30 ppm (dipped)	1.830	976	0.073	92.73	2.25	5.02	1.60	188
Post-bloom, 7 d after full-bloom	BA 800 ppm + KGA ₃ 80 ppm (sprayed)	1.284	297	0.030	21.89	72.05	6.06	1.94	268
Post-bloom 7 d after full-bloom	BA 800 ppm (sprayed)	0.727	201	0.014	15.92	68.16	15.92	1.75	189
L.S.D. P = 5%		0.216	83					0.21	+

The Thompson Seedless variety has stenospermic berries (10) of smaller size than preferred by consumers of table grapes. If the size of the berries could be increased by means of growth regulators, its use as table variety would increase considerably with the economic advantages it implies.

Treatments three days after bloom (post-bloom stage) with BA¹ 800 ppm as 1% isopropyl alcoholic solution using Tween 20 as wetting agent and KGA₃ 80 ppm³) increased berry size up to 5 times (Fig. 3, Table 4). In the Black Corinth variety, that has parthenocarpic berries (11), such noteworthy results were not obtained with the same treatments (Table 4).

Rose Muscat (local variety)

Meteorological data: day of treatment 26. 11. 1966; temperature: mean 24.3° C, maximum 28.9° C, minimum 13.6° C, relative humidity 65%. Average of the first 10 days following treatment: temperature: mean 20.3° C, maximum 26.3° C, minimum 12.6° C, relative humidity 63%, precipitation 67 mm.

Rose Muscat is a variety of local origin with a pronounced predisposition to "Millerandage" (pellet grains), it has few seeds and pronounced muscat flavor. The response to treatments with growth regulators differs to that of other varieties.

Treatments with BA 800 ppm + KGA₃ 80 ppm, applied by immersion at beginning of bloom stage, reduced the number of seed to 1% of the berries (practically seedless clusters) and increased the number of berries (seedless) to 96%, according to the number of flowers per clusters; the control, without treatment, produced only 14% seedless berries. Size and appearance of the clusters treated can be seen in Fig. 4. Characteristics of the clusters and berries are given in Table 5. In this case, according to our judgement, the application of kinin BA and KGA₃, at a high dose, results in an anticipated and accelerated development of the berries, thus causing the abortion of recently fecundated ovules and making the non-fecundated not viable.

However, the same dosis (BA 800 ppm + KGA₃ 80 ppm) applied 15 days before beginning of bloom stage, produced long clusters with numerous very small berries (pellet-like). Pre-bloom applications with KGA₃ 30 ppm and 4CPA 30 ppm produced very small clusters with berries of reduced size.

When BA was not combined with auxins or gibberellin-like substances its application resulted in clusters with smaller and less numerous berries.

Discussion

The auxins 4CPA and gibberellin-like substances (KGA₃) in single or combined treatments, have shown to have the greatest effect in the inhibition or delay of the abscission of the calyptra in *V. vinifera* L. NAA completely inhibits abscission of the calyptra but it does not stimulate parthenocarpic development of the berries. This inhibiting effect is diminished when it is applied together with KGA₃ or 4CPA. The pre-bloom treatments 3 days before beginning of bloom, gave the highest production of parthenocarpic berries when 4CPA and KGA₃ at concentrations of 30 ppm were used. In this case, according to our judgement, two recurrent factors combine to provoke parthenocarpy: premature development of the berry without fecundated ovules and delay of the abscission of the calyptra.

The stimulus towards parthenocarpic development of the berry increased considerable with post-bloom treatments (7 days after bloom) with KGA₃ at concentrations of 50 to 100 ppm and of auxins (4CPA) at 20 to 30 ppm. More pronounced

¹) The solution is kept at 35° C for 1 hour before application.

effects were obtained in some cases and varieties with a combination of KGA₃ 50 ppm and 4CPA 20 ppm.

When BA was applied singly, the response of stimulus towards a parthenocarpic development was small, but the results were surprising when combined with auxins (4CPA 30 ppm) or gibberellin (KGA₃ 80 ppm) since size and number of berries was increased in clusters with both seeded or seedless berries

Summary

Stimulative parthenocarpy was induced in two varieties of *Vitis vinifera* L. Flame Tokay and Rose Muscat (local variety) out of eight varieties studied.

In Flame Tokay the delay or inhibition of the abscission of the calyptra and parthenocarpic development of the berries, was obtained with pre-bloom treatments (3 days before beginning of bloom) of 4CPA 30 ppm + KGA₃ 30 ppm. Induction and growth of parthenocarpic berries was most pronounced after post-bloom sprays (7 days after the end of bloom) with BA 1500 ppm + KGA₃ 80 ppm or 4CPA 30 ppm. A parthenocarpic development of the berries was also obtained with post-bloom treatments of KGA₃ at concentrations of 50 to 100 ppm. BA (Benzyladenine) alone had only a slight effect on the development of parthenocarpic berries. However, the results were surprisingly satisfactory when applied in combination with gibberellin (KGA₃ 80 ppm) or auxins. Treatments at bloom or after bloom with BA 800 ppm + KGA₃ 80 ppm increased the number of berries and cluster weight.

Applications of BA 800 ppm + KGA₃ 80 ppm to Rose Muscat at the beginning of bloom resulted in clusters with practically all berries seedless. The artificially accelerated growth of the berries may provoke abortion of all the recently fecundated ovules and the non viability of the not fecundated ones. Clusters of the treated plants with an average of 520 flowers originated 501 parthenocarpic berries (96%), whereas the control with an average 635 flowers per cluster gave a percentage of seeded + seedless berries of 14% only (95 berries per cluster). BA applied with auxin or gibberellin-like substances in full-bloom or after bloom produced seedless berries, which were smaller in size than the seeded berries of unsprayed clusters.

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