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Exogenous Gibberellin as Responsible for the Seedless Berry Development of Grapes.

VIII. Growth of GA-induced seedless fleshy berries affected by additional GA application, shading and pinching.

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Summary

The effects of additional GA application and shading and pinching of shoots on the growth of seedless fleshy berries induced by the prebloom GA application were investigated using 16-year old 'Delaware' and 'Campbell Early'. The seedlessness ratio was still increased by the additional GA application but not by the other treatments. The ratio and size of seedless fleshy berries and 100-berry weight were increased also by the additional GA application but decreased by shading. They were also decreased with decreasing leaf areas following pinching and halving of leaves, though not parallel to the leaf area. These results were discussed in relation to the further growth of seedless fleshy berries induced by the prebloom GA application.

It was reported previously (11-17) that, on a inflorescence treated once with GA two weeks before the expected full bloom of the untreated inflorescences, three kinds of berries, namely, seeded berries, seedless fleshy berries and shot berries including small green berries and retained ovaries, were found at harvest, and their distribution ratios varied with the decreasing rate of applied GA. However, applied GA activity decreased to a low level around flowering. Thus, it is possible that the ratios of seedless and seedless fleshy berries are increased by keeping high GA activity until flowering by additional application. In addition, growth of GA-induced seedless fleshy berries requires the incorporation of photoassimilates from leaves. The intensity of incorporation may be influenced not only by some growth regulators including GA but also by some practices such as shading and pinching of the shoots. It is well known that the pincing before full bloom effectively increased fruit set and that the number of leaves on the shoot affects the fruit set and berry growth in grapes (1-10).

In this paper, the effects of additional GA application, shading and pinching on the growth of seedless fleshy berries induced by the prebloom GA application were investigated.

Materials and Methods

Experiments were carried out from 1976 to 1978 using 16-year old vines (in 1977) of 'Delaware' and 'Campbell Early'. Inflorescences were thinned out except one on the third node of each shoot, and about 120 flower buds were left on each inflorescence with the others thinned out. All shoots used were ringed below the basal node. GA was applied to all inflorescences by dipping at 100 ppm with 100 ppm Aerol OP 15 days before the expected full bloom of the untreated inflorescences.

To observe the effect of additional GA application, 10 inflorescences were treated again with 50 ppm GA 10 days after the prebloom GA application and another 10 inflorescences were used as a control.

For the shading experiment, 10 shoots were covered with one layer of cheesecloth immediately after the prebloom GA application and the shading was continued until harvest. The light intensity under cover was about 50% that of the uncovered control. For the pinching and halving experiment, 20 shoots each were pinched leaving 10 and 5 basal leaves, and in addition, with each 10 of them the leaves were cut in half along the midvein. Within several days after treatments, leaf areas of all shoots were measured by transferring process and expressed in relative values. Lateral shoots were removed as soon as they appeared.

Inflorescences were harvested when the seedless fleshy berries ripened but the seeded and shot berries were still green. From the numbers of seeded, seedless fleshy and shot berries, their distribution ratios in a inflorescence were calculated as described previously (11). The 100-berry weight was obtained from the total number of berries and weight of inflorescence excepting rachis and pedicels.

Results

1. Effects of additional GA application.

In 'Delaware', additional GA application increased the seedlessness ratio, the ratio and size of seedless fleshy berries and 100-berry weight. In 'Campbell Early', also, almost the same results were obtained except for the size of seedless fleshy berries, which was little affected by the additional GA application. (Table 1).

2. Effects of shading.

In the seedlessness ratio, there were found no significant differences between the inflorescences on the shaded and control shoots. The ratios of seedless fleshy berries were higher and the diameter of seedless fleshy berries and 100-berry

TABLE 1. *Effects of Additional GA Application on the Growth of Seedless Fleshy Berries.*

Cultivar	Additional GA application[z]	Seeded (%)	Seedless			Diameter of seedless fleshy berry (mm)	100-berry weight (g)
			Seedless fleshy (%)	Shot (%)	Total (%)		
Delaware	−	14.3	70.8	14.9	85.7	10.2	97.7
	+	8.5	80.5	11.0	91.5	11.1	102.2
		**	**	**	**	*	**
Campbell Early	−	16.6	34.5	48.9	83.4	14.4	151.5
	+	13.1	40.3	46.6	86.9	14.6	159.1
		**	**	*	*	NS	**

[z] Applied again 10 days after the prebloom application.

NS, *, ** Nonsignificant (NS) or significant at 5% (*) or 1% (**) levels.

weight were larger in the control than shaded inflorescences regardless of cultivars (Table 2).

3. Effects of pinching.

The leaf area on a shoot differed remarkably, according to the extent of pinching and halving of leaves. The seedlessness ratio, however, differed little with different leaf areas. On the other hand, the ratio and size of seedless fleshy berries and 100-berry weight were higher in the inflorescences with larger leaf areas at the early stage of berry growth, though not in parallel to the leaf areas. The size of seedless fleshy berries and 100-berry weight were greater on the shoot

TABLE 2. *Effects of Shading on the Growth of Seedless Fleshy Berries.*

Cultivar	Shading[z]	Seeded (%)	Seedless			Diameter of seedless fleshy berry (mm)	100-berry weight (g)
			Seedless fleshy (%)	Shot (%)	Total (%)		
Delaware	−	1.2	82.5	16.3	98.8	11.1	97.7
	+	1.8	79.5	18.7	98.2	9.3	45.8
		NS	**	**	NS	**	**
Campbell Early	−	0.9	74.6	24.5	99.1	14.4	153.6
	+	1.0	65.7	33.3	99.0	11.6	100.0
		NS	**	**	NS	**	**

[z] Covered with one layer of cheese cheesecloth the period immediately after the prebloom application till harvest.

NS, *, ** Nonsignificant (NS) or significant at 5% (*) or 1% (**) levels.

TABLE 3. *Effects of Pinching and Halving of Leaves*

Cultivar	Treatment	Seeded (%)	Seedless	
			Seedless fleshy (%)	Shot (%)
Delaware	Not pinched	12.4	71.1a[x]	16.5
	10[z]	12.5	71.8a	15.7
	5[z]	13.1	68.2b	18.7
	10/2[y]	13.0	67.9b	19.1
	5/2[y]	13.2	66.8b	20.0
Campbell Early	Not pinched	1.8	82.2a	15.9
	10[z]	2.2	84.2a	13.6
	5[z]	1.9	80.6b	17.5
	10/2[y]	2.0	79.3b	18.7
	5/2[y]	2.1	51.9c	46.0

[z] Pinched leaving 10 and 5 basal leaves, respectively.
[y] The leaves were halved along the midvein (expressed by 1/2).
[x] Mean separation in columns by Duncan's multiple range test, 5% level.

with 10 basal leaves than that with 5 basal leaves in both cultivars. When leaves were halved, however, they differed little between the two shoots in 'Delaware', while in 'Campbell Early' they were greater in the former than the latter. In comparison of the shoot with 5 intact basal leaves with that with 10 halved basal leaves, the leaf area differed little between them in 'Delaware' and was larger in the former in 'Campbell Early' at the early stage of berry growth, although it became larger with time in the latter in both cultivars, though not measured. In spite of these facts, the inflorescence on the shoot with 5 intact leaves was superior in the size of seedless fleshy berries and 100-berry weight to that on the shoot with 10 halved leaves (Table 3).

Discussion

The authors previously proposed three steps in the formation of seedless fleshy berries following GA application, that is, induction of seedlessness, induction of seedless fleshy berries and further growth of seedless fleshy berries (14).

In this experiment, the prebloom GA application was carried out before treatments. Censequently, more than 98% of the flowers set in all inflorescences, and there could be found no effects on fruit set even with pinching, which was known to increase fruit set in GA-untreated inflorescences (1), perhaps this was because of removing the shoot apex competing with the inflorescence for photoassimilates. On the other hand, seedlessness was increased by the additional GA application but not by shading and pinching. Seedless fleshy berries were also *on the Growth of Seedless Fleshy Berries.*

Total (%)	Diameter of seedless fleshy berry (mm)	100-berry weight (g)	Relative Leaf area (%)
87.6a	11.1a	87.2a	—
87.5a	11.0a	86.0a	100
86.9a	10.0a	76.2b	41
87.0a	8.6b	50.1c	40
86.8a	8.5b	50.3c	32
98.2a	14.4a	166.6a	—
97.8a	14.5a	176.5a	100
98.1a	13.3b	131.0b	74
98.0a	12.8b	91.8c	46
97.9a	11.5c	77.3d	40

increased by the additional GA application but decreased by shading and pinching. Thus, high GA activity around full bloom proved to be still effective in increasing seedless and seedless fleshy berries.

Both the activity of GA and the intensity of incorporation of assimilates into the inflorescence may participate in the induction of seedless fleshy berries. Moreover, GA activity may participate in the intensity of incorporation of assimilates through hormone-directed transport as reported by Quinlan *et al.* and others (18–23). Shading and pinching decreased the production of photoassimilates and resultantly the incorporation of them into the inflorescence.

Concerning the third step, the growth of the seedless fleshy berries was represented by the average diameter of seedless fleshy berries and 100-berry weight at harvest. They were increased by the additional GA application but decreased remarkably by shading. They were also decreased with decreasing leaf areas following pinching and halving of leaves, but not parallel to the leaf areas. Moreover, they were superior on the shoot with 5 intact leaves than that with 10 halved leaves. The leaf area on the shoot, however, was surely larger in the latter at later stage of berry growth, although it differed little between the two shoots (in 'Delaware') or was larger in the former (in 'Campbell Early') at the early stage. Thus, for the inflorescence on the third node, the final growth of berries seemed to be greatly influenced by the early growth, which in turn, was supported by the basal leaves. Previously, we investigated the incorporation of ^{14}C-assimilates from different leaves on the shoot into the inflorescence on the third node after assimilation of $^{14}CO_2$ by respective leaves at different stages of berry growth. From those data, the ratios of assimilates incorporated into the inflorescence from the 5 basal leaves to those from the 10 basal leaves were estimated on the

TABLE 4. *Rate of ^{14}C-Assimilates Incorporated into the Inflorescence on the Third Node from the Basal 5 Leaves to Those from the Basal 10 Leaves Varying with the Stage of Berry Growth (Tentatively Estimated[z] Using the Data in the Previous Report[y].)*

Time of measurement	Delaware (%)	Campbell Early (%)
2 weeks before full bloom	99.5	99.7
1 week before full bloom	88.9	93.5
At full bloom	96.6	97.3
1 week after full bloom	44.4	51.7
2 weeks after full bloom	42.1	33.0
3 weeks after full bloom	33.6	25.0

[z] Calculated as follows:
A = Percentage distribution to the inflorescence × Percentage total export from ^{14}C-fed-leaf × Dry weight of ^{14}C-fed-leaf.
Rate $= (\sum_{i=1}^{5} A / \sum_{i=1}^{10} A) \times 100$. i = leaf number on the shoot (the basal is No. 1)
[y] Refer to 16 in literature cited.

supposition that the leaves had a uniform photosynthetic rate based on unit weight of dry matter (Table 4). From Table 4, more than 90% of the assimilates proved to be incorporated into the inflorescence from the 5 basal leaves at the early stage of berry growth, namely, from prebloom to around full bloom.

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