

Induction of inflorescence by CCC application on primary shoots of grapevines

by

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Die Induktion von Infloreszenzen durch Behandlung der Haupttriebe von Reben mit CCC

Zusammenfassung. — Junge Pfropfreben oder Stecklinge der Sorte Muskat von Alexandria, deren Haupttriebe sich im Streckungswachstum befanden, wurden wiederholt mit 500 ppm CCC behandelt. Hierdurch wurden im ausgedehnten Langtag und in einem niedrigeren Temperaturbereich (ca. 20 °C) anstelle von Ranken speziell Infloreszenzen induziert. Längs des ganzen Triebes wurden in den Winterknospen bei 30 °C (ohne CCC-Behandlung) viel mehr Infloreszenzen angelegt als bei 20 °C. Durch CCC wurde die Infloreszenzbildung in beiden Temperaturbereichen beträchtlich gefördert, wobei für 20 °C eine auffälligere Wirkung festzustellen war.

Introduction

Grape inflorescence and tendrils are formed at similar positions on the vine shoot and various kinds of gradations are found between the perfect inflorescence and the perfect tendril (BARNARD and THOMAS 1933, ALLEWELDT 1964). So these two organs are regarded as homologous and potentially interchangeable. Nevertheless, inflorescence is normally initiated on a condensed shoot of a winter bud and rarely is initiated directly on a current primary shoot, though it is sometimes formed on a lateral (secondary) shoot depending on the cultivar. On the other hand, a tendril is usually initiated on a current shoot while extending. Little is known about what factors might be involved in their direction of differentiation.

Recently, COOMBE (1967) reported that the growth retardant CCC increased the occurrence of inflorescence on lateral shoots of grapevines and induced inflorescence even on one primary shoot of a treated vine. Such transformation of a primary shoot is quite unusual but his result has not since been followed by more detailed study.

If inflorescence could be induced easily at the expense of tendrils on extending current shoots, whether they are primary or secondary ones, this procedure might become a promising tool for studying physiological processes underlying the initiation and development of inflorescence primordia and also have a practical value for producing second crop.

The purpose of this paper is to search for a definite way of inducing inflorescence on primary shoots of young graftings or cuttings by using CCC.

Materials and Methods

The cultivar used for the study was Muscat of Alexandria (*Vitis vinifera*). In the first experiment (1972), potted one-year-old graftings with one shoot were grown

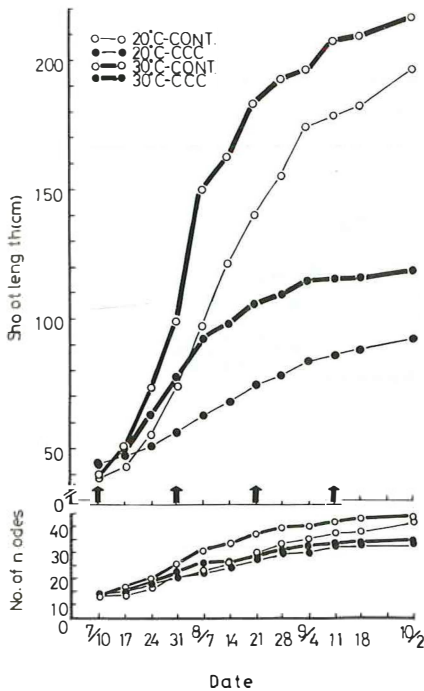


Fig. 1: Effect of CCC sprays and temperature on shoot growth in length and number of nodes of Muscat of Alexandria grapes. Arrows indicate the dates of CCC sprays.

Der Einfluß von CCC und Temperatur auf die Trieblänge und die Nodienzahl der Sorte Muskat von Alexandria. Die Pfeile bezeichnen den jeweiligen Zeitpunkt der CCC-Behandlung.

under prevailing spring conditions until their shoot became about 15 cm long with 8 nodes, and assigned to two groups, one sprayed once to run-off with 500 ppm CCC solution containing Tween 20 at 0.05% as a wetting agent, and the other unsprayed. Those vines of each group were halved and transferred to either short day (8-hour natural daylight) or long day (8-hour daylight plus 8-hour illumination with 100 W incandescent lamp) treatment. Air temperature in the installation for the day-length treatments was not controllable and fluctuated according to natural change of field temperature. Day-length treatments were started on June 5 and terminated on July 31.

In the second experiment (1973), graftings used were similar to those in the first experiment and grown outdoors until the experiment was commenced in the natural daylight growth cabinets (1 m² in area and 1.5 m in height). When the average length of shoots reached about 40 cm, the graftings were assigned to two groups, then each transferred to either a growth cabinet of 20 ° or 30 °C. Half of the vines in each cabinet were sprayed with 500 ppm CCC at the start of treatment, then triweekly afterwards, and the half of the vines were unsprayed. Day-length in each cabinet was extended by illuminating with a 60 W incandescent lamp from 6.00 to 9.00 p.m. The experiment was started on July 10 and terminated on October 2. Upon termination, all the shoot apices and lateral winter buds from the basal to 25th nodes were harvested. Shoot apices were fixed in FAA, embedded in paraffin, sectioned serially at 15 μm and stained with haematoxylin and eosin. Winter buds were preserved in 70% ethanol and dissected later.

In the third experiment (1973—74), potted one-year-old cuttings were grown under natural field conditions and cut back close to the shoot base in summer to allow lateral buds to sprout and one shoot was left to grow. When the new shoot became about 17 cm long with 7 or 8 nodes, the cuttings were assigned to 4 groups and each was transferred to anyone of the following 4 growth cabinets: (i). 20 to approx. 25 °C (the temperature was set at 20 °C, but not strictly controlled and fluctuated within this range)/natural day-length (ca. 12—10 hours during experiment), (ii). 20 to approx. 25 °C/natural day-length plus all night illumination with low intensity light, (iii). 30 °C/natural day-length, and (iv). 30 °C/natural day-length plus all night illumination. All the cuttings in each group were sprayed fortnightly

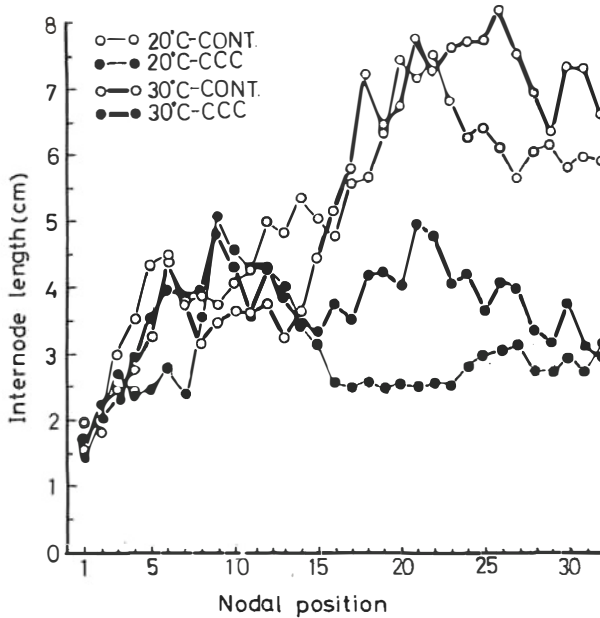


Fig. 2: Effect of CCC sprays and temperature on internode length of Muscat of Alexandria grapes. CCC was sprayed four times on July 10 and 31, August 21 and September 11, 1973, and internode length was measured on October 2, 1973.

Der Einfluß von CCC und Temperatur auf die Internodienlänge der Sorte Muskat von Alexandria. CCC wurde viermal gesprüht, nämlich am 10. und 31. Juli, 21. August und 11. September 1973; die Internodienlänge wurde am 2. Oktober 1973 gemessen.

with 500 ppm CCC. The experiment was started on September 24, 1973 and terminated on January 16, 1974.

All the graftings and cuttings used for this study carried no inflorescence in their preceding growth cycle. 5 graftings were used for each treatment in the first and second experiments and 10 cuttings in the third experiment. In all experiments, the numbers of inflorescences induced and florets developed in each inflorescence were counted before their blooming.

Results

In the first experiment, inflorescences were produced only on the primary shoot of CCC-sprayed graftings under long days. 4 out of 5 graftings bore 2 to 5 inflorescences with their total amounting to 12. They were formed between the 21st and 28th node from the base of the shoot. These inflorescences were rather small and the average floret number per inflorescence was 19.8 (min. 8 — max. 34), but they bloomed normally and set appreciably. All the tendrils developed up to the position of inflorescence were short and fragile, and eventually died off. Shoot developed normal tendrils above those inflorescences. Shoot growth was considerably retarded under long days plus CCC sprays as compared with under long days only, while it was markedly reduced under short days either with or without CCC.

In the second experiment, inflorescence induction by CCC was tested under two temperature regimes on extended long days. Shoot growth was again reduced by

Table 1
 Nodal position of inflorescences newly emerged on primary shoot and floret number per
 inflorescence in individual graftings at 20 °C — CCC spray treatment
 Insertionshöhe der an den Haupttrieben neu entstandenen Infloreszenzen sowie Blütenzahl
 je Infloreszenz bei den einzelnen Pfropfreihen der Versuchsvariante 20 °C — CCC

Plant no.	Nodal position													
	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1		42	45		30	d.a.		d.a.						
2			63	74		67	90		152	147		d.a.	d.a.	
3			48		32	59		70	73			90	d.a.	
4		5	72	41	55		68	54			d.a.			
5			26	58	47	70		78	88		d.a.	d.a.		

d.a. indicates that inflorescence primordia were formed but aborted.

CCC sprays to nearly one half that of controls at either 20 ° or 30 °C (Fig. 1). The length of internodes developed after the first spraying by CCC was also shortened greatly with the shortest at 20 °C — CCC (Fig. 2).

Inflorescence initiation and development on primary shoots occurred with those graftings alone which were sprayed with CCC at 20 °C. The first signs of initiation appeared about 4 weeks after the start of treatments and all the graftings sprayed at 20 °C bore 3 to 6 well-developed inflorescences with their positions ranging from the 22nd and 33rd node (Table 1). Some signs of initiation were also visible above the nodes carrying well-developed inflorescences up to shoot tips, but they did not develop further and eventually aborted. The length of internodes between the nodes carrying inflorescences was somewhat longer than those below.

Table 2

Effect of CCC sprays and temperature on the number of inflorescence primordia in the winter buds of Muscat of Alexandria grapes

Einfluß von CCC-Behandlung und Temperatur auf die Anzahl der Infloreszenzprimordien in den Winterknospen der Sorte Muskat von Alexandria

Treatment		Bud position					Average
		1—5	6—10	11—15	16—20	21—25	
30 °C — Control		0.92	0.72	1.28	1.16	0.92	1.00
30 °C — CCC 500 ppm		1.16	1.56	1.20	1.34	1.15	1.28
20 °C — Control		0.60	0.56	0.36	0.16	0.40	0.42
20 °C — CCC 500 ppm		0.96	1.32	1.00	0.36	0.44	0.82
LSD	5%	0.38	0.36	0.26	0.41	0.48	0.25
	1%	0.54	0.51	0.36	0.56	0.66	0.34

Microscopical observation revealed that in the CCC-sprayed apices at 20 °C some lateral primordia close to the growing point have already differentiated into inflorescence primordia, while no such differentiation was observed with comparable controls (Fig. 3).

Formation of inflorescence primordia in the winter buds of primary shoots was determined by dissection (Table 2). The number of inflorescence primordia per bud was greater at 30 °C than at 20 °C, notably at higher bud positions. CCC sprays increased the formation of inflorescence primordia at either temperature. The effect was most pronounced for the 6—10th buds at 30 °C and for the 6—15th at 20 °C.

In the third experiment, inflorescence initiation was also induced by CCC, though to a lesser extent, on the growing primary shoots of cuttings in the growth



Fig. 3: Longitudinal section of a shoot tip carrying inflorescence (I) sprayed with CCC at 20 °C.

Längsschnitt durch eine Triebspitze mit Infloreszenz (I) nach CCC-Behandlung bei 20 °C.

Table 3

Nodal position of inflorescences newly emerged on primary shoots and floret number per inflorescence in individual cuttings at 20 °C — CCC spray treatment

Insertionshöhe der an den Haupttrieben neu entstandenen Infloreszenzen sowie Blütenzahl je Infloreszenz bei den einzelnen Stecklingen der Versuchsvariante 20 °C — CCC

Plant no.	Nodal position															
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1						57			42							
2		20						26	d.a.							
3						28	32								d.a.	
4													12		d.a.	d.a.
5												39	d.a.			
6						56										
7									d.a.							
8									d.a.							
9										d.a.		d.a.	d.a.			
10																

d.a. = primordia formed, but aborted.

cabinet of 20 to approx. 25 °C/natural day-length plus all night illumination alone 6 out of 10 cuttings developed 1 or 2 inflorescences and they bloomed and set 3 cuttings differentiated inflorescence primordia but they aborted early; 1 cutting showed no sign of initiation (Table 3). Again, no inflorescence initiation was observed in other treatments.

Discussion

Growth retardants are well known to reduce vegetative growth on the one hand and promote flower initiation on the other in many fruit species (WEAVER 1972). In grapes, CCC is usually more effective in retarding shoot growth and in increasing the number of inflorescence primordia than B-9 (BARRIT 1970, BOURQUIN and ALLEWELDT 1970, WEAVER and POOL 1971, and our unpublished data).

The present result showed that CCC not only increased inflorescence primordia in the winter buds but also induced inflorescences on the position expected to carry tendrils otherwise on extending primary shoots. Although COOMBE (1967) observed the frequent transformation of tendrils into inflorescences by CCC on lateral shoots, especially in those cultivars prone to form secondary inflorescences, he found only one case of such phenomenon on one primary shoot. As is evident from the present result, the consistent formation of inflorescence on primary shoots was induced by repeated application of CCC under rather restricted environmental conditions: extended long days and a lower temperature of about 20 °C.

Extended long days probably favored the maintenance of shoot vigor and the prolonging of the duration of developing new nodes against the inhibiting action of CCC. In another trial where young graftings with similar vigor as used in this experiment were sprayed with CCC under naturally long days of summer, they bore only a few inflorescences on rare occasions. In addition to the adverse effect of high day temperature, the naturally long days of summer in Kyoto might have been insufficient.

It was surprising to note that lower temperature favored the transformation of tendrils to inflorescences on primary shoots, because the higher temperature is remarkably favorable for the inflorescence initiation in winter buds (BUTTROSE 1969, SUGIURA *et al.* 1975). In the case of the first experiment, lower night temperature might have favored the transformation since the temperature condition was not controlled and left to the natural fluctuation.

As seen in Table 1, first several inflorescences appeared on the primary shoot, developed normally, and bloomed, but those which appeared later aborted as the shoot vigor gradually decreased. Many of inflorescences induced in cuttings did not undergo the development and aborted mainly due to weak shoot vigors.

According to the previous reports (BUTTROSE 1969, SUGIURA *et al.* 1975), the winter bud of Muscat of Alexandria produced almost no inflorescence primordia at 20 °C but had the greater number of them at 30 ° or 35 °C. In the second experiment in this study which was conducted under naturally long days of summer plus supplementary illumination, this cultivar produced some primordia at 20 °C, but the number was considerably lower than that at 30 °C. The trend was more remarkable for the buds on those nodes which developed newly after the start of treatment. CCC application also increased the number of inflorescence primordia in winter buds at either temperature. The fruitfulness was significantly increased by CCC between the 6th and 10th nodes at 30 °C and between the 6th and 15th nodes at 20 °C. Low fruitfulness at 20 °C was thus greatly improved by CCC, attaining nearly the same levels as, or even exceeding, that at 30 °C.

Summary

Repeated CCC application at 500 ppm under the conditions of extended long days and lower temperature of about 20 °C specifically induced inflorescences in

place of tendrils on extending primary shoots of young graftings or cuttings of Muscat of Alexandria grapes.

Inflorescence formation in the winter buds was much greater at 30 °C than at 20 °C along the whole shoot. CCC application increased inflorescence formation remarkably at either temperature, the effect being more pronounced at 20 °C.

Literature Cited

- ALLEWELDT, G., 1964: Die Umweltabhängigkeit des vegetativen Wachstums, der Wachstumsruhe und der Blütenbildung von Reben (*Vitis*-Species). III. Die Blütenbildung. *Vitis* 4, 240—261.
- BARNARD, C., and THOMAS, J. E., 1933: Fruit bud studies. II. The Sultana: Differentiation and development of the fruit buds. *J. Council Sci. Ind. Res.* 6, 285—294.
- BARRIT, B. H., 1970: Fruit set in seedless grapes treated with growth regulators Alar, CCC and gibberellin. *J. Amer. Soc. Hort. Sci.* 95, 58—61.
- BOURQUIN, H. D. und ALLEWELDT, G., 1970: Der Einfluß von CCC und B-995 auf das Triebwachstum von Reben. *Vitis* 9, 105—120.
- BUTTROSE, M. S., 1969: Fruitfulness in grapevines: Effect of light intensity and temperature. *Bot. Gaz.* 130, 166—173.
- COOMBE, B. G., 1967: Effects of growth retardants on *Vitis vinifera* L. *Vitis* 6, 278—287.
- SUGIURA, A., UTSUNOMIYA, N., and KOBAYASHI, A., 1975: Effect of day-length and temperature on growth and bunch differentiation of grapevines. *J. Japan. Soc. Hort. Sci.* 43, 387—392.
- WEAVER, R. J., 1972: Plant growth substances in agriculture. W. H. Freeman & Co., San Francisco.
- — , and POOL, R. M., 1971: Effect of succinic acid-2,2-dimethylhydrazide and (2-chloroethyl) trimethylammonium chloride on shoot growth of "Tokay" grapes. *Amer. J. Enol. Viticult.* 22, 223—226.

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