Growth Regulation of the First Crops and Induction of the Second Crops of 'Kyoho' Grapes due to CCC under Open Culture

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Summary

Action of CCC [(2-chloroethyl) trimethyl ammonium chloride] for berry development of the first crops and induction of the second crops of 'Kyoho' grapes under open culture in the temperate areas like Japan was studied. Development of the first crops bearing on the primary shoots, i.e., maturation of the crops, was delayed by CCC. The delay was discussed in relation to the lower respiratory activities, the lower contents of sugar (refraction levels) and the lower values of pH compared with the control plants. The harvest of the first crops of the primary shoot treated by CCC was carried out in ca. 40 days after harvest of the control crops. As CCC inhibited flower shatters and berry drops of the first crops, the berry numbers per cluster increased and the berries showed small shapes compared with the control. CCC also elicited hardening of the berry flesh. Only the lateral shoots emerged on the primary shoots by CCC application and by treatment of shoot topping laded the second crops which matured (refraction ; ca. 16° Brix) in 3 weeks after harvest of the first crops treated with CCC. It was indicated that CCC application under open culture will be possible to produce the crops of 'kyoho' grapes twice a year.

Introduction

In the subtropical zones like Bangalore in India, Takao in Taiwan and so on, where the average temperature during a year is more 20°C, crops of grapes have been produced twice a year (5).

In the Temperate Zones like Japan, conventionally, 'Kyoho' grapes have produced crops once (1st crops) a year under open culture. Flower clusters for the first crops (1st flower clusters) of 'Kyoho' grapes are induced on the primary shoots and those of the 2nd ones (2nd flower clusters) are rarely induced on the (primary) lateral shoots emerged after topping of the primary shoots under open culture. And, better still, almost the 2nd crops remain unripe under open culture. It is possible that desirable development of the 2nd crops will ensure in the heating-forcing culture system by means of

using a glasshouse or a plastic film house. Therefore, the application of this system will result in production of the crops twice a year. However, this cultivating condition impose an economic burden on the cultivars at a great expense of facilities and their maintenance.

In order to yield the crops twice a year without economic burden obliged to use in the heating-forcing culture system, other methods of the grape cultivation should be tried.

In the pomological field, it is known very well that CCC and succinic acid 2,2-dimethylhydrazide (SADH) increase formation of the flower buds of many plants (1, 2, 3, 4, 6, 9, 11, 12, 13, 14, 15).

Coombe (3) reported that spraying with CCC increased numbers of inflorescences (2nd flower clusters) differentiated on the lateral shoots of 'Muscat of Alexandria' grapes. Utsunomiya *et al.* (17) tested CCC on 'Muscat of Alexandria' and 'Kyoho' grapes, and

also got similar results to Coombe (3). However, these works were examined not about formation of berries (fruit production) but about induction of flower buds.

Our trials to produce crops of 'Kyoho' grapes twice a year under open culture by CCC application and by treatment of shoot topping were carried out (9, 13, 14).

This article described that 'Kyoho' grapes under open culture in Japan could produce crops twice a year by CCC application in combination with treatment of shoot topping and effects of CCC on development of the first crops.

Materials and Methods

Four-year-old 'Kyoho' grapes (*Vitis vinifera* L. $\times$ *V. labruscana* Bailey) were used as described previously (15, 16). These 'Kyoho' grapes have been cultivated by using modified Munson training system (8) in the experimental orchard of Nagoya University. The plants were grown in soil placed in a bed which is 40 to 50 cm in depth, 20 m in length and 40 cm in width made of two layers of polyvinyl chloride film. After the emergence of shoots from the vines, a 500 ppm solution of CCC (Katayama Chemical Co., Osaka) was sprayed thoroughly twice on May 17 and 24 onto shoots with 12 or 13 leaves. As a control run, tap water was sprayed onto similar shoots. On June 1, a week after the 2nd spraying, one group of the CCC-treated vines were topped at the 13th internode. Thereafter, the lateral shoots emerged on the topped-shoots. The 2nd crops were harvested between the 2nd and 5th nodes of the lateral shoots.

30 berries were picked at random from the 1st crops on the primary shoots and the 2nd crops on the lateral shoots on each sampling day, respectively, and their height and diameter were measured with a pair of slide calipers.

Respiration of the 30 berries were measured using an infrared CO₂ gas analyzer (URAS-1, Hartman & Brawn Co. Ltd.) according to a previous article (16). The respiratory vessel (10 cm in diameter $\times$ 10 cm in height) was made of glass and closed with a rubber stop-

per. Temperature (25°C), darkness and air flow rate (2 l per min) were maintained in the constant condition through the experiments.

After measuring respiration, the berries were weighed and peeled. The peeled berries (flesh) were crushed with a spatula to get fleshy juice in a beaker. The juice was filtered through four layers of gauze. The filtrate was used to determine refraction (expressed as ° Brix) and pH.

Results

In this experiment, the plants without thinning of clusters and berries were used. CCC-treated and control shoots bearing fruit clusters between 2nd and 5th nodes were used. The fruit clusters (1st crops) of the primary shoots bore many berries (140–150% of control plants) due to inhibiting flower shatters and berry drops by CCC treatment.

Berry development of the first crops, i.e., the height and the diameter, was decreased by CCC treatment. Namely, CCC induced the small berries (Fig. 1) and caused the inhibition of the fresh weights (Fig. 2).

Berry size of the first crops also became small due to CCC. Further, the ratio of height to diameter (height/diameter) of the berries regardless treatment with and without CCC was gradually led up to the small values with time until the harvest (Fig. 3).

Respiration of berries of the first crops was repressed (ca. 70% of the control) by CCC treatment. Both respiratory activities

Fig. 1. Effect of CCC on berry development of the first crops in 'Kyoho' grape.

Fig. 2. Effect of CCC on berry weight of the first crops in 'Kyoho' grape.

Fig. 3. Effect of CCC on the ratio of height to diameter of berries of the first crops in 'Kyoho' grape. This figure was replotted on the basis of the data of Fig. 1.

of the berries by treatment with and without CCC showed two peaks until the respective harvest (Fig. 4).

Maturation of berries of the first crops were delayed by CCC compared with the control. These phenomena ran parallel with the low levels of refraction ($^{\circ}$ Brix) and pH in the juice of the berries. That is to say, the refraction of the berries by CCC treatment showed the lower values than those of the control; in addition, the refraction level of the treated-berries attained to the control level (18° Brix) in ca. 40 days after harvest of the first crops (Fig. 5). The pH of juice of the first crops was increased with time and CCC made lower

Fig. 4. Effect of CCC on respiration of berries of the first crops in 'Kyoho' grape.

Fig. 5. Effect of CCC on sugar contents of juice of the first crops in 'Kyoho' grape.

Table 1. Effect of CCC on pH values of juice of the first crops in 'Kyoho' grape.

Date*	Without CCC	With CCC
August 5	3.34	3.10
August 22	3.75	3.44
September 1	3.90	3.55

* (1978)

values of pH than those of the control, i.e., the decrease of acidity in the juice of the berries was delayed by CCC (Table 1).

Furthermore, CCC induced hardening of the berry flesh and made it difficult to peel the berry compared with the control.

The primary lateral shoots by treatment without CCC did not bear the second crops. But only those with CCC laden the second crops; in addition, the crops attained to maturation and were harvested on October 30 (3 weeks after harvest of the first crops treated with CCC). The height, the diameter and the ratio of height to diameter of berries

Table 2. Effect of CCC on development of berries of the second crops in 'Kyoho' grape.

Date*	Height (cm)	Diameter(cm)	Height/ [Diameter]
August 29	2.16	1.96	1.10
September 5	2.24	2.03	1.10
September 13	2.25	2.08	1.08
September 23	2.32	2.17	1.07
September 30	2.42	2.24	1.08
October 25	2.52	2.30	1.10

* (1978)

Table 3. Effect of CCC on sugar contents of juice of the second crops in 'Kyho' grape.

(°Brix)		
Portion of the cluster		
Upper	Medium	Lower
16.6±0.1	15.9±0.5	15.3±0.6

Results were expressed as mean±standard error. The harvest of the second crops was carried out on October 30.

of the second crops showed almost the same values as the first crops by treatment with CCC (Figs. 1 and 3) (Table 2). Namely, the berries of the second crops became somewhat small and spherical compared with those of the first crops of the control (Figs. 1 and 3).

The refraction in the juice of the second crops was ca. 16°Brix. That in berries of upper-, medium- and lower-portion (parted from the basal portions to the tips) of the clusters of the second crops was 16.6, 15.9 and 15.3°Brix, respectively (Table 3). The refraction of the berries of the second crops was lower than that of the first crops at the harvest (Fig. 5).

Discussion

CCC induced the inhibition of flower shatters and berry drops [the same to other reports (3, 4, 12)]. As the result, CCC elicited increasing of berry set percentage and decreasing of the berry size. These phenomena suggest that CCC increases the fertility, and also inhibits to form absciss layer of peduncles of the flower clusters and fruit clusters due to regulation of endogenous hormone balance. Because Skene (10, 11) reported that the level of cytokinins in bleeding sap of grape-

vines was increased by treatment with CCC. Niimi (6) also described that CCC influenced the level of cytokinin-like substances separated by Sephadex LH-20 column Chromatography from the xylem sap of 'Suffolk Red (N.Y. 21572)' grapes. These facts will be due to that the behavior of endogenous growth regulators such as cytokinin and gibberellin in florets relates to berry set increased by treatment with CCC.

Respiratory activity per fresh weight of a berry of the first crops was not influenced by CCC treatment. However, respiration per berry of the first crops was decreased by CCC, from which it is estimated that CCC could slow down the metabolic turnover in the berries, and that energy production [like NAD(H), NADP(H), ATP and so forth] due to respiration could be also decreased by CCC. Consequently, it is suggested that stimulation of coloring, and increasing of sugar contents (refraction) and pH values in the first crops of the CCC-treated plants were late to attain to maturation compared with the control crops. These estimation will mean that CCC may inhibit increasing of abscisic acid (ABA) contents in berries, because the increasing of the ABA contents at the stage of maturation of the berries were attended with the increasing of sugar contents and decreasing of organic acids (7). As the result, it is agreeable that sugar contents and pH values in the berries were decreased by CCC application.

The only lateral shoots with CCC induced the second crops. This fact suggests that CCC will activate primordia of the flower buds of the lateral shoots. In harvesting the crops, sugar contents of the second crops were lower than those of the first crops. This problem of the lower sugar contents in the second crops will be settled due to the pertinent thinning of clusters and berries. In effect, there is every possibility that the harvest of the second crops of 'Kyoho' grapes by CCC application under open culture in Japan is realized. However, there are many problems to be solved for production of the good second crops by CCC application. That is to say, as CCC elicits increasing of berry set

percentage per cluster and decreasing of the berry size, the thinning of clusters and berries will be required artificially. Furthermore, as CCC made the hard flesh of berries, the peeling of the berries was difficult. When concentration of CCC to be sprayed is high, the first and second crops do not ripen by keeking green. Therefore, further examination will be required to know adequate conditions of CCC application.

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露地栽培巨峰ブドウの CCC による一番果の発育制御及び二番果の誘導

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摘 要

日本のような温帯における露地栽培巨峰ブドウの一番果の発育および二番果の誘導に及ぼす CCC [(2-chloroethyl) trimethylammonium chloride] の作用を調べた。

新梢に着生した一番果は、CCC 処理によって、呼吸活性が低下し、糖度および pH 値の上昇つまり成熟が遅れた。処理区における収穫は無処理区のそれよりも約

40 日遅れた。また、CCC は花ぶるいや脱粒を防ぎ、果房当たりの着粒数が増えることにより果粒が小さくなった。さらに CCC は果肉の硬化をももたらした。

二番果は、CCC 処理後の新梢の摘心により発生する副梢にのみ着生し、CCC 処理区の一番果の収穫 3 週間後に収穫 (糖度: 16°Brix) できたことから CCC 処理による露地栽培ブドウの二期作の可能性が示された。