Breaking Bud Dormancy in Grapevine Cuttings with Garlic Volatiles

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Summary

We examined the effects of extracts and volatiles from garlic on breaking bud dormancy in ‘Muscat of Alexandria’ and ‘Kyoho’ grapevine cuttings. When commercial garlic oil was applied to the distal cross-sectional cut surface of cuttings, it greatly promoted a steady rate of budbreak, but slurried commercial garlic powder or lanolin paste containing freeze-dried garlic extracts had little or no effect. Application of both supernatants and precipitates of centrifuged boiled grated garlic had little effect, but exposure of cuttings to volatiles from grated garlic and commercial garlic oil promoted budbreak. These observations indicate that some volatile compounds in garlic are responsible for breaking bud dormancy in grapevines. Garlic volatiles were most promotive during the deep dormant stage in November but least effective toward the end of dormancy.

Key Words: budbreak, cuttings, garlic, *Vitis* spp., volatiles.

Introduction

The forcing of grapevines growing under protective structure is a common practice in Japan. Because grapevine buds are usually dormant when forcing starts, it is very important to break dormancy efficiently. Many investigations have been conducted to terminate artificially bud dormancy in woody plants, including grapevines, by applying chemicals such as mineral oils, dinitro-*o*-cresol (DNOC), calcium cyanamide (CaCN₂), hydrogen cyanamide (H₂CN₂), thiourea, and growth regulators (Broome and Zimmerman, 1976; Donoho and Walker, 1957; Iwasaki and Weaver, 1977; Iwasaki, 1980; Kuroi, 1985; Lin and Wang, 1985; Nir et al., 1988; Shulman et al., 1983; Weaver et al., 1961, 1968, 1974; Williams, 1987; Zelleke and Kliever, 1989). Since Kuroi et al. (1963) reported that an application of CaCN₂ suspension was successful, it has been adopted as a common practice in Japan to stimulate budbreak in various grape cultivars.

Some growers in Okayama Prefecture apply freshly grated garlic (*Allium sativum*) to the cross-sectional cut surface of the cane immediately after pruning to stimulate budbreak in dormant Muscat of Alexandria grapevines. Kubota et al. (1983, 1987) and Kubota and Miyamuki (1992) previously reported that grated garlic paste is as effective as the supernatant of CaCN₂ suspension in promoting budbreak in several grape cultivars, including ‘Muscat of Alexandria’. Iwasaki et al. (1981)

reported that the active substance in the supernatant of CaCN₂ suspension was =N–C≡N in the anionic fraction. There is little information on the nature of the compound(s) in garlic responsible for breaking bud dormancy.

Our purpose was to examine in detail the effects of garlic extracts and volatiles on breaking bud dormancy in grapevines.

Materials and Methods

Grapevines and general procedure

Most of the plant materials were obtained from grapevines (*Vitis vinifera* L. cv. Muscat of Alexandria and *V. vinifera* × *V. labruscana* Bailey cv. Kyoho) at the Research Farm of the Faculty of Agriculture, Okayama University; a few were collected from Kyoho grapevines at the Experimental Farm of the College of Agriculture, Ehime University. Unless otherwise stated, the following procedure was undertaken: triplicated, 10 single-bud cuttings (10 cm in length) were administered for each treatment. After the treatment, the basal ends were imbedded into “Kanumatsuchi” soil (soil for propagation bed) and placed in a greenhouse kept at ≥ 18 °C or a growth chamber. Buds were regarded as broken when their tips turned green.

Effects of organic solvent extracts from freeze-dried garlic.

Freshly sliced garlic cloves were freeze-dried, ground, and milled into a powder. A 20 g sample was packed into a glass column (9.5 mm inside diameter × 150 mm length) and eluted with 25 ml each of petroleum

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ether, benzene, ethyl acetate, and methyl alcohol successively. Each eluate was evaporated *in vacuo* at 30 °C and the residue mixed with 2 g of lanolin. The solids in the column were removed and the residual methyl alcohol evaporated at room temperature; the sample was then mixed with lanolin. The lanolin paste was applied to the distal cut surface of dormant 'Muscat of Alexandria' cuttings taken on December 16, 1983. The control cuttings were treated with lanolin paste only.

Effects of commercial garlic oil and powder

Both garlic oil and powder were obtained from Riken Chemical Industry Co., Ltd. (Kyoto, Japan). Garlic oil was diluted two-fold with deionized water; an equivalent weight of deionized water was added to the garlic powder to make a slurry. The garlic oil and the slurry were applied separately as above on dormant Muscat of Alexandria cuttings taken on December 17, 1983. The control cuttings were treated with deionized water only.

Effect of boiled grated garlic

Fresh garlic cloves were grated into a paste with an iron pestle; half of the grated garlic was boiled for 1 hour; the rest was not. The boiled and non-boiled samples were centrifuged at $12,000 \times g$ for 10 min. And the supernatants and precipitates were applied to the distal cut surface of dormant Muscat of Alexandria cuttings taken on December 16, 1983. The control cuttings were treated with deionized water.

Effects of garlic volatiles

One hundred and eighty cuttings were prepared from Kyoho grapevines on October 11, 1985, and divided into 6 sets of 30 cuttings each. Freshly grated garlic, commercial garlic oil, and deionized water were applied on the distal cut surface of one set of cuttings; the remaining three sets of cuttings were placed for 24 hours in a 3 liter desiccator containing any of these substances, 50 g of grated garlic, 5 ml of commercial garlic oil, and 5 ml of deionized water as the control. After the treatments, the cuttings were mounted on styrofoam plates floated in a water bath, and placed in a growth chamber kept at 25 °C.

Effect of duration of exposure to garlic volatiles

Cuttings of 'Muscat of Alexandria' grapevines, prepared on December 8, 1983, were placed for 6, 12, or 24 hours in a 3-liter desiccator containing 30 g of grated garlic. The control cuttings were placed for respective hours in a desiccator containing 30 ml of deionized water.

Effect of garlic volatiles in different dormant stages

Cuttings of 'Kyoho' grapevines were prepared on November 18 and December 25, 1983, and January 21, February 15 and March 16, 1984. Ten cuttings were placed for 24 hours in a 3 liter desiccator containing 50

g of grated garlic; control cuttings were exposed to 50 ml of deionized water. The cuttings were then mounted on styrofoam plates floated in a water bath, and placed in a growth chamber kept at 24 °C.

Results and Discussion

The effectiveness of the chemicals on budbreak in dormant grapevines is evaluated on the following basis: 1) the fewer number of days to initial budbreak after the treatment, indicating promotion of budbreak and 2) the rate of budbreak, that is, the uniformity of budbreak.

Budbreak in dormant 'Muscat of Alexandria' cuttings treated with garlic extracts using the various organic solvents was not significantly different, except that the methyl alcohol extract and the residual fraction slightly increased the percentage of budbreak (Fig. 1). This failure in extracting the active components from freeze-dried garlic with organic solvents indicates that such

Fig. 1. Effects of application of lanolin paste containing several extracts of freeze-dried garlic powder on budbreak of single-bud cuttings of 'Muscat of Alexandria' grapevines. Vertical bars are the SE. $n=3$.

Fig. 2. Effects of application of commercial garlic oil and powder on budbreak of single-bud cuttings of 'Muscat of Alexandria' grapevines. G.O.: garlic oil. Vertical bars are the SE. $n=3$.

compounds are easily vaporized by drying and evaporation.

Commercial garlic oil is produced from garlic cloves by steam-distillation. Budbreak in 'Muscat of Alexandria' cuttings treated with commercial garlic oil and its two-fold dilution was initiated in 12 and 8 days, respectively, compared to the control in which the first budbreak appeared 38 days after treatment with water (Fig. 2). The rate of budbreak in cuttings treated with the diluted oil was steady, whereas the undiluted oil resulted in an inconsistent and lowest rate of budbreak among treatments by the end of the experiment. This suggests that undiluted oil is too concentrated for budbreak. However, the slurried commercial garlic powder had no promotive effect and even seemed to delay budbreak compared with the control (Fig. 2).

Fig. 3. Effects of application of supernatants and precipitates of centrifuged boiled and non-boiled garlic on budbreak of single-bud cuttings of 'Muscat of Alexandria' grapevines. Vertical bars are the SE. $n=3$.

Fig. 4. Effects of application (closed symbols) of grated garlic and commercial garlic oil and exposure (open symbols) to their volatiles for 24 hr on budbreak of single-bud cuttings of 'Kyoho' grapevines. Vertical bars are the SE. $n=3$.

The supernatants and precipitates of grated garlic paste on budbreak of 'Muscat of Alexandria' cuttings exhibited a promotive effect (Fig. 3) but the supernatants from boiled or non-boiled samples were more effective than the precipitates. This difference supports our view that the active components in garlic are easily volatilized (Fig. 1).

The rate of budbreak in 'Kyoho' cuttings painted with garlic paste and commercial garlic oil, or exposed to their volatiles was steady, irrespective of the treatment (Fig. 4). However, the promotive effect was greater when the cut ends were painted rather than merely exposed to volatiles. Hosoki et al. (1985) also reported that garlic volatiles broke bud dormancy in some corms, tubers, and trees; he suggested that sulfur-containing compounds are responsible for the budbreak. Freeman and Whenham (1975), Kojima (1982) and Saghir et al. (1964) reported that garlic volatiles include sulfide compounds, such as diallyl mono-, di-, tri-sulfides.

Regardless of the duration of exposure to garlic volatiles, the number of days to initial budbreak in 'Muscat of Alexandria' cuttings was shorter than it was in the untreated controls (Fig. 5). A 12-hour exposure was the most effective, followed by the 6-hour exposure, whereas there was little difference in the rate of budbreak between the 24-hour cuttings and the untreated controls. These observations suggest that high concentrations and/or longer exposure to garlic volatiles may be injurious to apical meristem of 'Muscat of Alexandria' grapevine buds.

When cuttings of 'Kyoho' grapevine at various stages of dormancy were exposed for 24 hours to garlic volatiles, the promotive effect was most significant on cuttings taken in November, followed by those taken in December (Fig. 6). Uniform budbreak also occurred in the November and December cuttings. However, the

Fig. 5. Effects of exposure for 6 (○, ●), 12 (△, ▲), and 24 (□, ■) hr to garlic volatiles on budbreak of single-bud cuttings of 'Muscat of Alexandria' grapevines. Open and closed symbols represent garlic volatiles and control, respectively. Vertical bars are the SE. $n=3$.

Fig. 6. Effects of exposure of single-bud cuttings of 'Kyoho' grapevines at different dormant stages to garlic volatiles on their budbreak.

volatiles had no effect on budbreak in cuttings obtained in March, indicating that the deeper the dormancy, the more pronounced the effect on budbreak.

The reasons for different responses by buds of different cultivars to garlic volatiles are not known. We previously reported that the response of grapevine bud to garlic paste significantly varied among the cultivars (Kubota and Miyamuki, 1992).

The results of this work indicate that some volatile

compounds in garlic are responsible for budbreak in grapevines. However, the actual compound(s) in garlic volatiles responsible for budbreak in grapevines and its mode(s) of action remain to be elucidated.

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ブドウ挿し穂の休眠打破に及ぼすニンニクに含まれる揮発性物質の効果

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摘 要

ブドウの芽の休眠打破に効果のあるニンニクについて、その有効成分を検討するため、‘マスカット・オブ・アレキサンドリア’と‘巨峰’の挿し穂に対するニンニクの抽出物と揮発物の休眠打破効果を調査した。市販のガーリックオイルとニンニク磨砕物を挿し穂の切り口に塗布したところ、そのいずれにおいても発芽が著しく促進された。しかし、凍結乾燥したニンニクからの抽出物および市販のニンニク粉末をラノリンで混和して塗布したところ、休眠打破の効果は全く認められないか、極めて小さかった。磨砕したニンニクを煮沸すると、煮沸しない場合と比較して、上澄み液、沈殿物ともに休

眠打破の効果が低下した。挿し穂をニンニク磨砕物および市販のガーリックオイルで気浴処理したところ、塗布処理に比べて効果は小さいものの、いずれの気浴処理でも発芽が促進された。これらのことから、ニンニクに含まれるある種の揮発性物質がブドウの芽の休眠打破に有効であると推察された。ニンニク揮発性物質の休眠打破効果は、11月のようなブドウの芽の休眠が深い時期ほど大きく、休眠が浅くなるにつれて低下した。

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