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Effects of Electric Current on Breaking Bud Dormancy in Grapes

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Abstract

Electric current was introduced to scions of two-year-old 'Kyoho' grape vines to determine the effect of direct and alternating current, voltage polarity, duration and time of exposure during dormancy on bud break. The current was introduced by inserting electrodes into pith tissue 30 cm apart.

1. When direct current was introduced to the grape scions during the time of the deepest endodormancy, bud break was markedly hastened. However, alternating current did not have any influence on breaking bud dormancy.
2. Such an effect was more pronounced when the anode of direct current was set to acropetal end of the scion than the other way around.
3. On October 13 and 14, 1983, 60V-24 hrs treatment was the most effective and hastened bud break by 22 days when the anode of the current was applied to the acropetal end. However, fresh weight of the shoots treated by either 48 V-16 hrs or 48 V-8 hrs was greater.
4. From October 4, 1986, the current of 60 V-24 hrs was applied to the scions every 4 weeks at 3 different times of dormant stages by setting the anode to the acropetal end. The procedures done on October 4 and November 1 hastened bud break by 40 days, while the one done on November 29 did not have any influences in this respect.

Introduction

KUROI *et al.*[1] reported that water-extracted calcium cyanamide solution had influence on breaking bud dormancy of grapes growing in the vineyard, when applied at the end of December. HORIUCHI[2] demonstrated that a high temperature treatment or cytokinin application in early November was very effective in breaking bud dormancy of grapes. KUBOTA *et al.*[3] found that garlic juice, volatile substances from kinira (etiolated garlic) and scallion had a marked effect on breaking bud dormancy of grapes, when these substances were applied to the buds in mid November or mid December. In fact, calcium cyanamide and garlic have been commercially utilized for very early harvesting system (early May) of 'Delaware' and 'Muscat of Alexandria' grapes by heating practice under protected cultivation. However, little is known whether these substances were effective in breaking bud dormancy of grapes when carried out during their deepest dormancy.

Using potatoes, KAWARADA *et al.*[4] showed that electric current would be effective in breaking the bud dormancy. This study was carried out to determine whether electric current would have a similar effect on breaking bud dormancy in grapes.

Materials and Methods

Experiment I.

Scions used for this experiment were obtained from two-year-old 'Kyoho' grape growing in the Experiment Farm, University of Osaka Prefecture. On October 13 and 14, 1983, current year shoots having 6 buds between the 7th and the 12th nodes were prepared and cut in halves to obtain scions (about 30 cm) with 3 buds each.

Ten scions were used in each treatment. The scions were approximately 1 cm in diameter and had a length of about 30 cm. As shown in Fig. 1, a stainless steel electrode wire (ϕ 0.69 mm) was inserted into the pith of the scion to a depth of 10–15 mm. Regulated DC. power supply (SHOWA Electronics CO., LTD. cvc 65–5) was used as a power supply. The combination of the magnitude and duration of applied voltage was designed as follows: two different durations of 16 and 24 hrs at DC.60 V and three different durations of 4, 8 and 16 hrs at DC.48 V. In each combination, the current was applied to the cutting from both basal and top ends. After the treatment, all buds but the top one were removed, and the basal portion cut into a wedge-shape before planting it in a sand bed in the growth cahmber. Temperatures in the chamber were controlled at 25°C during the day and 20°C at night with a 16 hr photoperiod. Bud break was observed every day, and the cuttings were harvested 6 weeks after planting to determine their top and root weights.

Experiment II.

Current year shoots with 3 buds between the 5th and 7th node were prepared from potted 'Kyoho' grapes of uniform vigor on October 4, November 1 and November 29, 1986. Ten scions were used for each treatment. Only DC. 60 V-24 hrs was set up for the magnitude and duration of voltage applied, but polarity, sand bed, day and night temperatures, and determination of bud break were done as in Experiment I. Daylength was set at 12 hrs. In addition to this experiment, alternating current with 60 Hz (AC. 60 V-24 hrs) was introduced to the scion on November 1, 1986, to determine whether this current also would have influences on breaking bud dormancy of grapes or not. Introduction of the current was done by using a volt-slider (YAMABISHI Electric CO., LTD. N–130–10) at AC. 60 V-24 hrs setting. Other experimental conditions were the same as

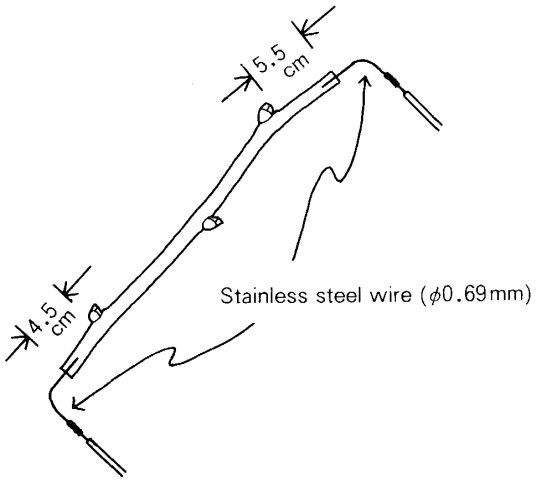

Fig. 1 The method of current introduction to grape scions.

those of direct current. Changes in the intensities of direct and alternating current were monitored by Digital Hitester (HIOKI E.E. Corporation 3209) and Digital Printer (HIOKI E.E. Corporation 9201).

Results

Experiment I. Effect of magnitude, duration and polarity of applied voltage on bud break.

Percentages of bud break due to direct current introduction basipetally are shown in Fig. 2-A and C, whereas those of the acropetal are shown in Fig. 2-B and D. Bud break was initiated at 10 days and was complete by around 20 days after the basipetal treatment at 60 V, regardless of the duration of the treatment. Compared to the control which took 27 days before buds started breaking, the time for an 80% bud break at 60 V-24 hrs ⊕ and 60 V-16 hrs ⊕ was hastened by 22 and 16 days respectively (Fig. 2 A). However, when the current was acropetally introduced, the change was not as dramatic (Fig. 2 B). Although bud break of the scions treated in 48 V-16 hrs ⊕ and 48 V-8 hrs ⊕ started 10 days after planting, the duration to 80% bud break was hastened only by 13 and 11 days respectively over the control (Fig. 2 C). All scion receiving 48 V-4 hrs ⊕, 48 V-16 hrs ⊖, 48 V-8 hrs ⊖, or 48 V-4 hrs ⊖ showed some response, but response is not remarkable (Fig. 2- C, D).

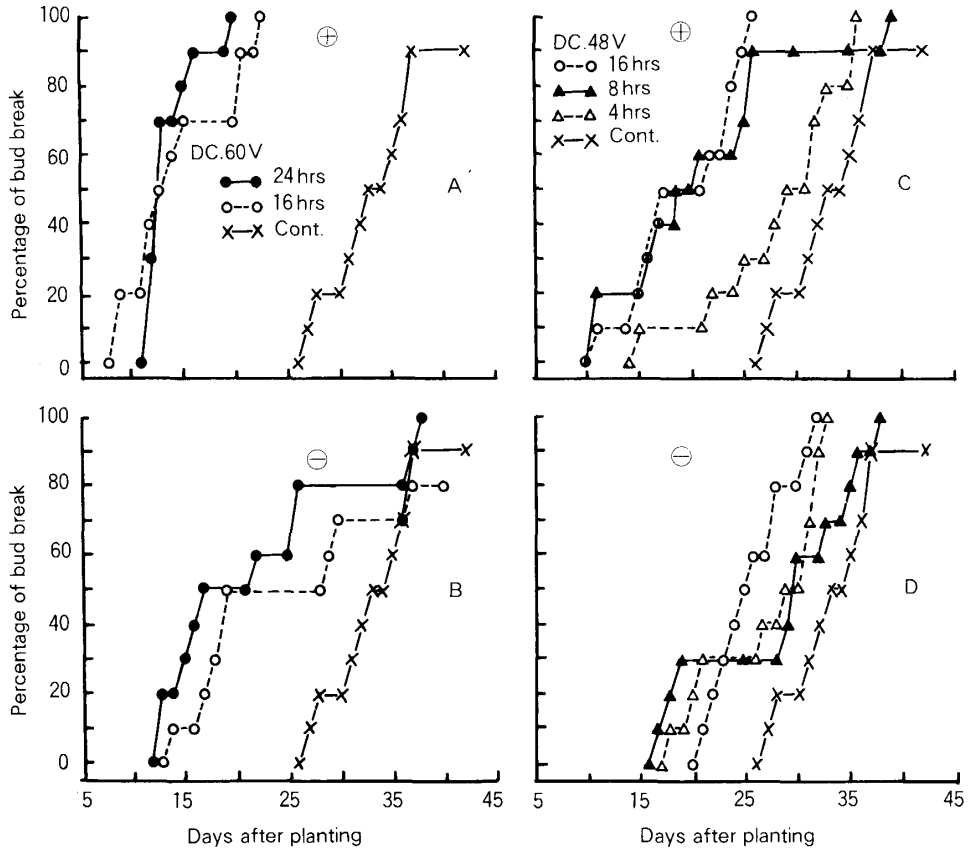

Fig. 2 The effect of differences in voltage, duration and polarity on breaking bud dormancy of grape scions. (⊕: Basipetal, ⊖: Acropetal)

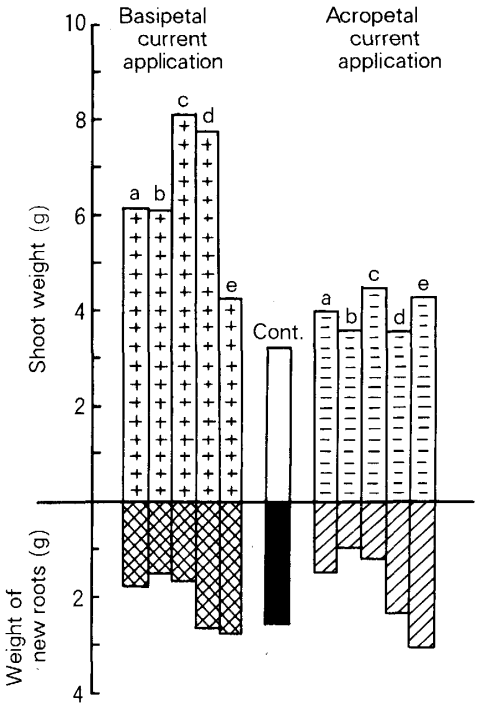

Fig. 3 The effect of current introduction to dormant grape scions on their fresh weights of shoots and roots 6 weeks after planting. a: 60 V-24 hrs, b: 60 V-16 hrs, c: 48 V-16 hrs, d: 48 V-8 hrs, e: 48 V-4 hrs.

Fresh weights of shoots and new roots from the scions 6 weeks after planting are shown in Fig. 3. Shoot weights were generally greater when the current was introduced basipetally, which should be due to earlier bud break than when it was introduced acropetally. This was more apparent when the scions were treated in 48 V-16 hrs ⊕ and 48 V-8 hrs ⊕. Bud break occured earlier in the 60 V-24 hrs ⊕ and 16 hrs ⊕ groups than in the 48 V-16 hrs ⊕ and 8 hrs ⊕ groups, but fresh weights of shoots were smaller in the former. Fresh weights of newly developed roots were smaller at higher voltage and longer durations of current applied (Fig. 3). Number of new roots observed in the scions treated with direct current basipetally was no different from that of the control, other than the fact that the tap root was somewhat thinner. When the scions were treated acropetally, the tap root in any combination of treatments was as thick as that of control, but the number of new roots was smaller in certain combinations (data not shown).

Experiment II. Effect of variable currents and duration on bud break during bud dormancy

In experiment I, introduction of direct current to the scions basipetally was more effective on breaking grape bud dormancy than that to acropetally. It was also demonstrated that one of the treatments, DC. 60 V-24 hrs carried out in mid October markedly shortened the length of time required for bud break in grapes, although the growth after bud break was slightly retarded.

Therefore, experiments were carried out to determine the effect of direct current (60 V-24 hrs) introduced basipetally to grape scions at three different times of bud dormancy (Oct. 4, Nov. 1 and Nov. 29) before planting them in a bed. The effect was most evident when the current (60V-24 hrs) was applied on October 4 when the dormancy

was the deepest; bud break initiated 7 days after the scion was set, and 80% bud break was observed 16 days after setting (Fig. 4). When the same voltage was applied to the scions on November 1, it took 14 days before initial bud break and 23 days before 80% bud break. However, the time to 80% bud break was hastened by about 40 days as compared to control. This length was almost equal to that applied on October 4 (Fig. 5). No evident effect was observed when the current was applied to the scion on November 29 (Fig. 6). Application of alternating current to the grape scions did not show any influence on bud break (Fig. 5).

Changes in current intensity monitored during introduction were shown in Fig. 7. When the basipetal introduction of 60 V-24 hrs ⊕ was done on October 4 and November 1, 601 and 420 μamp respectively, was recorded at the beginning of the procedure. These figures were down to half the initial amount (291 and 205 μamp) 2 hours later. A further

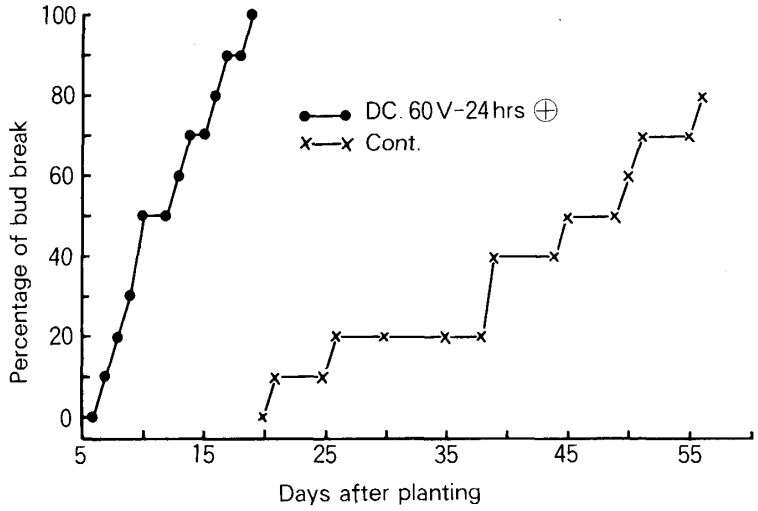

Fig. 4 The effect of current introduction on bud break when applied to dormant grape scions on October 4.

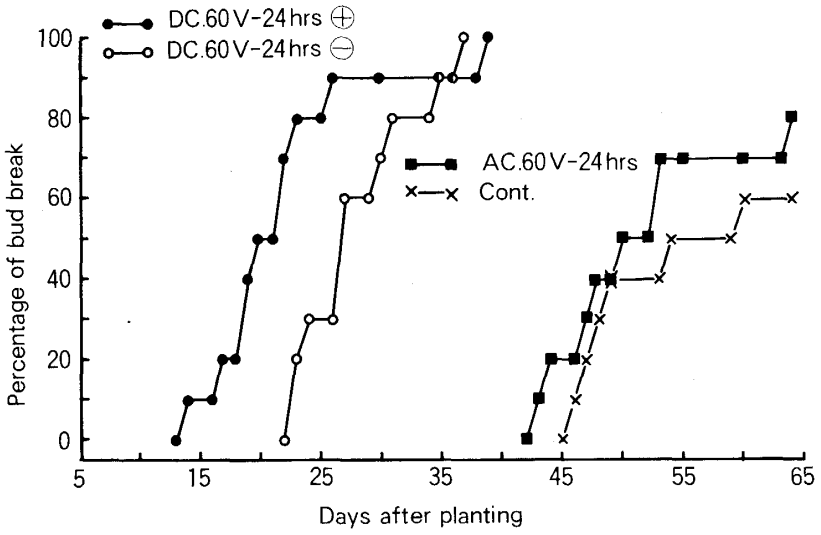

Fig. 5 The effect of current introduction on bud break when applied to dormant grape scions on November 1.

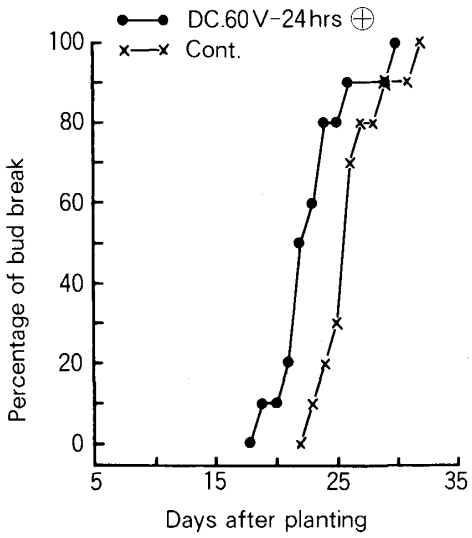

Fig. 6 The effect of current introduction on bud break when applied to dormant grape scions on November 29.

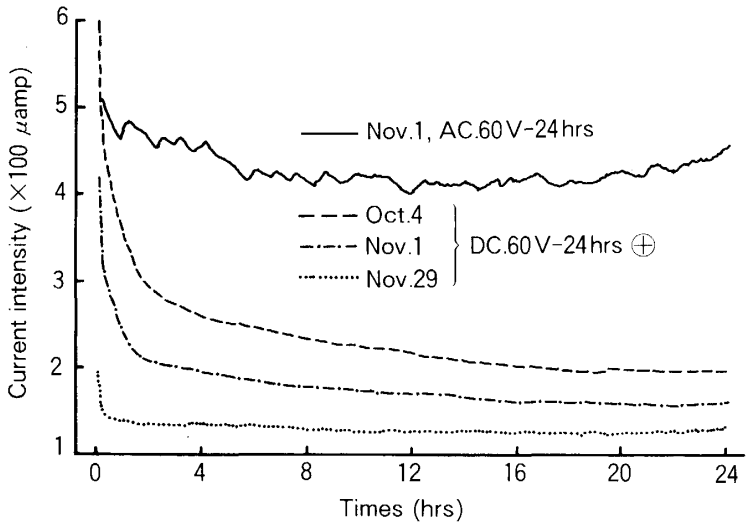

Fig. 7 Changes in current intensity during its introduction to the scions at different application times.

gradual reduction to 196 and 160 μamp was noted 24 hrs later. Contrary to the changes seen with direct currents, current intensity was kept high when alternating current was introduced to the scions. Among the treatments with direct current, the later the time of introduction, the weaker the current introduced to the scions became. Total electrical charge for each application date, October 4, November 11 and 29 was 20.1, 15.6 and 11.3 coul respectively.

Changes in currents applied basipetally, were slightly different from those applied acropetally even though length and thickness of the scions were identical. Therefore, the changes were monitored by alternately by introducing the current to a single scion from both ends at 30 minutes intervals. As shown in Fig. 8, current intensity was increased by 10% immediately after the polarity was switched and continued to rise for 2–5 min, before it showed a gradual down turn. When the intensity of the current was plotted at

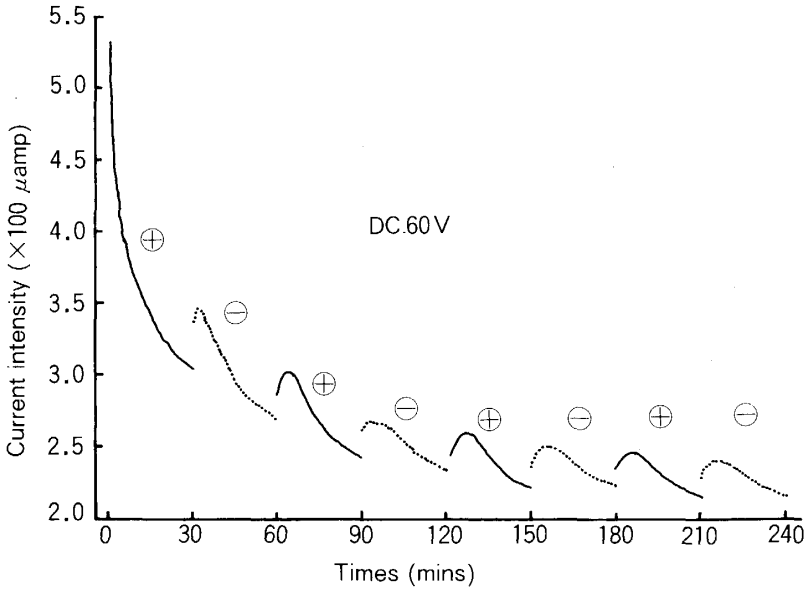

Fig. 8 Changes in current intensity when the polarity of its introduction was alternately converted. (⊕: Basipetal, ⊖: Acropetal)

either the beginning or end of 30 min, regardless of polarity, the attenuation curves as found in Fig. 7 were drawn. Consequently, the intensity was not influenced by current polarity.

Discussion

KUROI[5] applied calcium cyanamide to grape vines of several cultivars 'Neo Muscat', 'Koshu' and 'Muscat Baily A' on October 15. Thirty days after single bud scions were incubated at controlled temperature of 30°C, bud break was 90, 80 and 80%, respectively for each cultivar. In the present study, 80% bud break was achieved 15 and 16 days after treatment with electric current (60 V-24 hrs⊕). This is a 50% time gain compared to KUROI's results.

KAWARADA *et al.*[4] did not refer to the effect of polarity on breaking bud dormancy when direct current was introduced to potatoes. When direct current was introduced to the scions prepared from dormant grape vines, basipetal introduction proved to be more effective in breaking bud dormancy than acropetal introduction.

In an entirely different topic from breaking bud dormancy, RATHORE and GOLDSWORTHY[6] reported that the passage of one microamp between the callus and the medium stimulated the growth rate by about 70% when the callus was negative, but it that was slightly inhibited by the introduction of similar current in the reverse direction. They further studied and found that the passage of one or two microamps between them resulted in approximately five-fold stimulation of shoot regeneration when the callus was negative, and that the passage of similar current of opposite polarity was less effective[7]. We too found that the effects of current on breaking bud dormancy in potatoes, enhancement of bud break and an increase in shoot number of sweet potatoes, and stimulating shoot growth of figs were more evident when the terminal ends were negative. We were unable to explain why breaking bud dormancy of 'Kyoho' grape vines were effective

when the terminal end of the scions were positive.

There was an 18 day difference to 80% bud break between the scions treated with the current of 60 V-24 hrs ⊕ on October 13, 1983 and those treated with the same current on October 4, 1986. This may be attributed to the differences in the time of bud break in the control scions of both years, which is due to the differences in the cultural practices, the position of node prepared for the scion, and hours of day and night when temperatures are controlled after planting them in the bed.

Although direct current introduction to the scions during the deepest bud endodormancy was highly effective in breaking it, such a procedure at the completion of the dormancy (Nov. 29) was ineffective. This may be due to the fact that bud break of control scions had hastened, and that the current introduction at this time did not shorten the days for bud break in the treated scions.

MORI[8] suggested that electrical resistance of agricultural products was relatively influenced by their temperature, and that direct-current resistance generally decreased when temperatures rose in organic matters, and a temperature coefficient of negative resistance is observed. WISNIEWSKI *et al.*[9] pointed out that the electrical resistance became lowest during the active growing season, but peaked during the dormant season, when resistance was measured at an ambient temperature of above 12°C by delivering a pulsed current to the cambium of peach trunk. They further suggested that the resistance rapidly increased in late fall, and gradually decreased in late winter. In our experiment, current introduction was carried out in a laboratory without heating and by intercepting direct sunlight. Therefore, the later the time of current introduction, the lower the intensity. Later on, we found that when the scion temperature was raised either by higher room temperatures or by exposure to direct sunlight, current intensity passing through such scions became higher. Judging from these findings, exposure of the scions to higher temperatures or higher voltages might have hastened bud break.

IKEUCHI[10] suggested that since electrical resistance occurring in a living tissue to which direct current was introduced brought about polarization within the tissue, the intensity would differ by the direction of the current introduced. However, we did not fined any differences in this respect as shown in Fig. 8. As suggested by RATHORE and GOLDSWORTHY[6,7], it is not yet clear how applied current influences the physiological process of plant tissues, but artificial direct current introduced to such tissues would probably reinforce or supplement transcellular natural current. The evidence that direct current but not alternating current was effective in breaking bud dormancy of the scions from 'Kyoho' grape vines suggests that the mechanisms of the effect may be strongly related to endogenous plant hormones.

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