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# Effectiveness of electrical currents in breaking potato tuber dormancy compared with other methods

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SUMMARY

The effects of direct electrical current (DC) and alternating current (AC), were compared with bromoethane (BE), gibberellic acid (GA) and kinetin (Ki) for breaking tuber dormancy of potato (*Solanum tuberosum* L.). BE was the most effective treatment for high sprout numbers and for short emergence times of sprouts, but the growth regulators (GA and Ki) were most effective in promoting sprout elongation. Electrical currents were more effective for sprout numbers than were growth regulators, except for BE. Amylase and polyphenol oxidase (PPO) enzyme activities were different in the tuber parenchyma and the sprouts of treated tubers. Amylase activity was higher in the parenchyma than in sprouts, in contrast to PPO activity.

BREAKING of tuber dormancy is important for seed potato multiplication, rapid post-harvest disease testing and early production in the field or greenhouse (Coleman, 1983; Coleman and Coleman, 1986). If tubers are unable to sprout at favourable temperatures, they are considered dormant (Coleman, 1987). The dormancy period of potato tubers lasts approximately two months or more after harvest (Cho *et al.* 1983).

Some chemicals are already being used to break dormancy of potato tubers. The plant growth regulators gibberellins and cytokinins are known to break tuber dormancy (Clegg and Rappaport, 1970; Hemberg, 1970; Mioduszewska and Bielinska-Czarnecka, 1984; Turnbull and Hanke, 1985). Rindite ( a mixture of ethylene chlorohydrin, ethylene dichloride and carbon tetra-chloride) is routinely used as a dormancy breaking agent. However, bromoethane (BE) has been found to be as effective as rindite (Coleman, 1983; McDonald and Coleman, 1984). Recently, direct electrical current (DC) has also been found to be successful in breaking tuber dormancy (Kocaçalişkan *et al.* 1989), but there was no information on the effectiveness of alternating current (AC).

In this study, effects of AC and DC currents were compared with BE and the growth regulators gibberellic acid (GA) and kinetin (Ki) in breaking tuber dormancy. Effects on sprouting, and on amylase and polyphenol oxidase (PPO) enzyme activities are also discussed.

## MATERIALS AND METHODS

Tubers of potato (*Solanum tuberosum* L. cv. Famosa) were obtained from the Agricultural Faculty of Atatürk University two weeks after harvest, and treated as follows.

### *Application of the treatments*

Electrical current was applied to the tubers as described earlier (Kocaçalişkan *et al.*, 1989). Potential differences of 50 and 100 volts were applied in two ways:
(i) DC repetitively with 60 impulses for one minute, each impulse of 10 msec duration, and
(ii) AC of 50 Hz for one minute, continuously.

The growth regulators were injected into individual tubers by syringe as 0.3 ml at 0.4 mM (Turnbull and Hanke, 1985).

BE was applied at 0.2 $ml^{-1}$ by exposing the tubers to its vapour in a plastic container at room temperature for 24 h (Coleman, 1983).

Ten tubers were used for each application and after the application, treated and untreated (control) tubers were placed in an incubator at 20°C. Sprouting of the tubers was followed for

TABLE I
*ANOVA table for sprout elongation*

| Source of variation | d.f. | M.S. | F. |
|---|---|---|---|
| Treatments | 4 | 510.50 | 18.52* |
| Days | 5 | 1028.67 | 37.32* |
| Treatment x day | 20 | 26.66 | 0.96 |
| Error | 270 | 27.56 | |

*$P<0.01$

two weeks after treatment and enzyme activities were measured.

*Determination of enzyme activities*

Excised sprouts and the remaining tuber parenchyma were analyzed separately, 50 g parenchyma and 2 g sprouts were homogenized in 150 ml and 6 ml 0.05 M phosphate buffer (pH:6.0) respectively, then filtered. The filtrate was centrifuged at 0°C and 40 000 **g**. The resultant supernatant was used for determining enzyme activity. In this way, three extracts were prepared from plants from each treatment, two or three tubers being used for each extract.

Amylase activity was measured by the starch-iodine method and expressed as change in absorbance (608 nm) per g tissue (Jennings and Duffus, 1977). PPO activity was measured by the direct spectrophotometric method at 490 nm and the activity was expressed as absorbance units per g tissue (Matheis and Belitz, 1975).

*Statistical methods*

The experiment was conducted as a factorial layout using a completely randomized design with ten replicates for sprout elongation. Also a completely randomized design was used for sprout numbers and enzyme activities. In addition, Duncan's multiple range test was used for comparing the means of sprout numbers and the enzyme activities (Steel and Torrie, 1980).

RESULTS

*Sprouting of the tubers*

As shown in Table I, the effects of the treatments and days on sprout elongation were highly significant, but the interaction was not.

Sprout numbers were enhanced by BE much more than with the other treatments (about two or three fold). Although the control tubers did not sprout, all the BE treated tubers sprouted, compared with 80% in the case of electrical currents and GA, and only 70% following Ki treatment (Table II).

On the other hand, sprouting was affected differently by the same treatment. For example, GA was the most effective for producing sprout elongation despite low sprout numbers. Electrical currents have a smaller effect on sprout length than the other treatments, but they were more effective in increasing sprout numbers than the growth regulators (Table II).

Effects of the treatments on sprout elongation are shown in Figure 1. The most effective treatments were the growth regulators, especially GA, in increasing and promoting sprout elongation. Although BE was initially the most effective, later its effect decreased gradually. Electric treatments increased sprout elongation continuously, but the sprouts were shorter than those of tubers of other treatments. There was no important difference between DC and AC current in increasing sprout elongation, but sprout number was greater after AC than DC. As seen in Figure 1, emergence time of the sprouts also differed. After BE treatment, sprouts emerged in two days compared with 4–5 d after other treatments.

Treatments affected sprout morphology; growth regulators, especially resulted in long, thin sprouts (Figure 2), compared with thicker sprouts following BE and electrical treatments.

TABLE II
*Effects of treatments on sprouting two weeks after treatment*

| Treatments | Mean length (mm) of the longest sprouts | Mean no. sprouts/tuber | Sprouted† tubers (%) |
|---|---|---|---|
| DC (50 V) | 10.0b* | 2.1bc | 80 |
| AC (50 V) | 9.0b | 3.0b | 80 |
| BE (0.2 ml/l) | 12.0ab | 5.8a | 100 |
| GA (0.4 mM) | 19.0a | 1.4c | 80 |
| Ki (0.4 mM) | 14.0ab | 1.8bc | 70 |
| Control (no treatment) | 0.0c | 0.0d | 0 |

*Means with common letters within column are not significantly different (Duncan 5%). Each value is a mean of ten measurements.
†A tuber was defined as sprouted when it had one sprout at least 1 mm long.

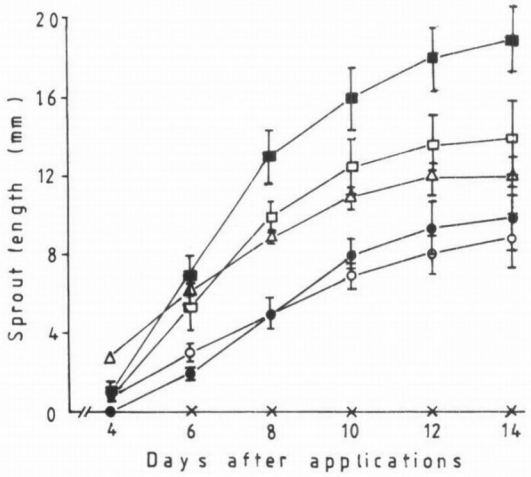



FIG. 1
Time course of sprout elongation measured in days from treatment application. Treatments (see Materials and Methods): DC current (●), AC current (○), BE (△), GA (■), Ki (□), and no treatment as control (x), where no sprouting occurred. Each value is a mean of ten measurements from the longest sprouts of the tubers. The vertical bars represent the standard errors of the means.

In the study, a potential difference of 100 V (DC and AC) was applied but there was no sprouting in AC-treated tubers and even this current caused necrosis at the applied sites. Effects of 100 V DC on sprouting were almost same as with 50 V DC. These data are therefore not presented separately.

*Enzyme activities*

Amylase activity of tuber parenchyma was found to be higher than that of sprouts. All the treatments increased amylase activity in the parenchyma, but GA increased the activity to double that of the control. PPO activity, in contrast, was higher in the sprouts than tuber parenchyma. Treatments increased PPO activity considerably in the parenchyma, but BE was the most effective in increasing PPO activity in both parenchyma and sprouts (Table III).

## DISCUSSION

Previous work (Kocaçalişkan *et al.*, 1989), showed that DC current, applied as impulses, breaks the dormancy of potato tubers. In this study, AC was also found to break tuber dormancy, but electric treatment was seen to be no better than BE, and in some cases than GA and Ki.

As reported here and by earlier studies (Clegg and Rappaport, 1970; Hemberg, 1970), exogenous gibberellins break tuber dormancy and as indicated by Coleman (1987) may act as endogenous regulators of bud dormancy and development. The primary effect of gibberellins is on the synthesis or activation of amylase in germination (Marcus, 1971). On the other hand, cytokinins break tuber dormancy by stimulating cell division (Turnbull and Hanke, 1985).

BE was the most effective treatment in the study. McDonald and Coleman (1984) also showed that BE is as effective as rindite in breaking tuber dormancy. Since BE is an anaesthetic, its mode of action was considered to be on cell membrane permeability (Taylorson and Hendricks, 1979). During sprouting, food reserves and enzyme effectors are translocated

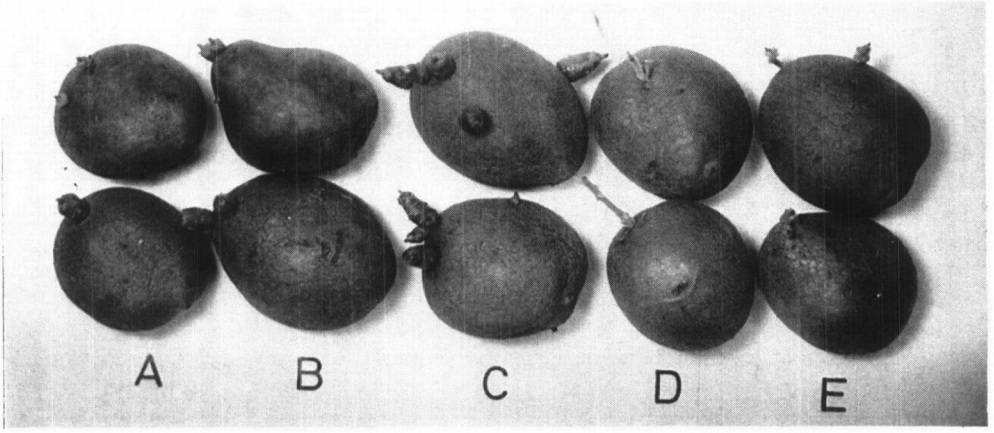



FIG. 2
Effects of treatments on the shape of sprouts. A = DC, B = AC, C = BE, D = GA, E = Ki.

TABLE III
*Effects of treatments on the enzyme activities two weeks after treatment*

| Treatments | Amylase activity ($A_{608}$/g tissue) Paren-chyma | Sprout | PPO activity ($A_{490}$/g tissue) Paren-chyma | Sprout |
|---|---|---|---|---|
| DC | 1.56b* | 0.28a | 20.0b | 37.6b |
| AC | 1.60b | 0.27a | 21.7b | 38.0b |
| BE | 1.70b | 0.30a | 29.8a | 44.2a |
| GA | 2.23a | 0.34a | 22.0b | 39.1ab |
| Ki | 1.45b | 0.26a | 21.0b | 36.7b |
| Control (no treatment) | 0.60b | 0.00b† | 12.4c | 0.0c† |

*Means with common letters within column are not significantly different (Duncan, 5%). Each value is a mean of duplicate measurements on three extracts.
†Zero is not an activity value. Because there was no sprout, no measurement was possible.

from the parenchyma to the eyes of the tuber (Morris, 1967; Edelman *et al.*, 1969; Nowak, 1977). Changes in membrane permeability are probably required for this translocation.

The mechanism(s) by which the electrical current breaks tuber dormancy is unknown at present, but its effect may be on the membranes. As indicated by Robinson (1985), externally applied electrical currents change cell membrane potentials and redistribute charged mobile components of membranes such as receptors.

Amylase and PPO enzymes would be important for sprouting as a result of the treatments. In this study, amylase activity was increased by GA much more than other treatments, and PPO activity was increased by BE more than the others. Although there is no report about the effect of BE on these enzymes, it is well known that GA increases amylase and PPO activities (Marcus, 1971; Jennings and Duffus, 1977). On the other hand, in this study, amylase activity was higher in tuber parenchyma, and, in contrast, PPO was higher in sprouts, perhaps reflecting the function of the enzymes, because amylase breaks down starch stored in the tuber parenchyma (Nowak, 1977), whereas PPO oxidizes some phenols to quinones which are important in the electron transport chain of respiration (Bewley and Black, 1983) which is rapid in the growing sprouts.

The shapes of the sprouts were affected by electric treatments in a similar manner to BE, which resulted in thick sprouts. This is a desirable result for increasing potato yield, because the stems of the potato plants will be derived from these sprouts.

In comparison with BE and growth regulators for breaking tuber dormancy, electrical current is most convenient and useful from considerations of environmental risk, ease and cost of application, its effectiveness in breaking tuber dormancy is less than that of BE. Further studies are therefore needed to establish more effective current doses or application methods.

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REFERENCES

BEWLEY, J. D. and BLACK, M. (1983). Biochemistry of germination and growth. In: *Physiology and biochemistry of seeds in relation to germination.* (Bewley, J. D. and Black, M., Eds), Volume 1, Springer Verlag, Berlin, New York, Heidelberg, 132–76.

CLEGG, M. D. and RAPPAPORT, L. (1970). Regulation of bud rest in tubers of potato, *Solanum tuberosum* L. VI. Biochemical changes induced in excised potato buds by gibberellic acid. *Plant Physiology,* **45,** 8–13.

COLEMAN, W. K. (1983). An evaluation of bromoethane for breaking tuber dormancy in *Solanum tuberosum* L. *American Potato Journal,* **60,** 161–7.

COLEMAN, W. K. and COLEMAN, S. E. (1986). The effects of bromoethane and ethanol on potato (*Solanum tuberosum*) tuber sprouting and subsequent yield responses. *American Potato Journal,* **63,** 373–7.

COLEMAN, W. K. (1987). Dormancy release in potato tubers: A review. *American Potato Journal,* **64,** 57–68.

EDELMAN, J., JEFFORD, T. C. and SINGH, S. P. (1969). Studies on biochemical basis of physiological processes in potato tuber. *Planta,* **84,** 48–56.

HEMBERG, T. (1970). The action of some cytokinins on rest period and the content of acid growth-inhibiting substances in potato. *Physiologia Plantarum,* **23,** 850–8.

JENNINGS, P. H. and DUFFUS, C. M. (1977). Effect of gibberellic acid on polyphenol oxidase activity in de-embryonated wheat and barley grains. *New Phytologist,* **78,** 383–9.

KOCAÇALIŞKAN, I., KÜFREVIOĞLU, I., KEHA, E. E. and ÇALIŞKAN, S. (1989). Breaking of dormancy in potato tubers by electrical current. *Journal of Plant Physiology,* **135,** 373–4.

MARCUS, A. (1971). Enzyme induction in plants. *Annual Review of Plant Physiology,* **22,** 313–36.

MATHEIS, G. and BELITZ, H. (1975). Multiple forms of soluble monophenol, dihydroxyphenylalanine: oxygen-oxidoreductase (EC 1.14.18.1) from potato tubers. *International Journal of Food Research and Technology,* **157,** 221–7.

MCDONALD, J. G. and COLEMAN, W. K. (1984). Detection of potato viruses Y and S in tubers by Elisa after breaking of dormancy with bromoethane and rindite. *American Potato Journal,* **61,** 619–22.

MIODUSZEWSKA, H. and BIELINSKA-CZARNECKA, M. (1984). Influence of GA treatment on acid phosphatase activity in potato tubers towards the end of growth, in dormancy and sprouting. *Acta Physiologia Plantarum,* **6,** 75–82.

MORRIS, D. A. (1967). The influence of light, gibberellic acid and CCC on sprout growth and mobilization of tuber reserves in potato (*Solanum tuberosum* L.). *Planta,* **77,** 224–32.

NOWAK, J. (1977). Biochemical changes in stored potato tubers with different rest periods. II. Influence of storage temperature and isopropyl phenylcarbamates on enzyme activities. *Zeitschrift für Pflanzenphysiologie,* **81,** 125–40.

ROBINSON, K. R. (1985). The responses of cells to electrical fields: A review. *Journal of Cell Biology,* **101,** 2023–7.

TAYLORSON, R. B. and HENDRICK, S. B. (1979). Overcoming dormancy in seeds with ethanol and other anesthetics. *Planta,* **145,** 507–10.

TURNBULL, C. G. N. and HANKE, D. E. (1985). The control of bud dormancy in potato tubers, evidence for primary role of cytokinin and seasonal pattern of changing sensitivity to cytokinin. *Planta,* **165,** 359–65.

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