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AUGMENTATION OF GRAFT COMPATIBILITY THROUGH ELECTRIC CONTROL

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ABSTRACT

Grafting is important means for getting good yields in plants because it does not implicate soma clone variation in products. The augmentation of graft compatibility contributes significantly in horticulture, floriculture and forestry production. The graft compatibility and its augmentation depend upon various natural factors like environment, weather, soil conditions and protective measures etc. The present study examines the role of external electric field on augmentation of graft compatibility. For this purpose, the external forward and reverse DC electric currents of 5, 10, 20 and 30 microampere were passed across the scion and stock in more than two hundred specimens of the Rosa indica graft for 24 hours after grafting and their percentage growths were recorded. It was found that the graft compatibility was augmented by applying D.C. current directed from stock of scion of graft union up to 20 ma. The electric control of graft compatibility, its dependency on direction of the current and its pattern of variation have been envisaged in the findings.

KEY WORDS: Electrical control, graft compatibility, augmentation, directionality, electric field effect

Electrical coupling and associated experiments have formed the basis of electrophysiological investigations of higher plant's plasmodesmata (Spanswick 1972; Drake et al. 1978; Goldsmith and Goldsmith 1978; Drake 1979; Overall and Gunning 1982; Lew 1994). The appearance of the plasmodesmata at the interface of scion and stock is directly proportional to the development of cohesion between them which results in better inter-cellular communication (Yang et al., 1992). However, the coupling ratio (the ratio of the voltage response to an injected current in one cell to the voltage response in a neighboring cell from the point of current injection), which is generally used as a measure of the extent of intercellular communication, depends not only on the resistance of plasmodesmata, but also on that of the plasma membrane (Spanswik, 1972).

The effect of external electric field on plant tissue has been reported in terms of characterization of the differentiating and non-differentiating callus tissues by external electrical potential (Goldsworthy, 1986, Goldsworthy and Mina 1991). The transfer of haunglongb in resistance trait from orange Jessamine to *citrus* was reported to be possible through protoplast electro fusion in which electric signal improved graft compatibility between orange Jessamine to *citrus* (Guo and Deng, 1998).

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The effect of electric field on graft compatibility in plants arising due to electric interaction between external field and internal electric coupling of scion and stock has been examined in the present study. For this purpose, weak external electric currents of various amounts were passed in forward and reverse direction both across the scion and stock at graft interface and enhancement in graft compatibility was observed. Extraordinary results under electric control were found in the augmentation of the graft success rates. It was also observed that the augmentation pattern was dependent on the direction of the current.

MATERIALS AND METHODS

Applying Weak External Electric Current across the Graft Interface

Auto grafts of *Rosa indica* were grown in natural environment of field and the weak external electric currents were passed through scion and stock at the graft interface by using stainless steel electrode of (0.25 mm diameter), carbon film resistor and DC electric source for 24 hours after grafting. The circuit diagram is shown in figure 1. The various strengths of the current were derived from the D.C. source as per the Ohm's law. The experiments were carried out for positive and negative electrical polarities on scion. When the scion is connected to negative terminal of the DC source, it has been called as scion negative, when it is at positive terminal it has been called as scion positive and when only electrode is inserted into the scion and the stock then it has been called as positive control. The current strengths tested in this experiment were 5, 10, 20 and 30 microampere.

Determination of the percentage growth of Graft

In the beginning 200 grafts were grown and a weak external electric current of the strength 5 microampere was applied across scion and stock at the graft interface in scion positive and scion negative conditions both and the percentage of the graft success of 200 grafts was calculated. The similar procedure was adopted for the current strengths 10, 15, 20, 25 and 30 microampere. The graft success rate was determined on the basis of percentage of the successful graft in each of the three conditions namely scion positive, scion negative and positive control. The percentage of graft success rate was determined in each of the three conditions namely scion positive, scion negative and positive control.

Statistical Analysis

Statistical analysis was done by standard method developed by Duncan (1995). At least three observations were taken for one set of the experiments and mean values of the experimental findings were compared using Duncan's Multiple Range Test (1995) at 5% probability level. Variability around the mean has been represented as ± standard deviation.

Mathematical representation

This characteristic phenomenon, in which external electric current augments the graft success rate in scion negative condition, can be expressed by a mathematical equation given below:

$$S(t) = S_o + CI, \text{ For } I = I_0$$
$$= S_m, \text{ For } I > I_0$$

Where, S (t) is the graft success rate, S_o is the graft success rate without external weak electric current, C is a constant in graft success rate per unit current, I is applied weak external electric current in micro ampere, S_m is the saturation value of the graft success rate and I_0 is the optimum value of the applied weak external electric current (in this case $I_0 = 20$ micro ampere).

RESULTS AND DISCUSSION

The applied external electric current does augment the graft success rate in "scion negative" condition as shown in table-1.

Table 1: Graft success rate by using external electric current in scion negative condition

Current (µA)	Graft success rate data	Graft success rate (% of 200 grafts)
5.0000	S1	25.0000 ± 1.0
10.0000	S2	48.0000 ± 1.0 [e]
15.0000	S3	66.0000 ± 0.64 [d]
20.0000	S4	90.0000 ± 1.01 [a]
25.0000	S5	90.0000 ± 0.28 [ab]
30.0000	S6	90.0000 ± 1.2 [abc]

Values represent mean ± standard deviation followed by letters according to Duncan's Multiple Range Test (Duncan, 1995). Values followed by same letters are not significantly different ($p \leq 0.05$).

Since flow of current takes place from positive to negative terminal in DC source hence the current flow in scion negative condition is from stock to scion which is parallel to the flow of minerals, molecules, water etc taking place from stock to scion in graft. At this configuration external current spurs the physiological flow which helps in growth of the plant cell. The external electric current enhances the rate of physiological flow in scion negative condition hence the electrical resistance appearing at graft interface may drop at faster rate which may result in faster appearance of the secondary plasmodesmata at the graft interface responsible for better inter-cellular communication as reported by Yang et al. (1992). The growth of graft is proportional to the strength of the applied weak external electric current up to an optimum value (20 microampere in this case) Beyond this optimum value of the applied external electric current graft success rate becomes stable because the high strength of the external current across the graft union may intervene the cell to cell communication and hence may stop the further appearance of the plasmodesmata at the graft union interface. The confirmation of these facts needs further study.

The pattern of variation of augmentation of graft compatibility under electric control in scion negative condition has been shown below in figure 1.

In the scion positive condition the graft success rate was not observed to be augmented because the flow of the external electric current in this condition takes place from scion to stock which is opposite to the physiological flow in graft. The opposite direction of flow of external current to the physiological flow in graft results in increase of electrical resistance at graft interface which causes to interupt inter-cellular communication.

In positive control no external current was applied across the graft union hence graft success rate was observed to be unaffected. This part of experiment was conducted to verify the fact that the augmentation in the graft success rate was only due to the applied weak external electric current across the graft union and not due to the electrode insertion in scion and stock.

CONCLUSION

The present study and subsequent results may enable the Scientists to overcome the difficulties arising due to the incompatibility of the graft which affects significantly the plant growth in Horticulture and Forestry production.

The augmentation in graft success rate was observed in scion negative condition at external current of 5 microampere and beyond. It was constantly observed that there was no significant alteration in graft success rates at the scion positive condition as well as in positive control.

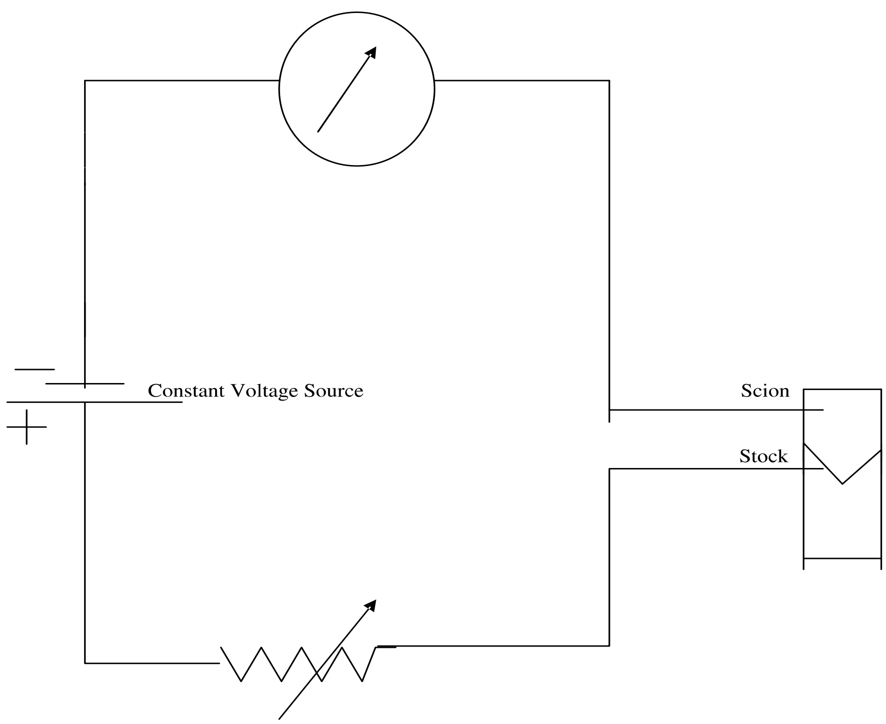

Figure 1: Circuit diagram for the application of the weak external electric current across the graft interface of the Rose auto graft in scion negative condition

There was surprising increase in graft success rate when the applied current strength was greater than 5 microampere in "scion negative" condition. Graft success rate was observed to be augmented linearly with applied external D.C. current in scion negative condition. There was surprising increase in graft success rate when the applied current strength was greater than 5 microampere and polarity was scion negative. At reaching about 20 microampere of applied current strength, the success rate stabilizes and there is no further increase in graft success rate. The growth rate of the grafts in the scion negative condition was faster than the growth without applying any current across the graft interface.

The graft incompatibility affects the plant growth and includes many complications in its remedy due to the diversity of its causes. The present study may provide a pathway to overcome the problems arising due to graft incompatibility in the area of Agriculture and Biotechnology.

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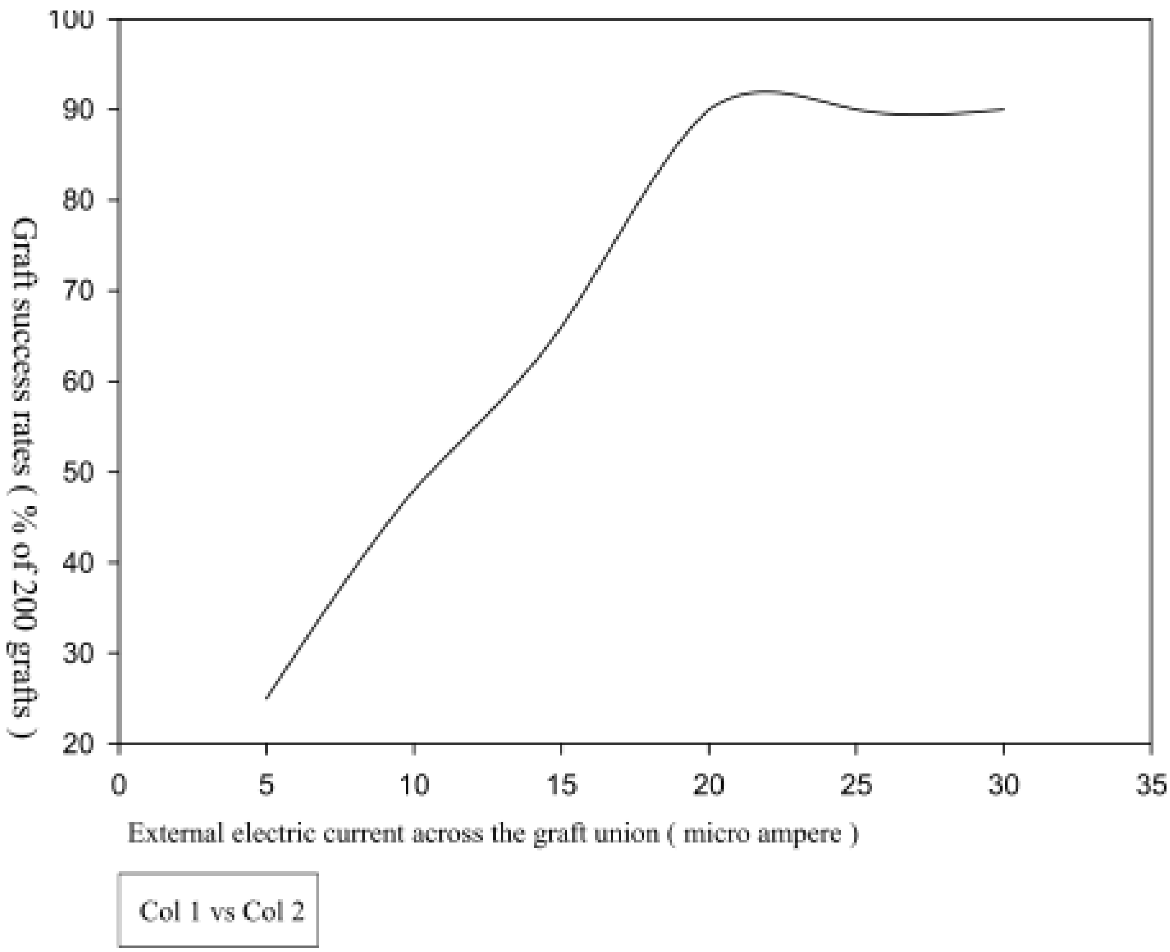

Figure 2: Graft success rate vs External electric current Curve

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