EVAPOTRANSPIRATION RATE AND GRAFT-TAKING OF GRAFTED SEEDLINGS UNDER ARTIFICIAL LIGHTING

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ABSTRACT

This paper represents the characteristics of evapotranspiration rate (EVTR) and graft-taking of watermelon grafted seedlings in a graft-taking enhancement system using fluorescent lamps as artificial lighting source. Four air temperature levels of 23, 25, 27 and 29C, three humidity levels of 85, 90 and 95%R.H. and two photosynthetic photon flux (PPF) levels of 30 and 50 μmol m^{-2} s^{-1} were provided to investigate the effects of air temperature, relative humidity and light intensity on EVTR and graft-taking of grafted seedlings. EVTR of grafted seedlings increased with increasing air temperature and the passage of time after grafting. Also EVTR increased with decreasing relative humidity. As relative humidity decreased and air temperature increased, vapor pressure deficit increased and thus EVTR increased. It is required to maintain a low level vapor pressure deficit for suppressing EVTR of grafted seedlings during first 1-2 days after grafting. Therefore, less EVTR at initial stage after grafting would be adequate for smooth joining of the scion and rootstock.

Key Word : Artificial Lighting Source, Evapotranspiration Rate, Grafted Seedlings, Graft-taking, Vapor Pressure Deficit

INTRODUCTION

The production area of fruit-bearing vegetables using grafted seedlings has increased in Korea. Grafting of fruit-bearing vegetables has been widely used to increase the resistance to soil-borne diseases, to increase the tolerance to low temperature or to soil salinity, to increase the plant vigor, and to extend the duration of economic harvest time. However, grafting requires time, space and materials. Also a high expertise is required for grafting, healing and acclimation (Oda, 1995).

After grafting, it is important to control the environments around grafted seedlings for the robust joining of a scion and rootstock. Usually the shading materials and plastic film are used to keep the high relative humidity and low light intensity around grafted seedlings in greenhouse or tunnel. It is quite difficult to optimally control the environment for healing and acclimation of grafted seedlings under natural light. Therefore the farmers or managers rely on their experience for the production of grafted seedlings with high quality.

If artificial light is used as a lighting source for graft-taking of grafted seedlings, the light intensity and photoperiod can be easily controlled. Although Nobuoka et al. (1996, 1997) have studied the suitable conditions for healing of graft unions on tomato scions in a growth chamber, there was no report for the graft-taking enhancement of whole grafted seedlings under artificial lighting. Recently Kim and Park(2000a, 2000b) developed the measurement system of evapotranspiration rate (EVTR) of grafted seedlings under artificial lighting and reported the effect of air temperature and relative humidity on EVTR of grafted seedlings.

The purpose of this study was to analyze the characteristics of EVTR and graft-taking of watermelon grafted seedlings under artificial lighting.

MATERIALS AND METHODS

Grafting and graft-taking

Watermelons having green rind with stripe and round shape (*Citrullus vulgaris* cv. Sweetdew, Hungnong Seed Co.) and bottle gourd (*Lagenaria siceraria* cv. FR-King, Hungnong Seed Co.) were raised on plug tray of 50 cells. The mixture of sphagnum peat moss and perlite (80:20, v/v) was used as medium.

One cotyledon and the apical meristem of rootstock was removed and a hole about 2mm in diameter was made at the top of the rootstock hypocotyl with a stick. The hypocotyl of scion was slantly cut at 45°. The cut hypocotyl of scion was then inserted into th hole of rootstock. Grafted seedlings were healed and joined for 5 days under cool-white fluorescent lamps (FL20SEX-d/18, Keumho Electric Co.) with photoperiod of 12 d h^{-1} except dark period for one day after grafting in a closed graft-taking enhancement system developed by Kim(2000).

Measurement and calculation for EVTR of grafted seedlings

EVTR was calculated as follows from data for the weight change of grafted seedlings, plug tray, and medium measured by a load cell (MLP-25, Transducer Techniques) shown in Fig. 1.

$$E = \Delta W/S \tag{1}$$

where E is EVTR of grafted seedlings($gH_2O\ m^{-2}\ h^{-1}$), ΔW is the change of weight($gH_2O\ h^{-1}$), and S is the surface area of plug tray(m^2).

Load cell with aluminum plate was in a wind tunnel developed by Kim et al.(1996). The output from a load cell was recorded by a data logger (CR23X, Campbell Scientific

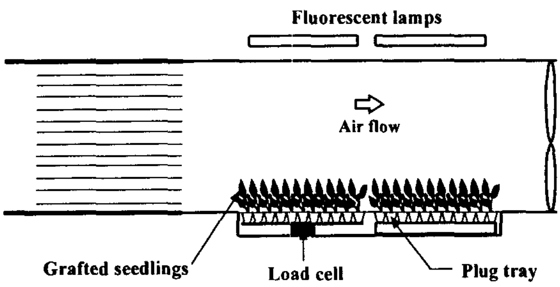

Fig. 1. Measurement system of evapotranspiration rate of grafted seedlings using a wind tunnel under artificial lighting.

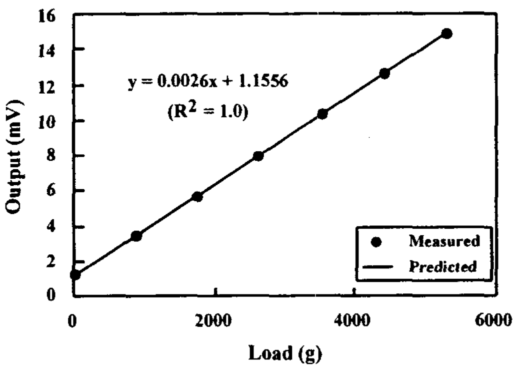

Fig. 2. Regressional relation between load and the output from load cell.

Co.) at an interval of 1 hour. Fig. 2 represents the regressional relationship between load and output from load cell used in this experiment. Load cell has a good linearity at loading or unloading.

Air temperatures were measured with copper-constantan thermocouples (ϕ 0.3 mm) at the inlet and outlet of a wind tunnel. At the same point, humidity sensors (BEAM 2000N, Japan Beam Electronics Co., Ltd.) were used for the measurement of relative humidity at the same points..

Four air temperature levels of 23, 25, 27 and 29C, three humidity levels of 85, 90 and 95%R.H. and two photosynthetic photon flux (PPF) levels of 30 and 50 μmol m^{-2} s^{-1} were provided to investigate the effects of air temperature, relative humidity and light intensity on EVTR of watermelon grafted seedlings. Table 1 represents the experimental treatments. Air current speed around the grafted seedlings was controlled to 0.1 m s^{-1} in all treatments.

RESULTS AND DISCUSSION

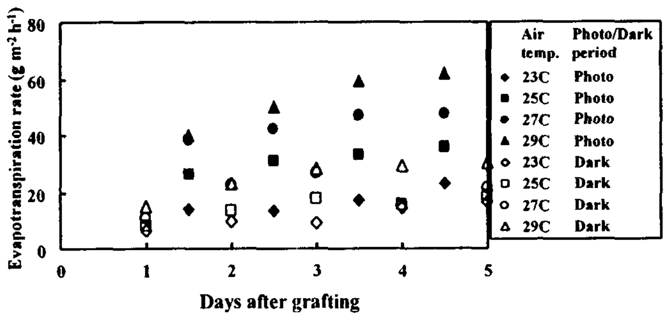

Fig. 3. Evapotranspiration rate of grafted seedlings affected by air temperature at the relative humidity of 95% and PPF of 30 μmol $m^{-2}s^{-1}$.

Effect of air temperature on EVTR

Effect of air temperature on the EVTR of grafted seedlings at relative humidity of 95%, PPF of 30 μmol m^{-2} s^{-1}, and air current speed of 0.1 m s^{-1} was shown in Fig. 3.

Table 1. Description of experimental treatments.

Treatments	Air temperature (C)	Relative humidity (%)	Vapor pressure Deficit (kPa)
L*(H)11	23	85	0.42
L(H**)12	23	90	0.28
L(H)13	23	95	0.14
L(H)21	25	85	0.48
L(H)22	25	90	0.32
L(H)23	25	95	0.16
L(H)31	27	85	0.54
L(H)32	27	90	0.36
L(H)33	27	95	0.18
L(H)41	29	85	0.60
L(H)42	29	90	0.40
L(H)43	29	95	0.20

* L stands for lower photosynthetic photon flux (30 μmol m^{-2} s^{-1})

** H stands for higher photosynthetic photon flux (50 μmol m^{-2} s^{-1})

At photoperiod, EVTR of grafted seedlings increased with increasing air temperature and the passage of time after grafting. EVTR of grafted seedlings at dark period, which increased slightly, reduced by half of those at photoperiod. The variation for EVTR of grafted seedlings at PPF of 50 μmol m^{-2} s^{-1} as shown in Fig. 4 was similar to those at PPF of 30 μmol m^{-2} s^{-1}. Although PPF had no effect on the tendency of variation in EVTR at relative humidity of 95%, PPF seemed to affect absolute value of EVTR.

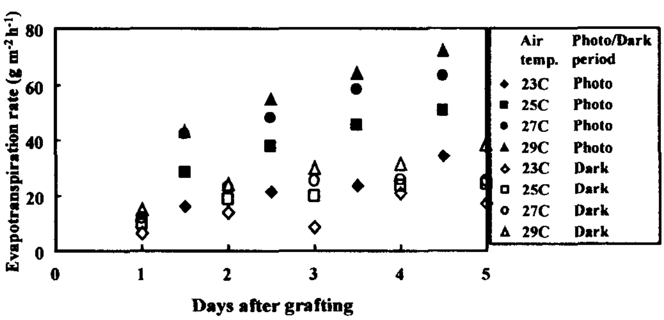

Fig. 4. Evapotranspiration rate of grafted seedlings affected by air temperature at the relative humidity of 95% and PPF of 50 μmol m^{-2} s^{-1}.

Effect of relative humidity on EVTR

Fig. 5 represents the effect of relative humidity on EVTR of grafted seedlings at air temperature of 27C, PPF of 30 μmol m^{-2} s^{-1}, and air current speed of 0.1 m s^{-1}. At relative humidity of 85%, EVTR of grafted seedlings during first 1-2 days after grafting rapidly

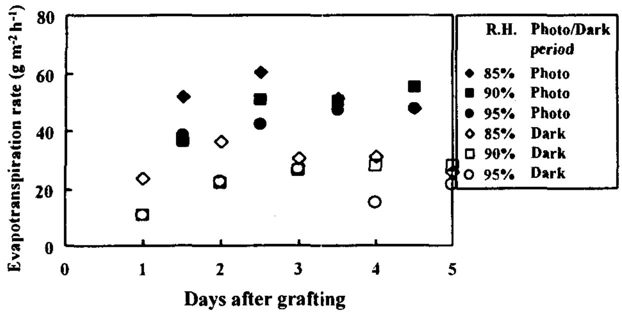

Fig. 5. Evapotranspiration rate of grafted seedlings affected by relative humidity at the air temperature of 27C and PPF of 30 μmol m^{-2} s^{-1}.

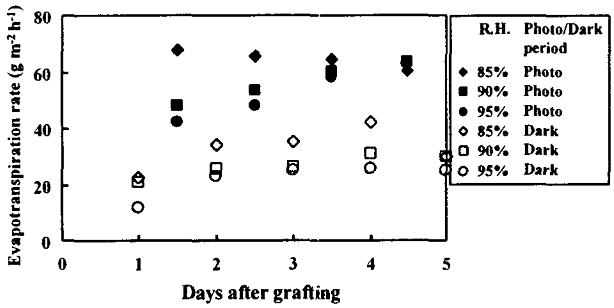

Fig. 6. Evapotranspiration rate of grafted seedlings affected by relative humidity at the air temperature of 27C and PPF of 50 μmol m^{-2} s^{-1}.

increased. But EVTR when 3 days after grafting elapsed decreased. Thus wilting was observed in some grafted seedlings grafted-taken at relative humidity of 85%. EVTR of grafted seedlings continually increased at relative humidity higher than 90%. Difference in EVTR between at relative humidity of 90% and at relative humidity of 95% was slightly observed.

Effect of relative humidity on the EVTR of grafted seedlings was distinctly shown at relatively high PPF. As shown in Fig. 6, EVTR of grafted seedlings at PPF of 50 μmol m^{-2} s^{-1} was highly observed during first 1-2 days.

EVTR increased with decreasing relative humidity. As relative humidity decreased and air temperature increased, vapor pressure deficit increased as shown Table 1. Therefore it is required to maintain a low level vapor pressure deficit for suppressing EVTR of grafted seedlings during first 1-2 days after grafting.

Graft-taking of grafted seedlings

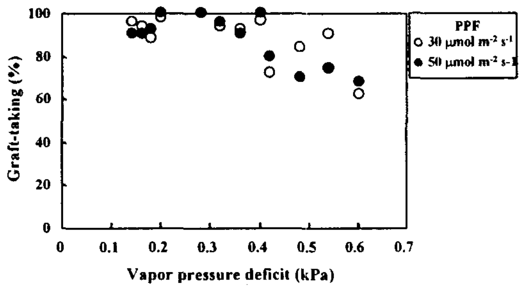

Fig. 7. Graft-taking affected by vapor pressure deficit and photosynthetic photon flux.

The graft-taking of grafted seedlings was defined as the percentage of number of surviving seedlings to the number of grafted seedlings at different treatment. Effect of vapor pressure deficit on the graft-taking of grafted seedlings was shown in Fig. 7. As the vapor pressure deficit decreased, the graft-taking of grafted seedlings increased. Graft-taking higher than 90% was observed at the vapor pressure deficit less than 0.4kPa.

Fig. 8 and Fig. 9 represent the graft-taking of grafted seedlings according to different treatment at PPF of 30 and 50 μmol m^{-2} s^{-1}. Graft-taking higher than 90% was observed at the high humidity of 90 and 95%. In these treatments, EVTR was relatively low during first 1-2 days after grafting and then gradually increased with days after grafting. Thus the scion and rootstock were also smoothly joined together. Grafted seedlings graft-taken under artificial light should move into a greenhouse under natural light for acclimation. Light intensity is very high and relative humidity is moderate under natural light

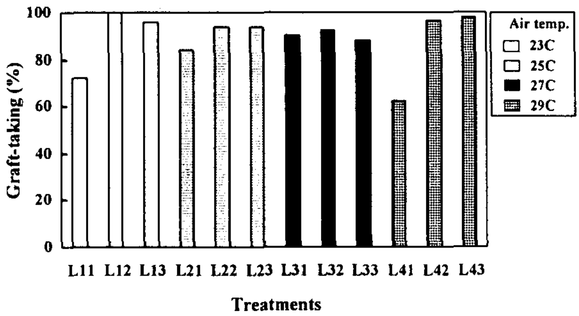

Fig. 8. Graft-taking of grafted seedlings by the different treatments at PPF of 30 μmol m^{-2} s^{-1}.

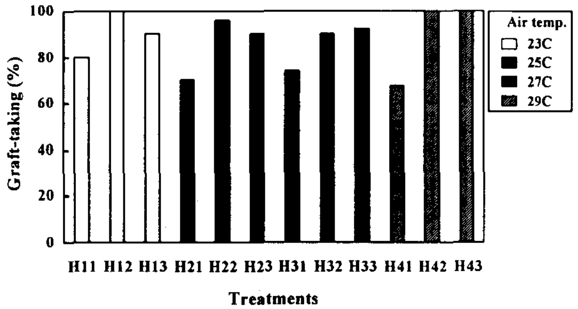

Fig. 9. Graft-taking of grafted seedlings by the different treatments at PPF of 50 μmol m^{-2} s^{-1}.

From the above results, it is required to control optimally the environment for decreasing the vapor pressure deficit and preventing the wilting of grafted seedlings under artificial lighting during first 2-3 days after grafting. And then it is suggested to lower the relative humidity and raise the PPF by steps for the robust joining of grafted seedlings.

CONCLUSIONS

When grafting is performed, it is important to increase the chance for vascular bundles of the scion and rootstock to come into contact and not to dry the spliced cut surfaces. It is needed to keep the environment for suppressing EVTR from grafted seedlings and thus for promoting the survival of grafted seedlings. Four air temperature levels of 23, 25, 27 and 29C, three humidity levels of 85, 90 and 95%R.H. and two photosynthetic photon flux levels of 30 and 50 μmol m^{-2} s^{-1} were provided to analyze the characteristics of EVTR and graft-taking of watermelon grafted seedlings in a graft-taking enhancement system using fluorescent lamps as artificial lighting source. EVTR of grafted seedlings increased with increasing air temperature and the passage of time after grafting. Also EVTR increased with decreasing relative humidity. EVTR of grafted seedlings at dark period reduced by half of those at photoperiod. Effect of relative humidity on the EVTR of grafted seedlings was distinctly shown at relatively high PPF. As the vapor pressure deficit decreased, the graft-taking of grafted seedlings increased. Under the high humidity more than 90%, EVTR was gradually increased with days after grafting and thus the scion and rootstock were also smoothly joined together. It is required to control optimally the physical environment for decreasing the vapor pressure deficit and preventing the wilting of grafted seedlings under artificial lighting during first 2-3 days after grafting. And then it is suggested to lower the relative humidity and raise the PPF by steps for the robust joining of grafted seedlings.

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