Effects of the Character of Cuttings and the Type of Auxin on Rooting Ability in Dragon Fruit©

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INTRODUCTION

Dragon fruit (*Hylocereus undatus* Britt & Rose), also called pitaya of pitahaya, is a climbing cactus native to the tropical forest regions in Mexico and Central and South America (Mizrahi et al., 1997). Dragon fruit has been cultivated in Vietnam and currently in some countries such as Nicaragua, Columbia, and Israel (Merten, 2003).

In Japan dragon fruit has been cultivated mostly in Okinawa. In 2009 the growing area and amount shipped were 46 ha and 335 t, respectively (Ministry of Agriculture, Forestry and Fisheries, 2011). Dragon fruit can be grown without heating in warm regions; therefore the cultivation has been increasing recently in areas north of Okinawa.

Cutting propagation is the most common method for dragon fruit propagation. Special equipment such as mist for promotion of rooting is not required because *H. undatus* is easy to root. But the character such as age and fresh weight of cuttings is considered to affect rooting. Dragon fruit cuttings root well without auxin treatment, however, rooting is promoted by IBA treatment (Elobeidy, 2006). The effect of the auxin type on rooting is not well known. The objective of the present study was to identify suitable conditions for rooting cutting of dragon fruit.

MATERIALS AND METHODS

This study was conducted from 2006 to 2008, using cuttings collected from 4- to 6-year-old plants cultivated in a greenhouse at the experimental farm of Kinki University.

Cutting propagation was basically conducted in the following way. Herbaceous stems (cuttings) were cut to a predetermined length, sprayed with solution of 500 ppm benomyl, and 150 ppm streptomycin, and placed in a shaded, well-ventilated place for 2 days for healing of the cut end. Then they were inserted to a depth of 4 cm in polyethylene pots (10.5 cm in diameter × 9.0 cm in height) filled with a soil mixture [mountain sand, peat moss, and vermiculite; (2 : 1 : 1, by vol.)], placed in a 50% shaded greenhouse, and irrigated daily with tap water. Auxin treatment was not carried out, except for Experiment 5.

Measurement of rooting of cuttings was performed after 60 days. Cuttings with root growth more than 2 mm were regarded as rooted. Rooting percentage was calculated by dividing the total number of cuttings with the number of rooted cuttings. Cuttings were removed from the pots and washed thoroughly with tap water before root fresh weight was measured.

In Experiments 1 and 2, six cuttings similar to those used in the experiments were prepared, and initial fresh and dry weights were measured to determine initial dry matter percentages. In all experiments, 20 cuttings were used for each

treatment, and three replicates were performed in Experiments 4 and 5. Data on rooting percentage, root fresh weight, and root dry matter percentage were analyzed for significant differences by Tukey-Kramer's multiple range test.

Experiment 1. Effects of the Herbaceous Stem Part on Rooting Ability.

1) *Mature Herbaceous Stems.* One-year-old herbaceous stems (1 year after stopping of stem elongation) of 30-40 cm length was collected and cut into three parts (upper, middle, and basal) each 10–12 cm in length. Cutting preparation was performed in 2 May 2006, and the measurement of rooting was performed in 1 July 2006.
2) *Immature Herbaceous Stem.* Immature herbaceous stem (collected 1–2 months after stopping of stem elongation) of 30–40 cm length was collected, and cut into three parts as previously described. Cutting preparation was performed in 19 June 2006, and the measurement of rooting was performed in 21 Aug. 2006.

Experiment 2. Effects of the Age of Herbaceous Stem on Rooting Ability. Immature, 1-year-old and 2-year-old stems were collected, and cut into 12 cm length. Cutting preparation was performed in 19 April 2007 and the measurement of rooting was performed in 19 June 2007.

Experiment 3. Effects of Flesh Weight of Cuttings on Rooting Ability. One-year-old herbaceous stems of different thickness were collected and cut into 12-cm lengths. After measurement of fresh weight, they were divided into three fresh weight groups: 30–50, 51–70 and 71–90 g. The number of cuttings per group was 22, 23, and 35, respectively. Cutting preparation was performed in 19 April 2007, and the measurement of rooting was performed in 19 June 2007.

Experiment 4. Effects of Length of Cuttings on Rooting Ability. One-year-old herbaceous stems were collected and cut into 8, 12, and 16 cm lengths. Cutting preparation was performed in 30 May 2007, and the measurement of rooting was performed in 4 Aug. 2007.

Experiment 5. Effects of Auxin Type on Rooting Ability. One-year-old herbaceous stem cuttings were collected, cut into 12 cm lengths, and the cutting bases dipped for 10 sec in 2,000 ppm solutions (50% ethanol) of either α-naphthaleneacetic acid (NAA) or indole-3-butyric acid (IBA). The base of each cuttings was then left to dry naturally. The cuttings treated with NAA or IBA were compared with the control not treated with auxin. Cutting treatment was performed in 29 May 2008, and the measurement of rooting was performed in 30 July 2008.

RESULTS

Experiment 1. Effects of the Herbaceous Stem Part on Rooting Ability.

1) *Mature Herbaceous Stem.* Rooting percentage of the basal segment tended to be higher than those of the upper and the middle segments, and root fresh weight of the basal segment was higher than those of the upper and middle segments (Table 1). Dry matter percentage of each segment was not significantly different.

Table 1. Effects of the part of herbaceous mature stem on rooting ability in dragon fruit.

Position	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Upper	75	1.56 b[z]	11.8 a
Middle	85	1.76 b	12.2 a
Base	100	2.25 a	13.1 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

2) *Immature Herbaceous Stem.* Rooting percentage tended to be the highest in the basal segment, followed by the middle, and the lowest in the upper segment. Root fresh weight of the basal segment was higher than that of the upper part (Table 2). Dry matter percentage of the basal segment was higher than those of the middle and upper segments.

Table 2. Effects of the part of herbaceous immature stem on rooting ability in dragon fruit.

Position	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Upper	50	1.02 b[z]	7.1 b
Middle	55	1.48 ab	8.3 b
Base	100	2.34 a	10.7 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 2. Effects of Herbaceous Stem Age on Rooting Ability. Rooting percentages of the 1-year-old and the 2-year-old herbaceous stem cuttings tended to be higher than that of the immature stems (Table 3). Root fresh weights and dry matter percentages of the 1-year-old and 2-year-old herbaceous stems were higher than that of the immature ones.

Table 3. Effects of the age of herbaceous stem on rooting ability in dragon fruit.

Age	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Immature	25	1.42 b[z]	10.9 b
One-year-old	95	2.76 a	14.6 a
Two-year-old	95	2.59 a	15.6 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 3. Effects of Fresh Weight of Cuttings on Rooting Ability. Rooting percentage tended to increase with increase in the fresh weight of cuttings, and similarly root fresh weight increased with increase in the fresh weight of cutting (Table 4).

Table 4. Effects of fresh weight of cuttings on rooting ability in dragon fruit.

Fresh weight (g)	Rooting (%)	Root fresh weight (g)
30–50	81.8	1.34 b[z]
51–70	91.3	2.06 ab
71–90	100.0	2.89 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 4. Effects of Length of Cuttings on Rooting Ability. Rooting percentages of the cuttings of 12 and 16 cm lengths were higher than that of 8 cm length, and root fresh weight increased with increase in length of cuttings (Table 5).

Table 5. Effects of length of cuttings on rooting ability in dragon fruit.

Length (cm)	Rooting (%)	Root fresh weight (g)
8	53.3 b[z]	1.12 b
12	81.7 a	1.48 ab
16	83.3 a	2.73 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 5. Effects of Auxin Type on Rooting Ability. Rooting percentages of the cuttings treated with NAA or IBA were higher than that of the control not treated with auxin, and root fresh weight of the cuttings treated with NAA was higher than that treated with IBA and the control not treated with auxin (Table 6).

Table 6. Effects of the type of auxin on rooting ability in dragon fruit.

Type	Rooting (%)	Root fresh weight (g)
NAA	98.3 a[z]	5.43 a
IBA	91.7 a	3.04 b
Non-treated	78.3 b	2.28 b

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

DISCUSSION

The results of this study indicated that the rooting of cuttings increased by using herbaceous cutting material with solid stems. Rooting percentage and root fresh weigh were higher in cuttings of 71–90 g fresh weigh with 12 cm length than those with lower weight. This corresponds to 6.0–7.5 g per cm of cutting length. In addition, it was considered necessary to require more than 11% dry matter percentage for higher rooting.

Fresh weight and dry matter percentage of the mature herbaceous stem cuttings were higher than that of the immature one. Therefore, rooting of 1- to 2-year-old mature stem cuttings was higher than that of immature cuttings and so are more suitable as materials for cuttings.

With respect to the length of the cuttings, the shorter the length, the higher the reproductive efficiency. Elobeidy (2006) reported that rooting of cuttings of 5, 15, and 25 cm long were tested and 25-cm cuttings rooted successfully, and there was a significant effect of cutting size on rooting. In this study cutting of 8-cm length had low rooting percentage, therefore it was thought that cuttings more than 12 cm long were necessary for effective rooting.

The hormone IBA is an effective growth regulator in promoting rooting (Hartmann et al., 2002). Dragon fruit roots well without auxin treatment because of its high rooting ability, but better and more uniform rooting is promoted by IBA treatment (Elobeidy, 2006). In this study, rooting percentage was increased by treatment with NAA or IBA, but root fresh weight was remarkably increased by treatment with NAA. The NAA may have the effect of speeding up the rooting of cuttings in dragon fruit.

In conclusion, cuttings with high fresh weight per cm or dry matter percentage are suitable for making cuttings, and NAA is more effective in promoting the rooting than IBA in dragon fruit.

SUMMARY

Rooting of the basal segments in both mature and immature herbaceous stems were superior to those of the upper or the middle segments. Rooting of 1- and 2-year-old herbaceous stems tended to be higher than that of the immature ones. Rooting tended to increase with increase in the flesh weight of the cuttings. It was thought that cuttings more than 12 cm in length were necessary for effective rooting. Rooting percentage was increased by treatment with NAA or IBA, but root fresh weight was remarkably increased by treatment with NAA.

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