Effects of Plant Growth Regulators on the Vegetative Growth of Pitaya Cladodes©

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INTRODUCTION

Pitaya (*Hylocereus undatus* Britt & Rose) is a climbing cactus that is cultivated across a range of countries, including Vietnam and Nicaragua (Merten, 2003). In the Japanese archipelago, pitaya cultivation has been largely concentrated in the subtropical landscape of Okinawa Prefecture. However, many forms grown in the domestic warm region are cold tolerant and do not require greenhouse heating to prevent frost damage. Fumuro et al. (2007) and Fumuro and Sakurai (2013) reported that pitaya cultivation was possible on the Kinki University experiment farm located in Yuasa-cho, Wakayama Prefecture where daily minimum temperatures fell to about -4°C on four or five occasions during winter.

Pitaya forms flower buds on the cladodes (flattened leaf-like stems) when plants stop growing, but not during the period of elongation. Cladodes grow vigorously when young; if their growth is suppressed, flowering and yield increase incrementally. However, the cladode elongation rate declines during aging and yields are reduced in consequence.

Cultivated tree vigor is frequently controlled by application of plant growth regulators. Paclobutrazol, daminozide, and other agents are used as dwarfing agents, while gibberellin and other bioactive molecules are applied to promote growth. Little is known of the effects of these regulators on the vegetative growth of pitaya. Consequently, this study was conducted to measure the effects of growth regulators on pitaya cladode growth either through spraying plants or by application to the soil medium.

MATERIALS AND METHODS

Experiments were performed in 2006 and 2007 using rooted cuttings growing in pots (13.5 cm in diameter, 11 cm in height) held in a greenhouse located on the Kinki University experimental farm. The cladode cuttings were collected from 4- and 5-year-old plants growing in a greenhouse. Each cutting was trimmed to a 12-cm length, sprayed with a solution of 500 ppm benomyl and 150 ppm streptomycin, and placed in a shaded, well-ventilated location for 48 h to allow healing of the wound. The bases of cuttings were dipped into a 2000 ppm solution of NAA (1-naphtaleneacetic acid; Wako Pure Chemical Industries, Osaka, Japan) for 10 s to promote rooting. Each cutting was planted to a depth of 4 cm in a polyethylene pot (10.5 cm in diameter, 9.0 cm in height) filled with a soil mixture (2 mountain sand, 1 peat moss, and 1 vermiculite (by volume) and held them in a greenhouse under 50% light shading. The plants were watered once a day and applied 150 ml of liquid fertilizer ($N:P_2O_5:K$ in concentrations of 120:200:100 ppm) to each cutting once per month.

Experiment 1. The Effects of Gibberellin Solution Spraying on Cladode Growth

Cladode plants were used 3 months after initial potting when growth had begun. Ten plants were sprayed with a 10 ppm gibberellin (GA) solution (Gibberellin, Kyowa-Funmatsu, Kyowa-Hakko-Bio, Tokyo, Japan) three times (1 Sept., 10 Sept., and 20 Sept.). Ten untreated plants were used as controls.

The lengths of new cladodes were measured each month, and recorded their weights on 14 Feb.

Experiment 2. The Effects of Ethephon and Paclobutrazol Solution Spraying on Cladode Growth

Rooted cuttings with new elongating cladodes were used 2 months after the initial potting. New cladodes were hand sprayed twice with 500 or 1000 ppm solutions of ethephon (Nissan-Esureru 10; Nissan Chemical Industries, Tokyo, Japan) combined with 1000 or

2000 ppm solutions of paclobutrazol (Bonzai-Furoaburu, Syngenta Japan, Tokyo, Japan) on 23 July and 23 Aug. 15 replicate plants were used in the treatments and controls.

The lengths of new and old cladodes were measured on 10 Nov. and then separated them into new cladodes, old cladodes, and roots; then their fresh weights were measured before drying to constant dry weight in an oven at 75 °C. The weights were measured after drying. The summed lengths and weights of new cladodes produced by each plant were obtained.

Experiment 3. The Effect on Cladode Growth of a Natural-Type Abscisic Acid (ABA) Applied to the Soil

Rooted cuttings with no new cladodes were used 2 months after the initial potting. An 120 ml solution of 1, 10, or 100 ppm of the natural-type (S)-(+)-abscisic acid (Miyobi; Baru-Kikaku, Ichinomiya, Japan) were applied to the soil in each pot on five occasions (23 July, 7 Aug., 1 Sept., 3 Oct., and 6 Nov.). Untreated controls were also established. Controls and treatments were replicated 15 fold. The numbers and lengths of new cladodes were measured each month.

Experiment 4. The Effect on Cladode Growth of CPPU, BA, NAA, and Daminozide Applied to the Soil

Rooted cuttings with elongating new cladodes were used 6 months after the initial potting. An 120-ml solution containing 2 ppm CPPU [N-(2-Chloro-4-pyridyl) -N-phenylurea] (Fulmet; Kyowa-Hakko-Bio, Tokyo, Japan), 200 ppm BA (6-benzylaminopurine; Wako Pure Chemical Industries, Osaka, Japan), and 200 ppm NAA, or 500 ppm daminozide (Bi-Nain-Suiyozai 80; Nisso Green, Tokyo, Japan) were applied to the soil of each pot on five occasions (28 April, 28 May, 28 June, 30 July and 28 Aug.). Untreated controls were also established. Controls and treatments were replicated 12-fold.

All response variables (variables were identical to those in Expt. 2) were measured on 25 Nov.

RESULTS AND DISCUSSION

Experiment 1. The Effects of Gibberellin Solution Spraying on Cladode Growth

Gibberellin is registered as an agricultural chemical that maintains vigor in satsuma mandarin and other fruit trees, and promotes growth in some vegetables (Food and Agricultural Materials Inspection Center, Japan. 2014). Gibberellin spraying promoted elongation of new cladodes (Fig. 1), but did not influence their fresh weights (Fig. 2), suggesting that the treatment did not affect the thickening of cladode.

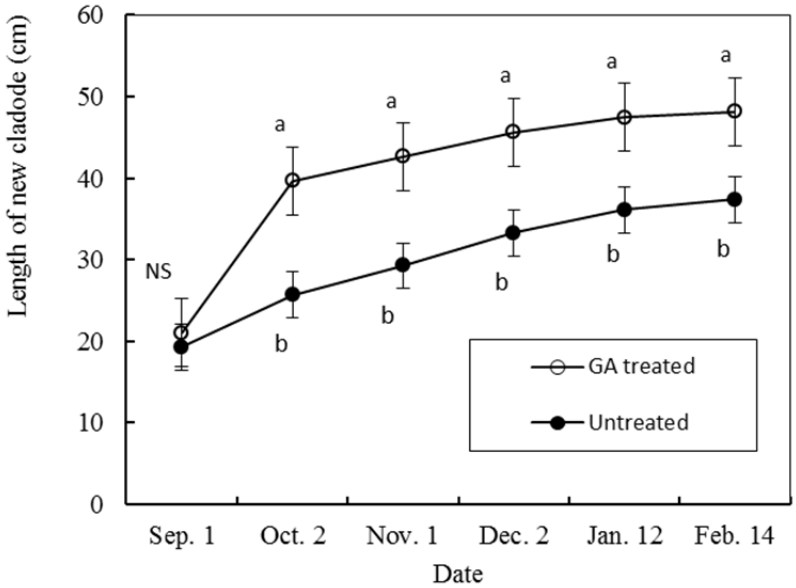

Fig. 1. The effect of spraying with gibberellin solution on the elongation of new cladodes. Vertical bars represent ± SE. Values followed by same letter and NS are not significantly different ($P<0.05$; *t*-test).

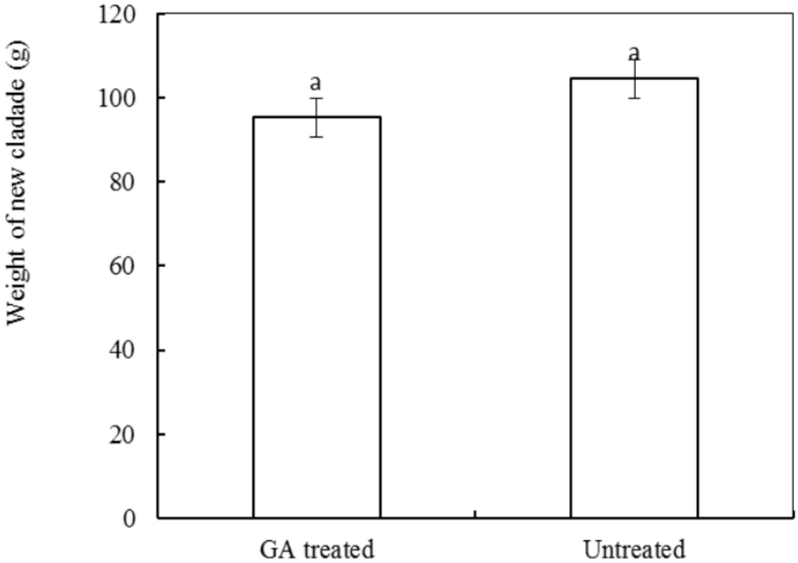

Fig. 2. The effect of spraying with gibberellin solution on the fresh weights of new cladodes. Vertical bars represent ± SE. Values followed by the same letter is not significantly different ($P<0.05$; *t*-test).

Experiment 2. The Effects of Ethephon and Paclobutrazol Solution Spraying on Cladode Growth

The lengths of new cladodes and the fresh and dry weights of new cladodes and roots were reduced in ethephon-treated plants in comparison with controls (Fig. 3, Table 1). No spray concentration effects were detected. Paclobutrazol had no significant effects on any of the response variables.

Ethephon is registered as an agricultural chemical that inhibits internode elongation in barley and wheat, and prevents excessive flower and berry abscission in 'Kyoho' grapes through inhibition of shoot elongation. Pacrobutrazol is registered as a chemical that inhibits shoot elongation in fruit trees, such as peach. Although expected effects of ethephon in our experiment were observed, this was not the case for pacrobutrazol. This disparity should be examined in future trials.

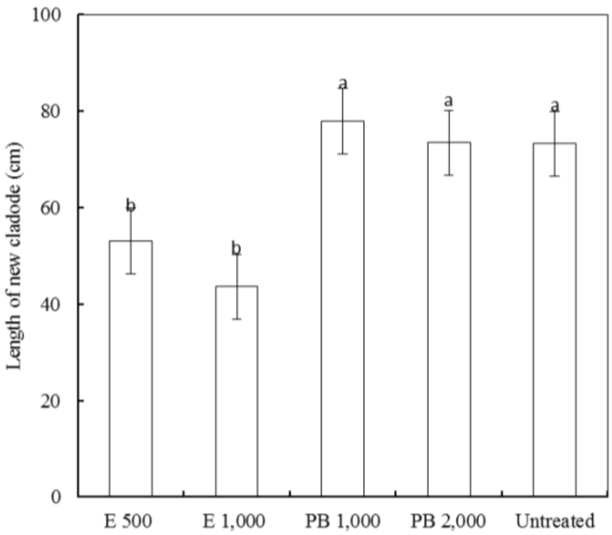

Fig. 3. The effect of spraying with ethephon and paclobutrazol solution on the elongation of new cladodes. Vertical bars represent ± SE. Values followed by the same letter are not significantly different (*P*<0.05; Tukey-Kramer multiple range test).

Table 1. The effect of spraying new cladodes with ethephon and paclobutrazol solution on the lengths of new cladodes.

	Flesh weight (g)				Dry weight (g)			
	Old cladode	New cladode	Root	Total	Old cladode	New cladode	Root	Total
E 500	51.7 a[z]	88.2 b	3.0 b	142.9 b	5.7 a	8.8 bc	0.6 b	15.1 b
E 1000	64.1 a	77.5 b	2.9 b	144.5 b	7.0 a	7.0 c	0.6 b	14.6 b
PB 1000	62.8 a	122.1 a	4.0 a	188.9 a	6.4 a	12.2 a	0.8 a	19.4 a
PB 2000	50.8 a	111.9 a	3.7 ab	166.4 ab	5.5 a	10.4 ab	0.8 a	16.7 ab
Untreated	62.9 a	121.5 a	4.2 a	188.6 a	7.0 a	12.0 a	0.9 a	19.9 a

[z]Values followed by same letter indicate not significantly differ (*P*<0.05) according to the Tukey-Kramer's multiple range test.

Experiment 3. The Effect on Cladode Growth of a Natural Type Abscisic Acid (ABA) Applied to the Soil

The effect of ABA on cladode growth in pitaya was examined because this phytohormone promotes rooting of strawberry runners (Saito et al., 2008). ABA did not affect the elongation of new cladodes (data not shown), but the higher the concentration of ABA the sprouting rate of new cladodes tended to reduce 1 month after the first soil application (Fig. 4). New cladode sprouting occurred on all plants with or without treatment 2 months after of the first soil application.

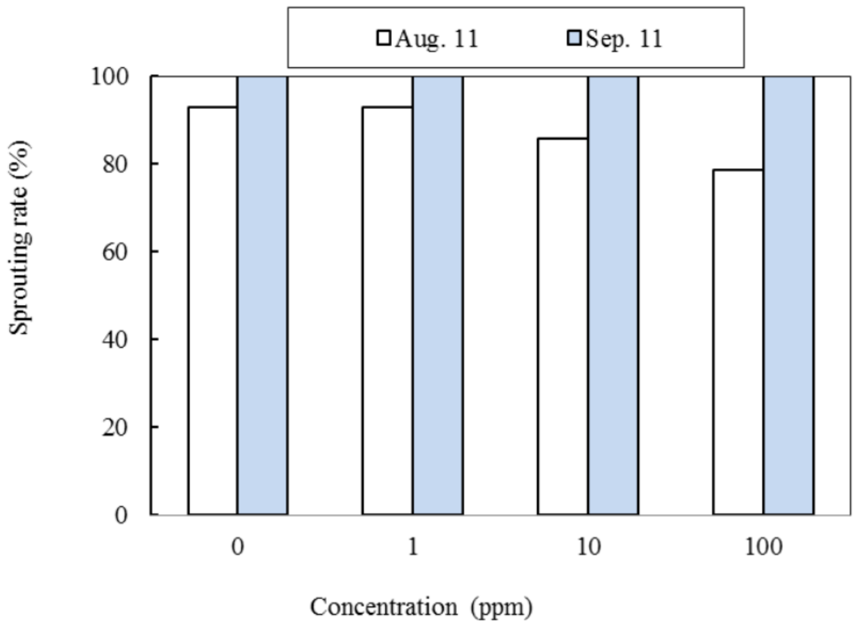

Fig. 4. The effect of treatment of soil with abscisic acid on cladode sprouting growth.

Experiment 4. The Effect on Cladode Growth of CPPU, BA, NAA, and Daminozide Applied to the Soil

The application of NAA to the soil reduced the lengths and fresh and dry weights of new cladodes (Fig. 5, Table 2). Effects on roots were not clear. CPPU, BA, and daminozide applications to the soil did not affect cladode growth.

NAA is one of the plant growth regulators with auxin-like activity; it also functions as a fruit-thinning agent for satsuma mandarin and other fruit trees. It is registered as an elongation inhibitor of summer and autumn shoots. Our experimental results were consistant with these general effects.

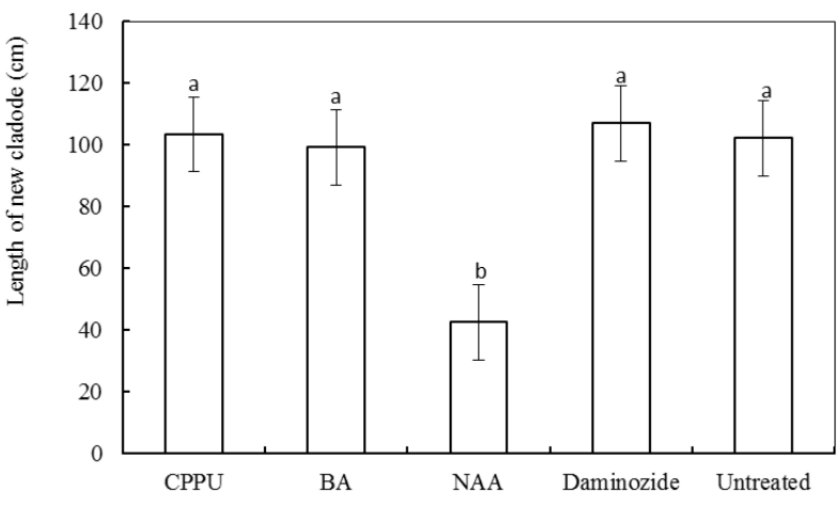

Fig. 5. The effect of treatment of soil with CPPU, BA, NAA and daminozide on the elongation of new cladodes. Vertical bars represent ± SE. Values followed by the same letter are not significantly different ($P<0.05$; Tukey-Kramer multiple range test).

Table 2. The effect of treating soil with CPPU, BA, NAA and daminozide on cladode growth.

	Flesh weight (g)				Dry weight (g)			
	Old cladode	New cladode	Root	Total	Old cladode	New cladode	Root	Total
CPPU	44.5 b[z]	228.6 a	18.2 a	291.3 b	8.2 a	34.3 a	3.7 a	46.2 a
BA	51.1 ab	260.8 a	16.5 a	328.4 ab	9.2 a	37.7 a	3.3 a	50.2 a
NAA	63.8 a	143.3 b	10.3 b	217.4 c	9.9 a	21.0 b	2.1 b	33.0 b
Daminozide	60.0 a	262.5 a	19.4 a	341.9 a	10.3 a	36.3 a	4.0 a	50.6 a
Untreated	49.9 ab	234.3 a	11.9 ab	296.1 ab	8.0 a	33.0 a	2.4 ab	43.4 a

[z]Values followed by same letter indicate not significantly differ ($P<0.05$) according to the Tukey-Kramer's multiple range test.

Abbreviations note: NAA = 1-naphtaleneacetic acid, BA = 6-benzylaminopurine, CPPU = N-(2-Chloro-4-pyridyl)-N-phenylurea.

Daminozide is registered as an internode elongation inhibitor for chrysanthemum and other species, but no effects were detected on pitaya.

Appropriate management of pitaya cultivation practices should reduce labor inputs and make the species better suited to general amateur gardeners who would be able to harvest year-round and enjoy the large, white, night-blooming flowers. Although cactuses are supplied in pots by retailers, it is not considered suitable for pot cultivation because of the excessive growth vigor of the cladodes in pitaya. However, soil application of NAA suppresses cladode growth and may facilitate the production and sale of potted plants.

CONCLUSION

Spraying cladode with ethephon and applying NAA to the soil inhibited cladode growth; conversely, gibberellin spraying of cladode promoted cladode growth. Other growth regulators tested had no observable effects.

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