

STUDY ON THE PROPAGATION OF *Actinidia latifolia* AND *Actinidia deliciosa* IN LAM DONG PROVINCE, VIETNAM

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Abstract

Actinidia latifolia and *Actinidia deliciosa* (kiwifruit) are two species with many applications in food and medicine. They are capable of growing and developing in Lam Dong province and similar temperate climates. This study assesses the effect of three plant growth regulators (NAA, IBA, and IAA) on the root formation of *Actinidia latifolia* cuttings. At the same time, seed germination and the effect of various soil and coir mixtures on the growth of kiwifruit seedlings were tested in the nursery. The results for the *Actinidia latifolia* cuttings after 60 days showed that NAA and IBA at 1.00% concentration gave the best results, with a rooting percentage of 76.67%, number of roots/cutting of 3.91, and length of roots/cutting of 5.65 cm for NAA. For IBA at 1.00% concentration, the rooting percentage was 66.67%, the number of roots/cutting was 2.43, and the length of roots/cutting was 4.42 cm. When using IAA, the concentration of 1.50% brought the best results, with a rooting percentage of 66.67%, number of roots/cutting of 2.81, and length of roots/cutting of 4.34 cm. The germination percentage of kiwifruit reached 81.00% after 25 days. The best growth of *Actinidia deliciosa* seedlings was in a media mixture of 25.00% soil and 75.00% coconut coir, with survival percentage, height of seedlings, and number of leaves/seedling of 96.00%, 5.02 cm, and 7.17 leaves, respectively, after 45 days.

Keywords: *Actinidia latifolia*; Germination; Kiwifruit; PGRs; Propagation; Rooting.

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1. INTRODUCTION

The *Actinidia* genus has 6-7 species in Vietnam (Huang, 2016; Phạm, 2000). *Actinidia latifolia* habitats are distributed across the country in Kon Tum, Lam Dong, Quang Ninh, and elsewhere (Phạm, 2000; Võ, 2012). The plants usually grow in ravines, open forests, and near streams. The fruit, stems, and roots of *Actinidia latifolia* are used to make medicine and treat many different diseases, such as urolithiasis, indigestion, rheumatism, high blood pressure, back pain, breast swelling, hemorrhoids, snake bites, and cancer. The plant is often used in traditional medicines (Võ, 2012). The fruit is edible and high in vitamin C and antioxidants (Du et al., 2009; Võ, 2012). *Actinidia latifolia* has a high potential for food applications such as jam, juice, or fruit wine.

Actinidia deliciosa (kiwifruit) is an imported fruit with many nutrients. It is rich in vitamins A, E, and C, fiber, potassium, copper, magnesium, manganese, and omega-3 fatty acids, and phytonutrients. It has many health benefits, such as fighting obesity, cancer, heart disease, preventing diabetes, and treating asthma in children. In particular, kiwifruit contains actinidin, a unique natural proteolytic enzyme that breaks down proteins and facilitates digestion (Richardson et al., 2018). Currently, kiwifruit is widely cultivated and has become a commercial, high-income crop globally. Areas with temperate climates such as Da Lat (Lam Dong province) and Sa Pa (Lao Cai province) of Vietnam have suitable conditions to grow this plant.

Kiwifruit cultivation has become popular in Vietnam and worldwide. Kiwifruit has been tested for propagation by various methods, including seeds, cuttings, and plant cell tissue culture (Duong et al., 2012; Celik et al., 2006; Üçler et al., 2004). Kiwifruit is an imported plant, so the initial research materials are effectively seeds. However, there have been no trials related to sowing, finding suitable substances for seedlings, or evaluating the adaptability of this potential crop in our country. Step-by-step experiments on kiwifruit propagation aim initially to assess its ability to germinate and adapt to the climatic conditions of Da Lat (Lam Dong province).

Actinidia latifolia propagation is still limited; there is no research related to sexual and asexual propagation of this plant worldwide and in Vietnam. *Actinidia latifolia* produces edible fruit. It is difficult to collect the fruit when ripe because it is often eaten by birds and small animals so that only the stems are suitable research materials. The propagation by cuttings of *Actinidia latifolia* aims to preserve and develop this non-wood forest product, and the cuttings can also be used as graft trees for imported kiwifruit varieties. Therefore, this study aims to assess the effect of three plant growth regulators, naphthyl acetic acid (NAA), indole-3-acetic acid (IAA), and indole-3 butyric acid (IBA), on the root formation of *Actinidia latifolia* cuttings. At the same time, seed germination and the effect of different soil and coir mixtures on the growth of kiwifruit seedlings were tested in the nursery.

2. MATERIALS AND METHODS

2.1. Materials

Zespri commercial green kiwifruit was used, and *Actinidia latifolia* was collected from natural forests near Da Lat, Lam Dong province.

2.2. Methods

2.2.1. Conditions

Experiments were conducted in a greenhouse in Da Lat, Lam Dong province. The average temperature ranged from 15 °C to 25 °C, and the average humidity in the greenhouse ranged from 80% to 90%. The water misting regime in the greenhouse was 5 seconds in duration at 30 minute intervals.

2.2.2. Experiment design

- Influence of NAA on root formation of *Actinidia latifolia* cuttings:

The experimental material was *Actinidia latifolia* semi-hardwood cuttings about 10-12 cm in length (Figure 1). NAA plant growth regulator was used in concentrations of 0.0%, 0.5%, 1.0%, 1.5%, and 2.0% w/w (denoted A1, A2, A3, A4, and A5, respectively). The experiment was performed on a sand tray in a greenhouse. Each treatment used 30 cuttings that were harvested after 60 days. The rooting percentage (%), number of roots/cutting, and length of roots/cutting (cm) were recorded.

- Influence of IAA on root formation of *Actinidia latifolia* cuttings:

The experimental material was *Actinidia latifolia* semi-hardwood cuttings about 10-12 cm in length (Figure 1). IAA plant growth regulator was used in concentrations of 0.0%, 0.5%, 1.0%, 1.5%, and 2.0% (denoted B1, B2, B3, B4, and B5, respectively). The experiment was performed on a sand tray in a greenhouse. Each treatment used 30 cuttings that were harvested after 60 days. The rooting percentage (%), number of roots/cutting, and length of roots/cutting (cm) were recorded.

- Influence of IBA on root formation of *Actinidia latifolia* cuttings:

The experimental material is *Actinidia latifolia* semi-hardwood cuttings of about 10-12 cm in length (Figure 1). IBA plant growth regulator was used in concentrations of 0.0%, 0.5%, 1.0%, 1.5%, and 2.0% (denoted C1, C2, C3, C4, and C5, respectively). The experiment was performed on a sand tray in a greenhouse. Each treatment used 30 cuttings that were harvested after 60 days. The rooting percentage (%), number of roots/cutting, and length of roots/cutting (cm) were recorded.

- Germination and growth of kiwifruit on sand substrates:

The materials are green kiwifruit seeds extracted from fresh fruit and washed under tap water. The experiment was performed on a sand tray in a greenhouse. The treatment used 100 seeds. The plants were harvested after 30 days and the following data were recorded: germination percentage (%), height of seedlings (cm), the initial day of germination (day), and the final day of germination (day).

- Influence of different growth media mixtures on kiwifruit seedling growth:

The experimental materials were kiwifruit seedlings with a height of 1.0-1.2 cm. The substrate test was based on the mixing ratio of coconut coir and soil with coir contents of 0%, 25%, 50%, 75%, and 100% (denoted D1, D2, D3, D4, and D5, respectively). The experiment was performed in plastic bags of size 6 x 12 cm placed in the greenhouse. Each treatment used 25 plants that were harvested after 60 days, and the survival percentage (%), height of seedlings (cm), and number of leaves/seedling were recorded.

2.3. Statistical analysis

The statistical analysis was performed with Statistical Package for Social Sciences (SPSS) software version 16.0 using Duncan's range test (Duncan, 1955).

3. RESULTS AND DISCUSSION

3.1. Influence of NAA, IBA, and IAA on root formation of *Actinidia latifolia* cuttings

Phytohormones are auxiliary substances that act as plant growth regulators (PGRs) under nursery conditions to increase the number of seedlings, shorten rooting time, increase rooting percentage, and increase the number of roots per plant (Kulevanona, 2011). Many research results show that PGRs influence rooting parameters and that different types of PGRs are suitable for different plant species. Nazir et al. (2018) showed that *Taxus wallichiana* cuttings are best rooted using 1,000 ppm IBA and cuttings in the spring (March to May). *Salvia fruticosa* has the best rooting results when IAA is used (Sağlam et al., 2014). Zhang et al. (2015) compared the effects of NAA, IBA, and IAA on *Carya illinoensis* and demonstrated that the rooting effect on this plant is best with NAA, intermediate with IBA, and least with IAA.

Results of experiments that evaluated three different types of PGRs (NAA, IBA, and IAA) on *Actinidia latifolia* rooting formation to find suitable concentrations and PGRs for cuttings are shown in Table 1. The rooting percentage in the treatments with NAA at all concentrations were higher than for the control. The rooting percentages for the NAA treatments ranged from 50.00% to 76.67%, compared to the rooting percentage of 30.00% for the control. The rooting percentage was highest with the 1.00% NAA treatment (2.5 times higher than the control). In addition to the rooting percentage, the number of roots and their lengths are very important in assessing the quality of the

cuttings. The number of roots was lowest in the control treatment (1.33 roots/cutting) and highest in the 1.00% NAA treatment (3.91 roots/cutting). The root lengths were in the range of 2.41-5.65 cm/cutting with the shortest lengths for the control treatment and the longest for the 1.00% NAA treatment. For an experiment using NAA, a concentration of 1.00% is recommended for the best cuttings results.

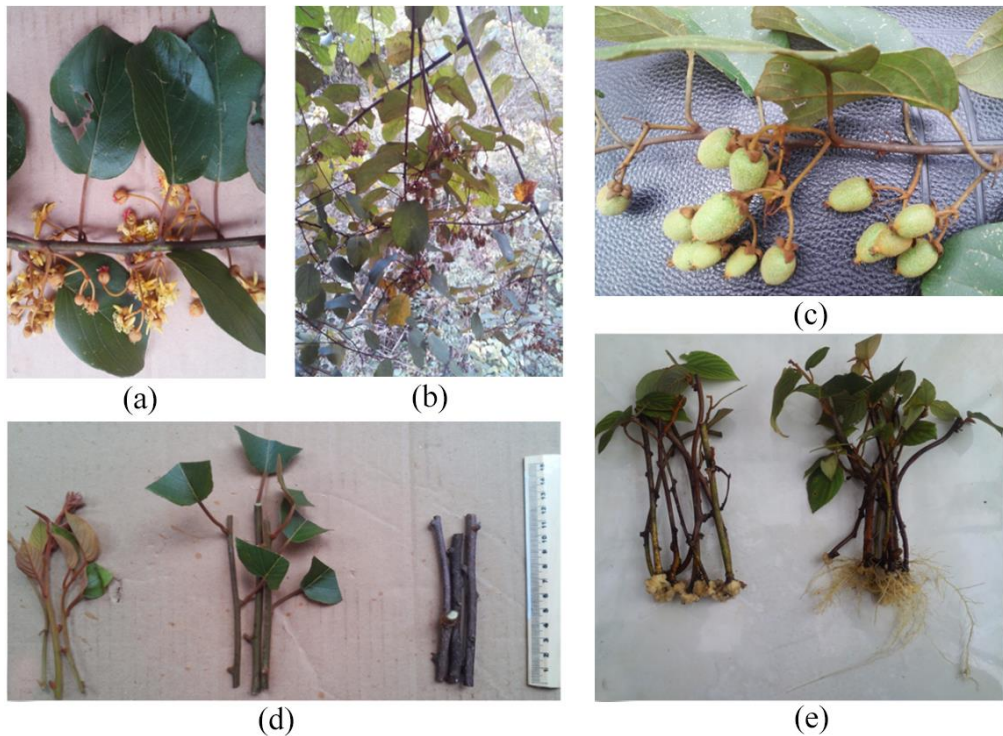


Figure 1. Experimental *Actinidia latifolia* cuttings

Note: (a) Branch with flowers; (b, c) Branches with fruit; (d) Cuttings (left to right: softwood, semi-hardwood, and hardwood); (e) Callus formation cuttings and rooting cuttings.

Table 1. Influence of NAA on root formation of *Actinidia latifolia* cuttings

Treatment	Concentration (%)	Rooting percentage (%)	Number of roots/cutting	Length of roots/cutting (cm)
A1	Control	30.00	1.33 ± 0.50 ^c	2.41 ± 0.42 ^c
A2	0.50	60.00	1.72 ± 0.89 ^{bc}	2.82 ± 0.85 ^c
A3	1.00	76.67	3.91 ± 1.65 ^a	5.65 ± 1.18 ^a
A4	1.50	56.67	2.41 ± 1.28 ^b	3.66 ± 0.94 ^b
A5	2.00	50.00	2.00 ± 0.65 ^{bc}	3.53 ± 0.86 ^b
Mean		54.67	2.49 ± 1.49	3.87 ± 1.50

Note: Data are shown as mean ± SD. Data in each column followed by different letters were significantly different at $p \leq 0.05$ using Duncan's test.

The use of IBA also affects rooting similar to NAA (Table 2). All experimental treatments gave rooting parameters higher than the control. The best rooting treatment was IBA at 1.00% concentration, which gave a rooting percentage of 66.67%, 2.43 roots/cutting, and root lengths of 4.42 cm/cutting. The most effective concentration is followed by treatments with IBA at concentrations of 1.50%, 2.00%, and 0.50%. The control treatment has the lowest rooting efficiency. The most effective concentration of IAA of 1.50% (compared to 1.00% for NAA and IBA) produced a rooting percentage of 66.67%, 2.81 roots/cutting, and root lengths of 4.34 cm/cutting (Table 3). The next best treatments were 1.00% IAA and 2.00% IAA. The treatment of 0.50% IAA and the control treatment had similar results.

Table 2. Influence of IBA on root formation of *Actinidia latifolia* cuttings

Treatment	Concentration (%)	Rooting percentage (%)	Number of roots/cutting	Length of roots/cutting (cm)
B1	Control	30.00	1.33 ± 0.50 ^c	2.41 ± 0.42 ^c
B2	0.50	60.00	1.39 ± 0.61 ^c	2.68 ± 0.40 ^c
B3	1.00	66.67	2.43 ± 1.25 ^a	4.42 ± 0.85 ^a
B4	1.50	60.00	2.06 ± 0.54 ^{ab}	4.29 ± 0.57 ^a
B5	2.00	36.67	1.82 ± 1.25 ^{ab}	3.17 ± 0.48 ^b
Mean		54.67	1.88 ± 0.99	3.57 ± 1.02

Note: Data are shown as mean ± SD. Data in each column followed by different letters were significantly different at $p \leq 0.05$ using Duncan's test.

Table 3. Influence of IAA on root formation of *Actinidia latifolia* cuttings

Treatment	Concentration (%)	Rooting percentage (%)	Number of roots/cutting	Length of roots/cutting (cm)
C1	Control	30.00	1.33 ± 0.50 ^b	2.41 ± 0.42 ^d
C2	0.50	56.67	1.29 ± 0.47 ^b	2.69 ± 0.61 ^d
C3	1.00	63.33	1.47 ± 0.51 ^b	3.81 ± 0.58 ^b
C4	1.50	66.67	2.81 ± 1.21 ^a	4.34 ± 0.57 ^a
C5	2.00	50.00	1.73 ± 0.88 ^b	3.13 ± 0.62 ^c
Mean		53.33	1.81 ± 1.00	3.43 ± 0.91

Note: Data are shown as mean ± SD. Data in each column followed by different letters were significantly different at $p \leq 0.05$ using Duncan's test.

Comparing the use of growth regulators in all three treatments, 1.0% NAA, 1.0% IBA, and 1.5% IAA, the rooting parameters were better, but more variable than with the control (Figure 2). PGRs should be used at appropriate doses because high concentrations inhibit rooting, similar to the above experiments (Tables 1-3). When NAA and IBA were used in concentrations of 1.5% and 2.0%, the rooting parameters were less than with the

1.0% treatment. Similarly, concentrations over 1.5% should not be used with IAA. The above results are also consistent with previous research results (Nazir et al., 2018; Sağlam et al., 2014; Sun & Bassuk, 1991; Zhang et al. 2015).

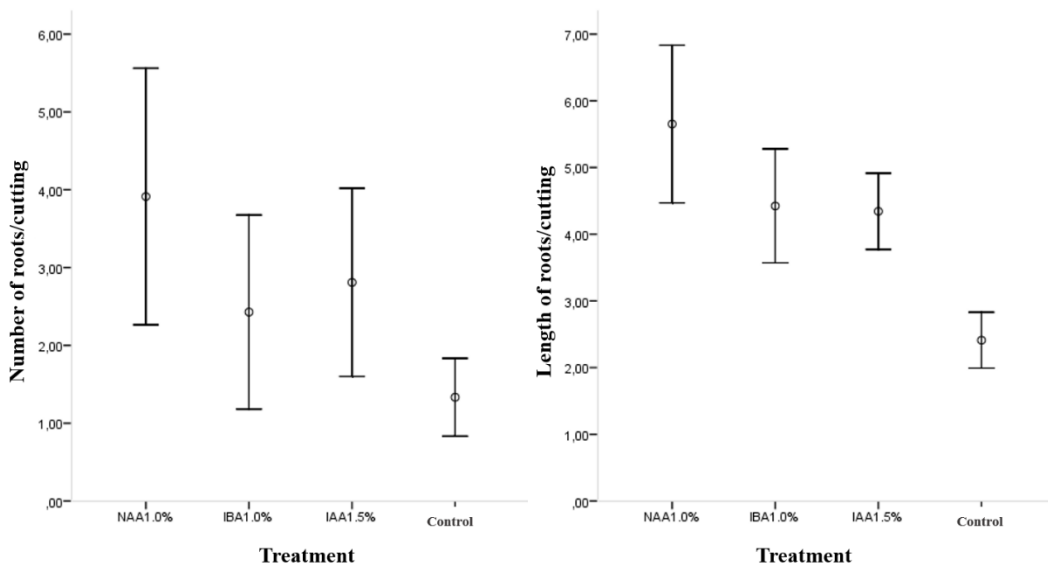


Figure 2. Influence of three plant growth regulators at various concentrations on root formation of semi-hardwood cuttings

3.2. Germination and growth of kiwifruit on sand substrates

Results of kiwifruit sowing are shown in Table 4. Kiwifruit seeds sown on sand have a germination percentage of 81.00%. The seeds began to germinate after 19 days and germination ended after 25 days. The germination percentage can be increased by carefully selecting seeds, using germination stimulants, controlling the temperature, and choosing the right substrate. By so doing, the germination percentage reached 99.17% (Celik et al., 2006).

Table 4. Germination and growth of kiwifruit on sand substrate

Substrate	Rooting percentage (%)	Height of seedlings (cm)	Initial day of germination (day)	Final day of germination (day)
Sand	81	1.0-1.2	19	25

3.3. Influence of substrates on kiwifruit growth

When the seeds had germinated, hulled, and had two cotyledons, they were transplanted for the substrate mixing experiments. Plants are adapted to different soil types, with soil porosity and water-holding being important factors affecting plant growth. Table 5 shows growth results of kiwifruit seedlings for different soil-coconut coir combination ratios. The survival percentage is over 90% in all treatments. The most suitable soil and coconut coir mixture for kiwifruit seedlings is 25% soil mixed with 75%

coconut coir. The tallest seedlings and the highest number of leaves/seedling were 5.02 cm and 7.17 leaves, respectively. For the least effective treatment, 100% soil, the plant height was only 2.10 cm and seedlings had only 3.88 leaves on average. The variations in the number of leaves and plant height in the experimental treatments are expressed in the standard deviation values (Figure 3). The standard deviation of the number of leaves in the treatments ranged from 0.40 to 0.52 (except for treatment D2, which was 0.24). The standard deviation of plant height ranged from 0.61 to 0.80. These initial results show that the nursery-stage kiwifruit seedlings are suited to soils with high porosity and moisture content rather than compact, low-moisture soils. The growth results of the substrate treatments are shown clearly in Figure 4. Seedlings in the nursery grew and adapted well to the weather conditions in Da Lat (Lam Dong province) (Figure 5).

Table 5. Influence of substrates on kiwifruit growth

Treatment			Living percentage (%)	Height of seedling (cm)	Number of leaves/seedling
Symbol	Soil (%)	Coconut coir (%)			
D1	100	0	96.00	2.10 ± 0.41 ^e	3.88 ± 0.80 ^d
D2	75	25	96.00	2.66 ± 0.24 ^d	5.17 ± 0.70 ^c
D3	50	50	100.00	3.28 ± 0.44 ^c	5.96 ± 0.61 ^b
D4	25	75	96.00	5.02 ± 0.40 ^a	7.17 ± 0.64 ^a
D5	0	100	92.00	4.28 ± 0.52 ^b	6.30 ± 0.70 ^b
Mean			96.00	3.46 ± 1.14	5.69 ± 1.31

Note: Data are shown as mean ± SD. Data in each column followed by different letters were significantly different at $p \leq 0.05$ using Duncan's test.

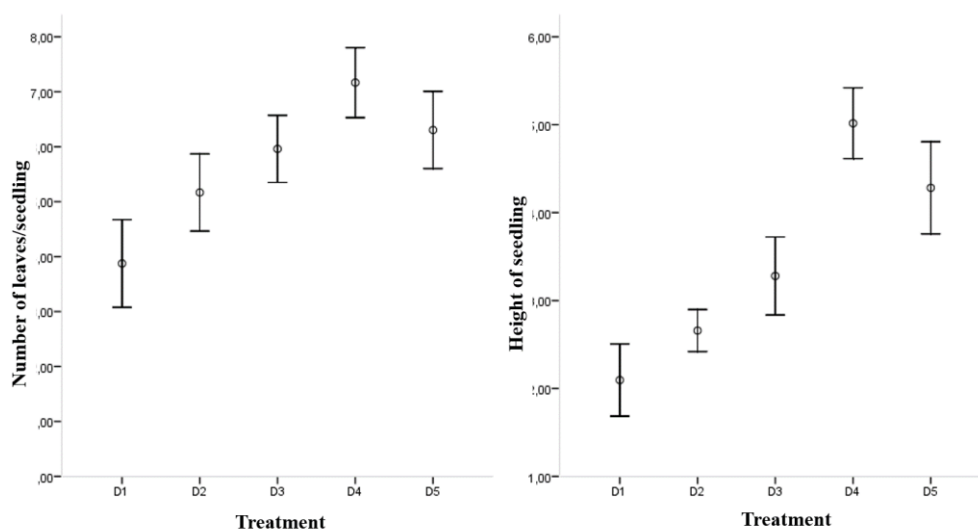


Figure 3. Height and number of kiwifruit seedling leaves for various experimental treatments

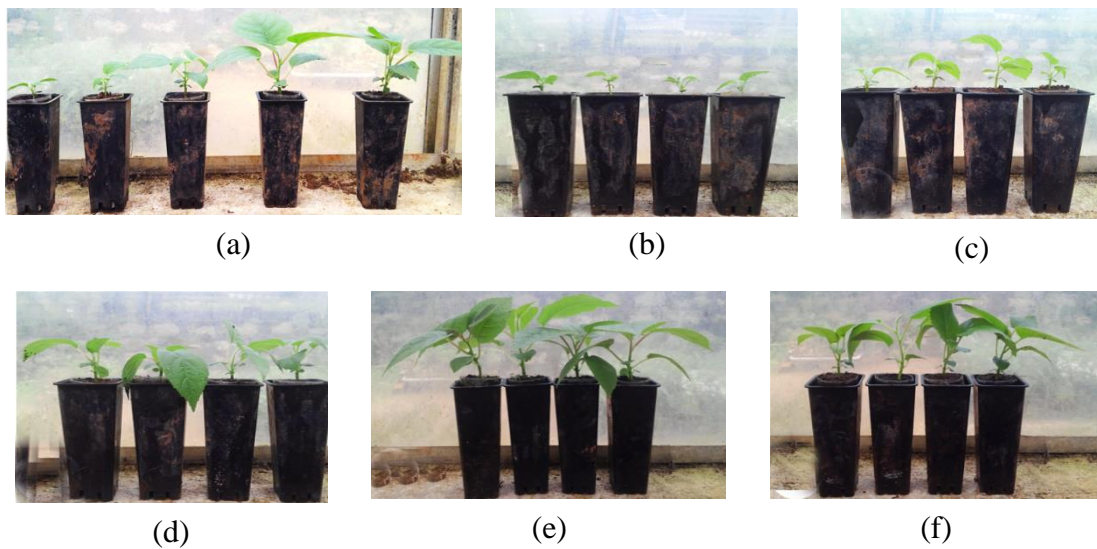


Figure 4. Growth of kiwifruit seedlings for various experimental substrates

Note: (a) Mixed soil and coconut coir substrates, from left to right: 0%, 25%, 50%, 75%, and 100% coconut coir; (b) Control (0% coconut coir); (c) 25% coconut coir; (d) 50% coconut coir; (e) 75% coconut coir; (f) 100% coconut coir.



Figure 5. Growth of kiwifruit seedlings after three months

4. CONCLUSIONS

The results of this study show that PGRs can promote the root formation of *Actinidia latifolia* in propagation by cuttings. Using a concentration of 1.0% for NAA and IBA and a concentration of 1.5% for IAA showed the strongest effect on root growth. The germination percentage of kiwifruit seeds reached 81.0% after 25 days. The best substrate for the growth of kiwifruit seedlings is 25.0% soil with 75.0% coconut coir.

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