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STUDY ON ROOTING OF KIWIFRUIT CULTIVARS (*Actinidia chinensis*) IN DIFFERENT SUBSTRATES AND ROOTING HORMONES

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ABSTRACT. *Kiwifruit genus (Actinidia) includes twenty different species. One of the best methods of kiwifruit propagation is the use of hardwood and semi- hardwood cuttings using rooting hormone. The effect of substrate and concentration of indole butyric acid (IBA) and naphthalene acetic acid (NAA) on rooting of kiwifruit cuttings was investigated under greenhouse conditions in a factorial study (4×3×3) with three factors and three replications. The first factor was rooting substrate at three levels (a_1: sand, a_2: sand + perlite and a_3: sand + azocompost (1:1)), the second factor was kiwifruit cultivar including Hayward (b_1), Mateua (b_2), and Bruno (b_3), and the third factor included water (c_1), IBA 4000 mg/l (c_2), NAA 2000 mg/l (c_3), and IBA 2000 + NAA 2000 (c_4). Trait measurement of each cutting included callus percentage, callus dry and fresh weight, root length, the length of the longest root, rooting percentage, roots dry and fresh weight, the number of roots and the diameter of roots. It was found that the application of IBA 4000 mg/l had the greatest impact on increasing callus percentage and the length of the longest root. The maximum diameter of roots was obtained under sand × Mateua× NAA2000 mg/l and sand + perlite was found to be the most suitable substrate for rooting of kiwifruit cuttings.*

KEY WORDS: *rooting substrate, IBA, NAA, Actinidia chinensis.*

INTRODUCTION

Kiwifruit (*Actinidia*) includes 20 different species. About ten species of

Actinidia are of commercial importance in the world out of which seven species are used as ornamental vine and three other species including *Actinidia chinesis*, *A. arguta*, and *A. kolomickta* are used to produce fruit. Among these three species, *A. chinesis* has special economic importance owing to its high quality for exporting (Ebrahimi 1981, Rashed & Akbarzadeh 1991). Kiwifruit is a subtropical fruit that is more resistant to frost than the citrus. It has a high water and humidity requirements, so it should be watered regularly. The results of a two-year experiment showed that the trees can easily tolerate the temperatures down to -7.5°C (Mohammadi & Abdi 1993). Kiwifruit is propagated by cuttings with different treatments, among which the application of plant growth regulators (PGRs) is one of the most common practices (Polat & Kamilogu 2007). Auxin is one of the most important PGRs regulating the speed of rooting. Plants produce natural auxin in their branches and young leaves, but synthetic auxin should be applied for better rooting. Natural auxins are more sensitive to auxin's catabolism enzymes than synthetic auxins (Stenfanic & Vodnik 2007). In a study on the effect of different levels of IBA on rooting of semi-hardwood and softwood cuttings of kiwifruit, Biasi et al. (1990) obtained to the best results under the treatment of 6000 mg/l IBA. The greatest success was achieved in plants such as kiwifruits, figs and apples through IBA treatment, which is necessary for hardwood and softwood cuttings (Ercisli et al. 2003). A suitable rooting medium has sufficient pores for appropriate aeration and high water holding capacity with good drainage. Lack of proper substrate reduces water absorption efficiency and results in plant wilting. It seems that the selection of appropriate substrate is an important step in the propagation of horticultural crops which increases the speed of rooting and improves the number of rooted cuttings (Khoshkhoy 2012). The purpose of the present study was to evaluate the response of cuttings of three cultivars of kiwifruit to different treatments of substrates (rooting media), auxins and water.

MATERIALS AND METHODS

The experiment was carried out in a greenhouse located in Nargestan of

Some'esara city in Guilan, Iran. It was a factorial experiment with three factors (4 × 3 × 3) and three replications. The first factor was rooting substrate at three levels (a_1: sand, a_2: sand + perlite and a_3: sand + azocompost with 1:1 ratio), the second factor was kiwifruit cultivars at three levels (b_1: Hayward, b_2: Mateua and b_3: Bruno), and the third factor included no hormone (c_1), IBA at the rate of 4000 mg/l (c_2), NAA at the rate of 2000 mg/l (c_3) and IBA + NAA at the rate of 2000 + 2000 mg/l (c_4). Two cuttings were used in each plot (in total 216 cuttings). Semi-hardwood cuttings of kiwifruit were classified in the binary category and were placed in the hormone solution by rapid submergence for 10 seconds. Then, they were placed in the fresh air for 10 seconds and were cultured in pre-prepared pots. The rooting of the cuttings was evaluated three months later. The traits including callus percentage, dry and fresh weight of callus, root length, rooting percentage, dry and fresh weight of root, root number and diameter of the root were recorded. Callus was observed 2 months after planting. At the end of the experiment, the number of rooted cuttings per experimental plot and the number of roots per cutting was counted and the percentage of rooted cuttings was calculated. The dry weight was investigated by placing the calluses and roots for 24 hours at 105°C. Statistical analysis was done by MSTATC software and mean comparison of treatments by the Tukey method.

RESULTS AND DISCUSSION

According to the analysis of variance (Table 1), the simple effect of substrate was significant on rooting rate, callus percentage, fresh weight of callus and root diameter ($p<0.01$), and on dry and fresh weight of root, length of the longest root and the number of roots ($p<0.05$). The effect of cultivar was significant on most recorded traits but it did not significantly influence dry and fresh weight of callus. The simple effect of hormone was significant on fresh weight of callus. The interaction of substrate × cultivar was significant for rooting rate and root diameter ($p<0.01$). The interaction of substrate × cultivar × hormone was significant for the diameter of roots, callus, fresh and dry weight of callus and the length of longest root ($p<0.01$ or 0.05).

Means comparison for the effect of substrate on rooting percentage (Table 2) showed that the highest rooting percentage (48.31%) was

Table 1. Analysis of variance of experimental factors effects on rooting traits of kiwifruit cuttings.

SOV	Df	Rooting %	Callus %	Fresh weight of callus	Dry weight of callus	Fresh weight of root	Dry weight of root	Longest root	Root diameter	Root number
Replication	2	334.9^{ns}	774.7^{ns}	0.38^{ns}	0.011^{*}	0.25^{**}	0.0001^{ns}	4.3^{ns}	0.00^{ns}	14.9^{ns}
Substrate (A)	2	10150.9^{**}	20154.3^{**}	3.7^{**}	0.016^{**}	0.15^{*}	0.001^{*}	10.2^{*}	1.5^{**}	41.8^{*}
Cultivar (B)	2	22242.3^{**}	17373.8^{**}	0.14^{ns}	0.006^{ns}	0.22^{**}	0.0001^{**}	28.4^{**}	5.2^{**}	102.3^{*}
AB	4	3704.0^{**}	861.4^{ns}	0.42^{*}	0.003^{ns}	0.04^{ns}	0.0001^{ns}	2.6^{ns}	0.7^{**}	20.5^{ns}
Auxins (C)	3	864.1^{ns}	840.9^{ns}	0.75^{**}	0.01^{*}	0.04^{ns}	0.0001^{ns}	2.1^{ns}	0.19^{ns}	6.25^{ns}
AC	6	897.7^{ns}	833.6^{ns}	0.17^{ns}	0.002^{ns}	0.03^{ns}	0.0001^{ns}	1.8^{ns}	0.29^{ns}	6.05^{ns}
BC	6	467.9^{ns}	641.9^{ns}	0.32^{ns}	0.004^{ns}	0.03^{ns}	0.0001^{ns}	2.8^{ns}	0.17^{ns}	13.8^{ns}
ABC	12	1375.2^{ns}	1174.8^{*}	0.30^{*}	0.005^{ns}	0.03^{ns}	0.0001^{ns}	5.1^{*}	0.47^{**}	20.9^{ns}
Error	70	890.6	481.3	0.16	0.003	0.04^{ns}	0.0001	2.2	0.18	11.8

^{ns}, * and **: not significant, significant at 5% and 1% levels, respectively.

Table 2. Means comparison of traits of kiwifruit cuttings in different substrates.

Substrates	Rooting %	Callus %	Fresh weight of callus (g)	Dry weight of callus (g)	Fresh weight of root(g)	Dry weight of root(g)	Longest root (cm)	Root diameter (mm)	Root number
Sand (a_1)	36.92a	56.00b	0.58a	0.05ab	0.15a	0.01a	1.66a	0.63a	3.00a
Sand + perlite (a_2)	48.31a	70.83a	0.75a	0.06a	0.11ab	0.005ab	1.24ab	0.61a	2.17ab
Sand + azocompost (a_3)	15.25b	24.50c	0.13b	0.02b	0.02b	0.002b	0.60b	0.26b	0.86b

†Means followed by the same letters in each column are not significantly different at 5% level according to Tukey test.

obtained under the treatment of sand + perlite and the lowest one (15.25%) under the treatment of sand + azocompost. As means comparison showed (Table 3), the highest and lowest rooting percentages were devoted to Mateua (52.28%) and Bruno (5.31%), respectively. Means comparison for the interaction of substrate × cultivar (Table 5) revealed that the highest percentage of rooting of 83.33% was obtained under the treatment of sand + perlite × Mateua and the lowest one was obtained under the treatment of sand + azocompost × Bruno. Ghasemi et al. (2013) demonstrated that substrates with neutral pH (perlite and sand) which are used for the improvement of the drainage resulted in the highest percentage of rooting. Morini & Isoleri (1986) reported that perlite was the best substrate for rooting of kiwifruit cuttings.

It was found that the highest percentage of callus (70.8%) was obtained in sand + perlite substrate and the lowest callus was obtained in sand + azocompost substrate (Table 2). Sand + perlite substrate produced almost three times more calls than sand + azocompost. Means comparison for the effect of cultivar on callus (Table 3) showed that the highest callus was produced by cv. Mateua (66.67%). Among different interactions of substrate × cultivar × hormone, the treatment of sand + perlite × Mateua × IBA at the rate of 4000 mg/l was found to be the best treatment with 100% callus. Since perlite can absorb and conserve more than 3-4 times as much water as its weight (Garillass et al. 2001), it can be used as an appropriate substrate for the production of callus at the base of cuttings and the prevention of the losses of cuttings. In the present test, the application of perlite + sand in rooting substrate improved callus of the cuttings. Razaghi et al. (2010) recommended IBA at the rate of 4000 mg/l for callus of kiwifruit cuttings.

According to the results of means comparison of the effect of substrate on fresh weight of callus (Table 2), the highest fresh weight of callus (0.75 and 0.58 g) was produced under the treatment of sand + perlite and pure sand, respectively. The lowest fresh weight of callus is observed under the treatment of sand + azocompost (0.13g). The fresh weight of callus under sand + perlite was nearly six times higher than that under sand + azocompost substrate. A look at the effects of hormones on fresh weight of

Table 3. Means comparison of effect of cultivars on rooting traits of kiwifruit cuttings.

Cultivars	Rooting %	Callus %	Fresh weight of root(g)	Dry weight of root(g)	Longest root (cm)	Root diameter (mm)	Root number
Hayward ($b_{1)}$	42.89a	59.22a	0.13a	0.008a	1.24a	0.62a	2.58a
Mateua ($b_{2)}$	52.28a	66.67a	0.14a	0.010a	2.01a	0.80a	3.33a
Bruno ($b_{3)}$	5.31b	25.44b	0.003b	0.0004b	0.24b	0.07b	0.11b

Table 4. Means comparison of effect of different auxins on weight of callus.

Auxins	Fresh weight of callus (g)	Dry weight of callus (g)
Control (c_1)	0.36b	0.03ab
IBA 4000 mg/l (c_2)	0.70a	0.07a
NAA 2000 mg/l (c_3)	0.54ab	0.04ab
IBA 2000 mg/l + NAA 2000 mg/l (c_4)	0.34b	0.02b

Table 5. Means comparison of effect of substrate and cultivar interaction on kiwifruits cuttings traits.

Substrate ×cultivar	Rooting %	Fresh weight of callus (g)	Root diameter (mm)
Sand × Hayward (a_1b_1)	60.92ab	0.57ab	1.02a
Sand× Mateua (a_1b_2)	40.17bc	0.60ab	0.73ab
Sand × Bruno (a_1b_3)	9.67cd	0.56ab	0.13cd
sand + perlite × Hayward (a_2b_1)	55.33ab	0.84a	0.62abc
sand + perlite × Mateua (a_2b_2)	83.33a	0.45abc	1.11a
sand + perlite × Bruno (a_2b_3)	6.25cd	0.96a	0.09cd
sand + azocompost× Hayward (a_3b_1)	12.42cd	0.19bc	0.21bcd
sand + azocompost× Mateua (a_3b_2)	33.33bcd	0.19bc	0.58abc
sand + azocompost× Mateua (a_3b_3)	0.00d	0.00c	0.00d

callus (Table 4) indicated that the highest and lowest fresh weight of callus is obtained by the treatment of IBA 4000 mg/l and IBA 2000 mg/l + NAA 2000 mg/l, respectively. Means comparison for the interaction of substrate × cultivar for callus fresh weight (Table 5) showed that the treatment of sand + perlite × Bruno was the best treatments. The interaction of substrate × cultivar × hormone showed that the highest fresh weight of callus was related to sand + perlite × Hayward × NAA 2000 mg/l treatment and no callus was produced under the treatments of sand ×Bruno × NAA 2000 mg/l, sand× Bruno × IBA2000 mg/l + NAA 2000 mg/l and in some other treatments.

As means comparison for the effect of substrate on fresh weight of kiwifruit cutting root (Table 2) showed, the highest fresh weight of the root was related to the treatment of sand +Azocompost. Cultivars Mateua and Hayward produced the highest root fresh weight and the lowest root fresh weight was observed in cv. Bruno. Razaghi et al. (2010) obtained the highest root fresh weight under the treatment of 6000 mg/l IBA and 6000 mg/l IBA + 2000 mg/l NAA. Shafaghi et al. (2012) reported the highest root fresh weight of *Thuja* to be produced in perlite substrate and 4000 mg/l IBA.

Means comparison for the effect of substrate on dry weight of callus (Table 2) suggested that the maximum and minimum dry weight of callus was obtained in sand + perlite and sand + azocompost substrates, respectively. Simple effect of the hormone on dry weight of callus (Table 4) revealed that the highest value was gained under the treatment of IBA at the rate of 4000 mg/l. Based on means comparison, the highest dry weight of roots was produced in sand and the lowest one in sand + azocompost. The highest root dry weight of cuttings was related to cultivars Mateua and Hayward (Table 3). Razaghi et al. (2010) produced the highest dry weight of roots under the application of 6000 mg/l IBA + 2000 mg/l NAA. Auxins such as IBA when applied in higher concentration resulted in higher root dry weight (Moalemi 2001). Different substrates and concentrations of hormones had significant effects on dry weight of the hopbush (*Dodoneae viscose* L.) roots of cuttings. But, the interaction of the substrate and hormone did not have significant effect on root dry weight (Safari & Safari 2012).

Means comparison for the effect of substrate on the length of the longest root of kiwifruit cuttings (Table 2) showed that the sand medium resulted in the production of the longest roots and the sand + azocompost had minimum effect on the length of root. Also, the cultivar effect (Table 3) shows that the longest roots obtained in Mateua cuttings and the shortest ones belonged to Bruno. The interaction of substrate × cultivar × hormone revealed that the longest root was related to sand × Mateua × IBA 4000 mg/l and the treatments of sand × Mateua with all hormones rates had negative effect on the root length of the cuttings. Nadafian et al. (2013) obtained the longest root in cuttings of miniature rose under perlite substrate without any auxins while the shortest one was produced in sand substrate without Auxins. Jalilzadeh-Khooye et al. (2013) found the longest roots of African violets' leaf cuttings in the perlite substrate and the shortest roots in sand substrate. The results indicated that different plants exhibited different responses to different substrates of rooting.

Tables 2 and 3 show that the maximum root diameter (thickness) of the cuttings was obtained under sand media, sand + perlite and Mateua cultivar. The interaction of substrate × cultivar for root diameter (Table 5) shows that sand + perlite × Mateua was the best treatment. According to the results, the maximum diameter of the root was devoted to the treatment of sand × Mateua × NAA2000 mg/l. Hashemabadi & Sedaghathoor (2006) stated that NAA increased root diameter of *Camellia japonica*. Golestani et al. (2013) found that IBA treatments had no significant effect on root diameter of cutting. Their findings confirm the results of the present experiment.

The highest number of roots was obtained in sand and the lowest number in sand + azocompost. Also, Mateua produced the highest number of roots among all studied cultivars (Table 3). Studies confirm that the highest number of roots is obtained in high concentrations of auxins (Razaghi et al. 2010, Hashemabadi & Sedaghathoor, 2006, Barzegar *et al*. 2003). The results of present study suggest that the hormonal treatments had no significant effect on the number of roots. Generally, the rooting ability of cuttings greatly varies with species and variety (Khoshkhoy 2012).

Given the significant effect of sand + perlite on most recorded traits and its superiority over other substrates, it can be regarded as the most appropriate substrate for the rooting of kiwifruit cuttings. In the present study, the application of auxins had no significant impact on the root number and rooting percentage. It is proposed to further study it in order to find better hormonal recommendations.

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