International Journal of Research in Agricultural Sciences
Volume 9, Issue 1, ISSN (Online): 2348 – 3997

Rooting Media and Growth Regulators Affect Propagation from Stem Cuttings of *carica papaya* L.C.v 'Tainung No. 2' and 'Red Lady'

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Date of publication (dd/mm/yyyy): 06/02/2022

***Abstract* – The objective of this study was to evaluate the effect of different substrates and growth regulators on cuttings of *Carica papaya* cv. 'Tainung No. 2' and 'Red Lady' for identifying effective practices for the vegetative propagation of these species. Apical cuttings with a standardized length of 18 cm and two pairs of leaves were harvested from hermaphrodite papaya plants planted in the net house. Two experiments were conducted: the first experiment tested the effect of six substrates (sand, perlite, peat moss, vermiculite, a mixture [50:50 by volume] of perlite and vermiculite, and a mixture [50:50 by volume] of peat moss and perlite) and the second experiment evaluated NAA and IBA at five concentrations (0.0, 1,000, 2,000, 3,000, 4,000 and 5,000 ppm). The experimental design was randomized blocks with four replications. After 30 days of planting, the analyzed variables were rooting rate, number and length of roots. In the first experiment, there were significant differences in responses of rooting success to kinds of substrate. The best results of rooting rate, number and length of roots in both varieties were recorded in the peat moss, and a mixture of peat moss and perlite. The data of parameters showed that effect of rooting of the cuttings in both 'Tainung No.2' and 'Red Lady' were better in IBA treatments than in NAA ones. The best results in 'Tainung No.2' and 'Red Lady' propagation by cutting were achieved in treatments by 3,000 ppm IBA and 4,000-5,000 ppm IBA respectively.**

***Keywords* – *Carica papaya*, Cutting, Propagation, Indole Butyric Acid, Naphthaleneacetic Acid, Substrate.**

I. INTRODUCTION

Papaya (*Carica papaya* L.) is a polygamous species with many forms of inflorescences. The species has three sex types: staminate, pistillate and hermaphrodite [1]. Papaya is one of the few fruit crops still propagated mainly by seed. Papaya seedlings propagated from seed is hindered by problems because of the inherent heterozygosity and heterozygosity, production of non-true-to-types and susceptibility to papaya ring spot virus [2]-[3]. In the commercial plantations of most producing countries, male plants are useless and only hermaphrodite individuals are agreed by growers [4]. However, it was found that undesirable male plants prevail as high as 30% and sometimes over 50 % of trees planted in papaya fields [5]. In addition, the plants grown from seeds are considerable variation in disease susceptibility, fruit quality, and yield [3].

One advantage of asexual propagation is that the sex is known. It had been reported the possibility of developing materials highly productive and resistant to diseases, which can be spread safely keeping intact the characteristics of the papaya mother plants through asexual propagation [6]. Cutting, grafting and tissue culture are the preferred method to supply the expanding industry and the demand for more uniform product in papaya propagation. While, the grafting technique and tissue culture propagation more expensive and required high technical skill to plant propagators and not appropriate for small papaya farmers [7]. Cutting technique is simpler and can be easily applied in farming condition using transitional technique. The success of vegetative

propagation from cuttings depends on numerous factors, among them the type of rooting substrate, rooting growth regulator and the genotype are the most factors to affect the success of cutting propagation [8]-[9]-[10]. It is very important to use the 'right' propagation substrate for optimal rooting of cuttings [9]. The chemical composition and physical properties of the substrate affect the regulator to initiate callus formation resulting in the root development of cuttings and seedling development [11]-[12]. In cutting technique, there are many rooting substrates used in cutting propagation such as sand, perlite, vermiculite, peat moss, pine bark, sawdust, etc. and varies according to the species to be propagated [13]. Loach [14] reported that substrates like sawdust with relatively high water content are generally associated with higher rates of water uptake in the cuttings and consequently higher rooting percentages. Mabizela *et al.*[10], stated that a mix of fermented pine bark and river sand (1:1) is the best substrate for rooting of *C.subternata* stem cuttings. Adugna [15] achieved the highest rooting percentage of *Vanilla planifolia* stem cuttings (99.3%) planted in a sand substrate. Alan [16] obtained high success propagating papaya 'Hortus Gold' when cuttings were placed under intermittent mist in a sandy substrate kept at 30 ◦C.

Using exogenous rooting hormones is the most cutting technique to promote rooting of stem cuttings in many plant species. Plant growth regulators (PGRs) such as indole-3-acetic acid (IAA), naphthalene acetic acid (NAA) and indole-3-butyric acid (IBA) have been successfully employed in many plant species to improve the rooting ability of cuttings ([8]-[17]-[18]-[19]-[20], [21]. In these IBA and NAA shows more effectively than naturally occurring phytohormones like indole-3- acetic acid (IAA) to optimize rooting of cuttings [22].

The rooting of cuttings may be large differences in rooting potential among clones of many plant species [23]- [24]. Many different reports have predicated variations in rooting ability of cutting within genotypes in the same locations due to natural genetic variation [25]-[26]. To date, there is hardly any information on rooting of cuttings of papaya cultivars 'Tainung No.2' and 'Red Lady'. An urgent need therefore exists to develop optimum techniques, including the appropriate rooting substrate to ensure good root initiation from stem cuttings that can easily be adopted by start-up nursery enterprises as well as rural communities. In order to standardize the methodology for commercial propagation of *carica papaya* cuttings, this study was conducted to determine the effect of rooting media and plant growth regulators on the rooting of cuttings of papaya cultivars 'Tainung No.2' and 'Red Lady'.

II. MATERIALS AND METHODS

Study Area, Preparation of Plant Materials and Propagation System

Study Area:

The experiments were conducted consecutively from February to June in 2015-2016 in a propagation unit established in green house at the Institute of Life Science, located at ThaiNguyen city, Northern Vietnam.

Preparation of Plant Materials:

Hermaphrodite papaya plants 'Tainung No.2' (V1) and 'Red Lady' (V2) planted in the net house were collected as source material to produce cuttings for this study. The selected plants for supplying scions were developing normally and free from diseases. Before collecting the scions, the mother plants were topped and sprayed on term with solution of 6-Benzylaminopurine (500 mg/l) and Gibberellic Acid (100 mg/l) three times

at weekly intervals to induce side shoot production [27]. After about 1.5 month, shoots 7 - 10 mm in diameter were selected as cuttings in propagation.

The cuttings were collected directly from selected healthy papaya trees without pest and diseases in the morning hours from 7 to 9 a.m. These cuttings were immediately put in water to avoid desiccation and transported to the nursery (Figure 1a). The base of this shoots were cut to 18 cm length by using a sharp and clean knife and the leaves were trimmed two-remained leaves per a cutting to reduce transpiration loss of cuttings in propagation process (Figure 1 b). Then, the bases of these cuttings were treated by plant growth regulators (PGR) before planting into growth media.

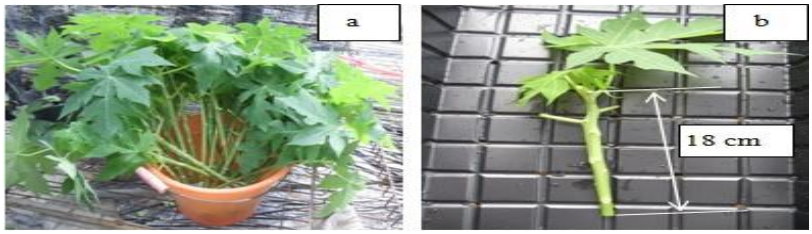

Fig. 1. Collecting and initial treating stem cuttings: (a), Been keeping water to avoid desiccation; (b), Trimming leave and base of cutting for suitable size.

After PGR treatment, the cuttings were planted 6 cm depth on trays which were filled 10 cm height substrate. Then, the trays were placed in propagator box in greenhouse to maintain the air humidity high (70–98% RH) by spraying mist intermittently, and about 12 h d^{-1} photoperiod, 300–400 µmol m^{-2} s^{-1} PPF light intensity (shaded sunlight). At the beginning of the experiment and every one week, all cuttings were also sprayed with RidomilGold (*Syngenta* products) to prevent the appearance of fungus diseases.

Experiment 1: Effect of Types of Substrate on Rooting of Cuttings in Papaya Propagation

The 'Tainung No.2' (V1) and 'Red Lady' (V2) papaya cuttings chosen were treated by 1000 ppm IBA [16] in 20 seconds before planting into different substrates. The propagation substrates were composed of sand [SA], perlite [PL], peat moss [PM], vermiculite [VE], a mixture [50:50 by volume] of perlite and vermiculite [PL+VE], and a mixture [50:50 by volume] of peat moss and perlite [PM+PL] (Figure 2). The experiment was established in randomized blocks, with each treatment replicated four times and ten cuttings for each replication per a treatment.

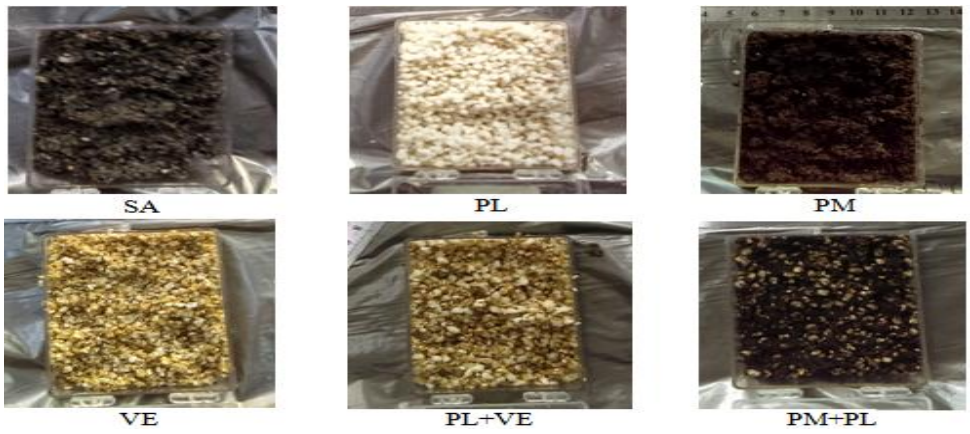

Fig. 2. Types of rooting media: sand [SA], Perlite [PL], Peat moss [PM], Vermiculite [VE], a mixture [50:50 by volume] of Perlite and Vermiculite [PL+VE], and a mixture [50:50 by volume] of Peat moss and Perlite [PM+PL].

Experiment 2: Effect of PGR on Rooting of Papaya Stem Cuttings

The 'Tainung No.2' (V1) and 'Red Lady' (V2) papaya cuttings chosen were treated by PGR in 20 seconds before planting into peat moss substrate. The experiment was conducted with six concentrations (0, 1,000, 2,000, 3,000, 4,000, and 5,000 ppm) of the rooting hormone 1-Naphthaleneacetic acid (NAA) or indole-3-butyric acid (IBA). The experiment was established in randomized blocks, with each treatment replicated four times and ten cuttings for each replication per a treatment.

Statiscal Analysis

The rooting of cuttings in two varieties was assessed at three parameters: rooting rate, number and length of roots after 30 days of planting. The collected data were statistically analyzed to find out the significance difference between treatments. Statistical analyses were conducted using SAS 9.0 software (SAS Institute, Cary, North Carolina, USA), and means were compared using Duncan's new multiple range test at $P \leq 0.01$.

III. RESULTS

Effect of Types of Substrate on Rooting of Papaya Cuttings

Type of substrate is one of the most important factors for the rooting of cuttings, and this study provided evidence of the effect of the different substrates on the rooting success of papaya (C. papaya) plants. The different substrates affect the rooting percentages, number and length of roots in both varieties (Table 1) ($P \leq 0.01$). After 30 days of planting, the best result for all parameters in two varieties were record in the [PM], and a mixture of [PM+PL]. And the lowest results in both varieties were recorded in [SA] substrate (Table 1). The rooting rate in the [PM] (40% for V1 and 20% for V2), and a mixture of [PM+PL] (37.5% for V1 and 20% for for V2) were higher than those in other substrates in the two varieties. The lowest rooting rates in two varieties (10.0% for V1 and 7.5% for V2) were recorded in [SA] substrate. In contrast, mean number and length of roots in two varieties did not differ significantly ($p<0.01$) in response to different substrate excepting sand substrate (Table 1).

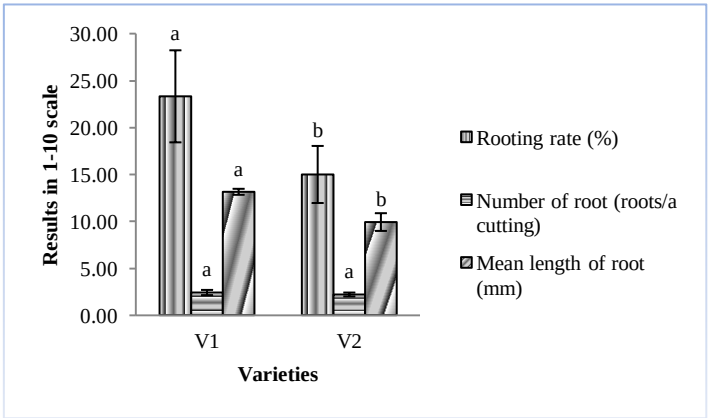

Fig. 3. Response of V1 and V2 papaya cuttings to rooting rate (%), number of root (root/a cutting), mean length of root (mm) in substrates (30 days after planting).

In the presence of 1000 ppm IBA, although, the best results of rooting rate, number and length of root in both V1 and V2 obtained in [PM] and [PM+PL] substrate, the V1 showed more rooting advantage than V2 in influence of different substrates. Rooting rate and length of root in V1 were higher than those in V2 (Figure 3).

Table 1. Effect of rooting media on rooting of the cuttings in papaya 'Tainung No.2' and 'Red Lady' propagation (30 days after planting).

Types of Substrate	V1						V2					
	Rooting Rate (%) (Mean±SE)		Number of Roots (mean±SE)		Mean Length of Roots (mm) (Mean±SE)		Rooting Rate (%) (Mean±SE)		Number of Roots (Mean±SE)		Mean Length of Roots (mm) (Mean±SE)	
Sand [SA]	10.00 ± 0.00	c[1]	1.75 ± 0.50	c	10.00 ± 1.35	c	7.50 ± 5.00	b	1.25 ± 0.96	b	6.50 ± 4.34	b
Perlite [PL]	17.50 ± 5.00	bc	2.38 ± 0.48	ab	12.63 ± 0.11	b	12.50 ± 5.00	ab	2.38 ± 0.48	ab	10.24 ± 0.62	a
Vermiculite [VE]	12.50 ± 5.00	bc	2.50 ± 0.58	ab	13.67 ± 0.73	ab	15.00 ± 5.77	ab	2.25 ± 0.29	ab	10.30 ± 0.56	a
Mixture of [PL+VE]	22.50 ± 5.00	b	2.54 ± 0.42	a	13.65 ± 0.19	ab	15.00 ± 5.77	ab	2.38 ± 0.48	ab	10.39 ± 0.28	a
Peat moss [PM]	40.00 ± 8.16	a	2.68 ± 0.13	a	14.74 ± 0.20	a	20.00 ± 0.00	a	2.50 ± 0.41	a	11.08 ± 0.50	a
Mixture of [PM+PL]	37.50 ± 12.58	a	2.64 ± 0.33	a	14.21 ± 0.21	a	20.00 ± 8.16	a	2.46 ± 0.42	a	11.04 ± 0.59	a

(1) Means followed by the same alphabet in a column are not significantly different based on DMRT (at p< 0.01)

Table 2. Effect of NAA concentration on rooting of the cuttings (after 30 days of planting).

NAA Concentration (ppm)	Tainung No.2 (V1)						Red Lady(V2)					
	Rooting Rate (%) (Mean±SE)		Number of Root (Mean±SE)		Length of Root (Mm) (Mean±SE)		Rooting Rate (%) (Mean±SE)		Number of Root (Mean±SE)		Length of Root (mm) (Mean±SE)	
0	5.00±5.77	c[1]	0.75±0.96	b	3.88±5.01	d	2.50±5.00	c	0.25±0.50	c	1.00 ± 2.00	d
1000	37.50±5.00	a	2.94±0.24	a	12.00±0.32	a	15.00±5.77	b	2.63±0.48	b	8.89 ± 0.47	b
2000	35.00±5.77	a	2.77±0.16	a	10.98±0.27	ab	35.00±5.77	a	3.35±0.29	a	11.02 ± 0.50	a
3000	17.50±5.00	b	2.75±0.29	a	9.18±1.15	abc	30.00±0.00	a	2.75±0.32	ab	9.68 ± 0.18	ab
4000	10.00±0.00	bc	2.50±0.58	a	6.50±0.79	bcd	17.50±5.00	b	2.75±0.29	ab	8.03 ± 0.32	bc
5000	12.50±5.00	bc	2.13±0.63	a	5.87±1.50	cd	12.00± 5.00	b	2.12 ±0.25	b	6.50 ± 0.58	c

(1) Means followed by the same alphabet in a column are not significantly different based on DMRT (at p< 0.01).

Table 3. Effect of IBA concentration on rooting of the cuttings (after 30 days of planting).

IBA Concentration (ppm)	Tainung No.2 (V1)						Red Lady (V2)					
	Rooting Rate (%) (Mean±SE)		Number of Root (Mean±SE)		Length of Root (Mm) (Mean±SE)		Rooting Rate (%) (Mean±SE)		Number of Root (Mean±SE)		Length of Root (mm) (Mean±SE)	
0	5.00±5.77	d[1]	0.75±0.96	d	2.38±2.75	e	2.50±5.00	d	0.50±1.00	e	0.88±1.75	c
1000	37.50±5.00	c	2.63±0.32	c	14.73±0.21	bc	17.50±5.00	c	2.25±0.29	d	10.58±0.33	b
2000	50.00±0.00	b	3.55±0.19	b	16.87±0.49	ab	32.50±5.00	b	3.79±0.25	c	10.88±0.09	b
3000	85.00±5.77	a	5.61±0.12	a	18.25±0.25	a	42.50±9.57	b	4.59±0.18	bc	11.34±0.19	ab
4000	80.00±0.00	a	5.53±0.21	a	13.20±0.27	c	60.00±8.16	a	5.33±0.12	ab	11.90±0.16	ab

5000	55.00±5.77	b	3.96±0.18	b	10.04±0.44	d	65.00±5.77	a	5.58±0.13	a	12.83±0.14	a

(1) Means followed by the same alphabet in a column are not significantly different based on DMRT (at p< 0.01).

Effect of PGRs on rooting of the cuttings in 'Tainung No.2' and 'Red Lady' papaya.

Effect of PGRs concentrations on rooting of the cuttings.

Effect of NAA Concentrations on Rooting of the Cuttings

The rooting rate, number and length of roots in two varieties were significantly affected ($p < 0.01$) by the NAA concentration variation (Table 2). The highest results of all parameters (the rooting rate, number and length of root) achieved in 1,000 ppm (37.5%, 2.94 roots/a cutting, 12.00 mm respectively) and 2,000 ppm (35%, 2.77 roots/a cutting, 10.98 mm respectively) NAA in V1, while the best results for cutting propagation of V2 were recorded in 2,000 ppm and 3,000 ppm NAA. The lowest results for all parameters in both V1 and V2 were recorded in control treatment without NAA in both varieties.

Effect of IBA Concentrations on Rooting of the Cuttings

The cultivars V1 and V2 responded in different manners to the increasing levels of IBA. The rooting rate, number and length of root increased linearly as did the concentration of IBA in V2, while rooting rate, number and length of root of V1 better fit a quadratic curve in response to increasing levels of IBA; that is, rooting success decreased at the highest concentration of IBA (5,000 ppm) for this cultivar (Table 3). The lowest values in most of the parameters were observed without treating PGRs in both V1 and V2. The best results of rooting rate, number of root and root length in 'V2' (60% and 65%, 5.33 and 5.58 roots/a cutting, 11.90 and 12.83 mm respectively) were reached with both 4,000 and 5,000 ppm IBA, while the highest rooting rate (85%), number and length of root (5.61 root/a cutting and 18.25 mm) obtained by treating IBA of 3,000 ppm compared to other IBA concentrations ($p<0.01$).

Effect of Type of PGRs on Rooting of the Cuttings

The effect of types of PGR on the rooting of the cutting in two varieties (V1 and V2) was significant at 0.01 probability levels. Rooting rate, number and length of roots of the cutting in both V1 and V2 were better in IBA treatments than in NAA ones (Figure 4, 5).

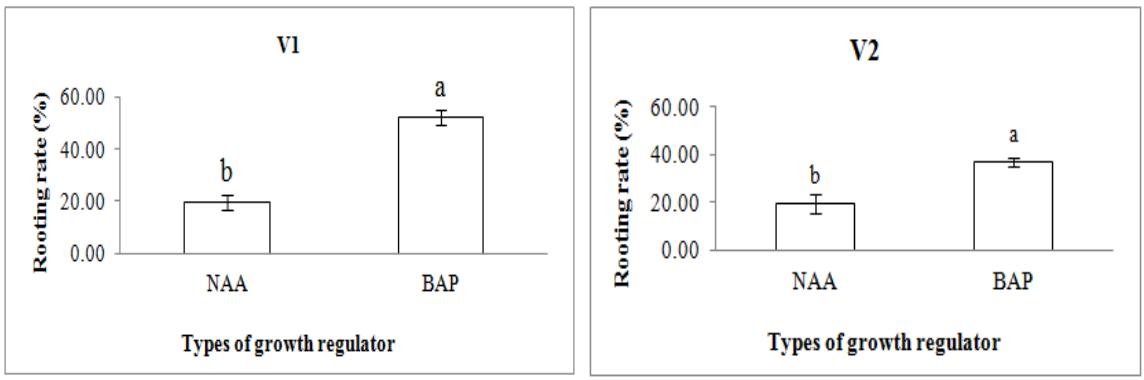

Fig. 4. Effect of type of growth regulator on rooting rate in cutting propagation for two papaya cultivars: V1: 'Tainung No.2' papaya; V2: 'Red Lady' papaya.

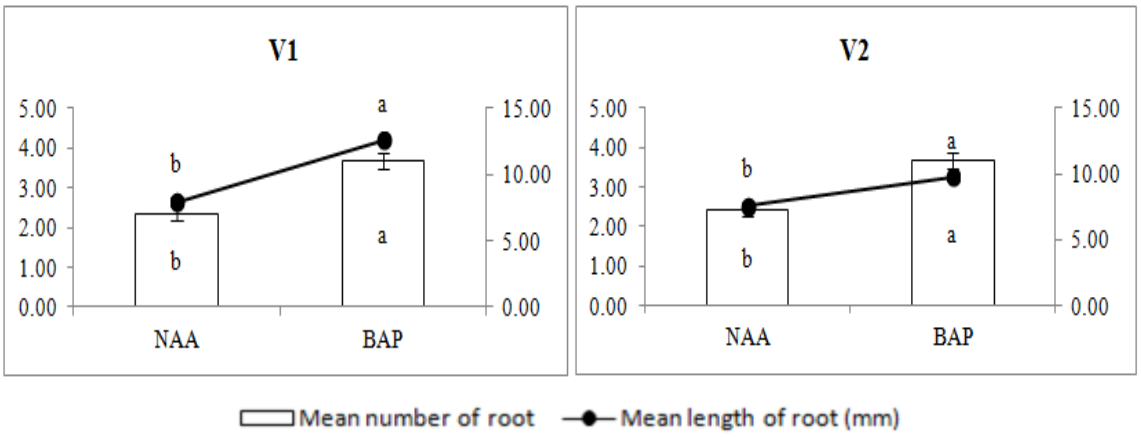

Fig. 5. Effect of type of growth regulator on mean number and length of root in cutting propagation for two papaya cultivars: V1: 'Tainung No.2' papaya; V2: 'Red Lady' papaya.

Effect of Varieties on Rooting of the Cuttings in Treating by NAA and IBA

There were different responses in different manners of V1 and V2 to PGRs. For comparison influence of IBA to rooting of V1 and V2, there were significant differences between the V1 and V2 in most of parameters ($p<0.01$). The data in this study candidate that rooting rate and length of root were in V1 better than in V2 and number of root in V1 is higher than in V2, but the effect was not significant ($P<0,01$) (Figure 6b). In contrast, in the presence of from 0 to 5,000 ppm NAA, there were no significant differences between the V1 and V2 in parameters (Figure 6a).

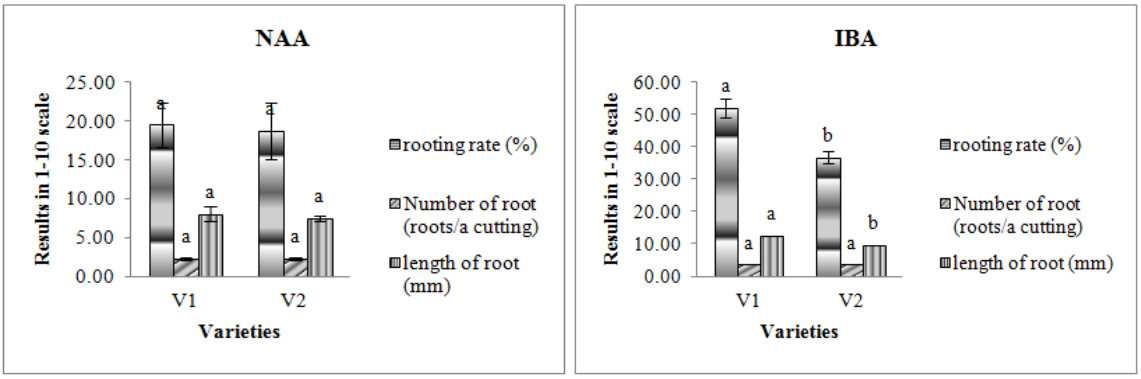

Fig. 6. Response of V1 and V2 papaya cuttings to rooting rate, number of root, mean length of root in treating by PGRs (30 days after planting) : (a): NAA ; (b): IBA.

IV. Discussion

Effect of Types of Substrate

Substrate propagation with oxygen, water and nutrient availability is known to affect the success of rooting ([28]-[29]. Poor aeration reduce respiration at the base of the cuttings [30] and is leading to decay of cuttings before root initiation due to waterlogged situations [31] . This problem was found in [SA] and [VE] substrates in this study. This is a explanation for lower rooting results of the cuttings in both substrates compared with other substrates. [PL] substrate with low water holding capacity did not facilitate holding of water to supply stable moisture for the cuttings [32]. The data shown that combination of [PL] and [VE] did not improve the rooting results compare with [PL] alone.

The well balanced oxygen and water-holding capacity of substrate propagation can promote oxygen availability, transpiration, nutrient uptake, growth and aeration during root initiation of the cuttings. Peat moss is fine textured with better moisture content and aeration flow between the particles [7]. Rabeea et al. [33] reported that [PM] substrate improves aeration condition (more porous, proper moist condition, good infiltration and aeration) with forming greater root system and promotes shoot nutrition uptake. In this study, the best success in root initiation of both varieties (V1 and V2) using [PM] or a mixture of [PM+PL] could be attributed to the positive interaction of aeration and water holding capacity, as compared to other substrates. In agreement with this results, Hafiz et al. stated that the use of [PM] is appropriate for rooting of papaya and promotes rooting of papaya cuttings [7]-[34] . Rabeea et al. [33] also had the similar in an application of [PM] to the Strawberry.

The rooting of cuttings is varied by the species to be propagated [13]. In this study, though [PM] and Mixture of [PM+PL] were demonstrated to be the best substrate for rooting of both V1 and V2 cuttings under initiating root by 1,000 ppm IBA the results of rooting in V1 was higher than those in V2. This may be due to the rooting response to combination of the substrates and 1000 ppm IBA by different varieties (V1 and V2).

Effect of Growth Regulator

In cutting propagation, auxins promotes the root ability of stem cuttings in many plant species [9]-[20]. However, a number of other tropical tree species formed roots successfully without applied auxin [31-[35]-[36]. Such results may be a effect of endogenous auxin in adventitious root formation of cuttings [9]. Whereas, application of exogenous auxin is needed to promote rooting of stem cuttings in many rooting recalcitrant species [37]-[38]. The better rooting response to cuttings by auxin treatment is due to accumulation of metabolites at the cut surface of application, synthesis of new protein, callus formation, cell division and cell enlargement [39]- [9]-[40]. In this study, the control treatment without NAA or IBA was found the very low rooting success and is the lowest result compared with other treatments having these auxin appearances. This evidences that application auxin in the two papayas propagation is needed.

Effect of Type of Auxin:

IBA and NAA are known as auxins to accelerate the rooting on stem cuttings [19], [21]. Effect at promoting root formation on stem cuttings of IBA and NAA is different at the same specials. NAA was more effective than IBA at promoting root formation on stem cuttings of Nyssa aquatica and Nyssa ogeche [41]. However, It has been documented that IBA promote adventitious rooting of stem cuttings more effectively than NAA in cutting propagation of many specials ([42]- [43]- [44]- [10]. In this regard, as in many other crops, rooting rate, number and length of root in both V1 and V2 was found better with treatment of IBA as compared to NAA in this study. In agreement, Yimsawat and Feungchan [45] reported that IBA had more strong beneficial effect than NAA at promoting rooting of papaya cutting. Many researchers treated stem cutting to increase the rooting success in some cultivars of papaya [46]-[12]-[44]. This demonstrated that application IBA is more effective than NAA in papaya cutting propagation.

Effect of Auxin Concentration

Besides the type of auxin, concentration of rooting auxin is an important respect in use of auxin in cutting propagation. The contrasting effects of auxin concentration have been found with different tree species. There are many deviations in the range of optimum NAA concentration on cuttings of different plant species. For

example, NAA concentrations of 200 ppm, 2000 ppm, 3000 ppm and 4000 ppm were determined the effective concentrations in cutting propagation of Hemarthria compressa [47] , Manhattan euonymus and 'Bright Golden Princess Anne' chrysanthemum [48] and *Zizphus spinosus* [49] respectively. Like auxin NAA, IBA has been applied for rooting of many tropical trees such as *Ricinodendron heudelotti* [11], *Azadirachta indica* [43], *Cabralea canjerana* [50] and *Eplingiella fruticosa* [51] at different optimum concentration of 200, 300, 100, 500, 3000 and 1500 ppm respectively. In this study, the optimum NAA and IBA concentrations for rooting of papaya stem cutting were recorded by 1,000-2,000 ppm and 3000 ppm in V1, 2,000-3,000 ppm and 4,000-5,000 ppm in V2 respectively. The difference may be due to response in initiation root of different tree specials to auxin concentration.

In a certain concentration range of exogenous auxins, rooting success increased linearly as did the concentration of auxins used. In this study, rooting rate, number and length of root in V2 were improved with increasing IBA concentration from 0 to 5,000 ppm. The opinion is consistent with claimed research of cutting propagation in other tree specials such as *Triplochiton scleroxylon* [39], *Nauclea diderrichii* [35], *Cabralea canjerana* [50], *Plukenetia polyadenia* [52] . In papaya 'Golden' propagation by cutting, Omar Schmildt et al. [53] stated that rotting rate increased linearly as did the IBA concentration.

Many researchers claimed in many reports in tropical tree cutting propagation that rooting is reduced when the used auxin exceeds the optimal concentrations [48]-[11]-[47]-[43]-[50]-[51]-[55]. In this study, NAA concentrations greater than 2000 in V1 and 3000 in V2 or with IBA concentrations greater than 3,000 ppm reduced the rooting rate, as well as number and length of root. In agreement with this opinion, Omar Schmildt *et al*. [53] reported that percentage of rooting was reduced with IBA concentration greater than 1,500 ppm in cutting propagation of 'Uenf/Caliman 01' papaya. This may cause the inhibitory to root initiation or cell death at auxin concentrations greater than to effective dosage [9]-[35].

Effect of Varieties

Clones of many plant species have a large difference in rooting ability of the cutting [23]-[24]. There are many studies reported variations in the rooting ability of the cutting within different genotypes in the same locations [25]-[26]. Mesen [54] and Mabizela [10] reported that clones of Cyclopia subternata and Cordia alliodora respectively was statistically significant for rooting of the cuttings under the influence of auxin concentration. In papaya cutting propagation, Omar Schmildt *et al*. [53] stated that the cultivars 'Golden' and 'Uenf/Caliman 01' responded in a different manner to the IBA concentrations. Many reported studies in papaya cutting propagation shown that a large variation of optimum IBA concentrations for rooting was found in different cultivars [45]-[12]. In this study, cultivars V1 and V2 responded in almost of parameters to IBA concentration, while rooting rate, number and length of root had different values between V1 and V2 in response to NAA concentration, but effects were not statistically significant. This may cause the difference in rooting response of combination of cultivars and PGRs concentration.

V. CONCLUSION

The results of experiments indicated that type of substrate affect the success in cutting propagation of 'Tainung No. 2' and 'Red Lady' papaya. Peat moss or a mixture (50:50 by volume) of peat moss + perlite promoted higher rooting in propagation of both varieties compared with other substrates and rooting of cuttings

in ‘Tainung No. 2’ was stronger than doing in ‘Red Lady’. Growth regulators type and concentration affect rooting of cutting in propagation of ‘Tainung No. 2’ and ‘Red Lady’ papaya: IBA promoted higher rooting in propagation of both varieties compared with NAA; Among 5 level concentrations (0, 1,000, 2,000, 3,000, 4,000 and 5,000 ppm), optimum IBA concentrations for promoting rooting of ‘Tainung No.2’ and ‘Red Lady’ cuttings were 3,000 ppm and 4,000-5,000 ppm respectively and optimum NAA concentrations for rooting of ‘Tainung No. 2’ and ‘Red Lady’ cuttings were 1000-2000 ppm and 2000-3000 ppm respectively; In application IBA, rooting response in ‘Tainung No.2’ cuttings was stronger than doing in ‘Red Lady’ cuttings, while there was no significant difference in rooting response of both varieties cuttings when application NAA. The results commend that we could apply IBA by 3,000 ppm for tainung No.2’ and by 4,000-5,000 ppm for ‘Red Lady’ in cutting propagation.

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