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The study of effectiveness root-up types and concentrations on root growth rate of potato (*Solanum tuberosum* L.) derived from cutting bud

E Ishartati¹, Sukardi², M J Mejaya³, A Zakia¹ and R Mardianto⁴

¹ Agrotechnology Department, University of Muhammadiyah Malang

² Food Science and Technology Department, University of Muhammadiyah Malang

³ Indonesian Center and Development for Food Crops Research and Development

⁴ Researcher

Email: ishartati.erny@gmail.com

Abstract. The aim of this study is to know the effect of root-up size and concentration on root potato growth on the number of different leaf stem leaves. This research was conducted using Randomized Complete Block Design at 3 factors and 3 replicates. The first factor was the Root-up Types [RT], consisting of R_A, R_B, R_C, and Rotten-F (as a comparison); the second factor was Root Up Concentration [RC] consisting of C5%, C10%, C15%, C20%, and C25%; and the third factor was the Number of Leaf on the Cuttings [NL] consisting of NL-1, NL-2, and NL-3. The contrasting orthogonal test shows Root-Up vs Control treatment was highly significant in all observed variables, except in stem diameter was increased. Based on data analysis, the Root-up vs Control treatment had a very real effect on all variables, except in stem diameter increase. In Root-up treatment: RT-RC-NL, there were no significant interaction in all observed variables. In RT-RC, there were an interaction between shoot height increase, number of leaves, and root length. RT_C with concentrations of 10-25% showed higher growth, better leaf count and root length. In RT-NL, interaction occurs on number of leaves, RT_C with the number of leaves 1, 2, and 3 on the shoot cuttings showed a better number of leaf. RC-NL occurred in the interaction of the increase in shoot height and number of leaves. RC of 20% with NL 1, 2, and 3 on shoot cuttings show highest increase and highest leaf number. Based on this study, the use of Root-up C with 10-20% concentration could be used as a reference for shoot cuttings multiplication.

1. Introduction

Potato (*Solanum tuberosum* L.) is one of commodities that has potential as the source of alternative carbohydrate, for food diversification program. Therefore, this commodity gets priority from the government to be developed in Indonesia. However, the availability of potato seeds currently only reaches 15% of the total requirement of 300 thousand tons of seed per year [1-3]. The fast and simple methods for seed multiplication, is using cuttings of buds.

Spinning buds are vegetative parts that can be used for plant propagation. Vegetative propagation was one way of propagation in a very simple way, does not require complex techniques that can be done by anyone [4-5]. The advantages of cuttings are the rapid mass propagation of selected clones and propagation may be done in both *in vitro* and *ex vitro*, which increases the propagation rate [6]. In



this study, the stem cuttings originated from buds grown through tissue culture. The success of plant growth by way of cuttings was marked by the formation of roots.

To prepare the cuttings to be planted, to be fast and have normal growth, it was necessary the addition of Growing Regulatory Substances (GRs) to stimulate root growth. The price of GRs in the market was less accessible to farmers, so we need to find alternative GRs with affordable price. Growth regulator substances (GRs) are non-nutrient organic compounds but able alter the physiological processes of plants. There are several kinds of growth regulator substances such as auxin, cytokinin, and gibberellin. Auxins, gibberellins, and cytokines are types of GRs that interact in stimulating the growth and development of plants. Auxins play a role in the physiological processes of plants that encourage cell extension, cell division, xylem and phloem network differentiation, root formation, encourage apical dominance, and inhibit leaf fall [7-11]. Gibberellin plays a role in cell division and growth leading to stem lengthening and leaf development to progress more rapidly, resulting in increased photosynthesis and increasing overall growth, including roots [9-10]. Cytokinin was one of GRs that serves spur cell division and formation of organs, enlargement of cells and organs, prevent chlorophyll damage and chloroplast formation, senescence delay, opening and closing stomata, the development of bud and bud eyes. GRs was compounded that come from outside plants that act like hormones. GRs comes from both synthetic and natural. GRs from natural ingredients derived from various types of plant materials, including aloe vera as auxin source, bamboo shoot as a source of gibberellin, coconut water source cytokinin, and many other plants. The use of natural GRs was an easily accessible alternative around us and relatively inexpensive.

The use of cuttings of buds with a certain number of leaves associated with the mother plant inventory, the less the number of leaves on the cuttings of seedlings that have the potential for seed, the more the number of cuttings that can be used for seed stock. Leaf on shoot cuttings, according to [11], was a catalyst for the formation of roots, but if too many of them increase the intensity of evaporation so that root formation was inhibited. The presence of leaves was very important, given the leaves play a role to produce carbohydrates through the process of photosynthesis [5]. Added by literature [12], carbohydrates derived from the leaves will be moved towards the bottom of the cuttings to produce the energy needed in root development.

The purpose of this study is to test the effectiveness of different types and concentrations of Root-up applied to potato leaf cuttings with different leaves to root growth of potato cuttings (*Solanum tuberosum* L.) resulting from tissue culture.

2. Research methods

The research was conducted in Jurangkuali, Sumber Brantas Village, Bumiaji District, Batu City, East Java Province, at altitude 1700 meters above sea level, rainfall average 195,83 mm/year and temperature ranged from 24 to 27°C. The tools used in this research were the seed box, scalpel blade, plastic nursery, gloves, tray, bucket, hand sprayer, petri dish, scales, ruler, camera and stationery. The materials used in this research are potato cultivars Madisu AP-4, NAA, BAP, GA3, Bamboo, Aloe vera, Soybean sprouts, Coconut Water, Coal Husk, Rootone F, Agar, and disinfectant. Root-up A [RA] was a combination of NAA, GA3, and BAP hormones; Root-up B [RB] was a combination of NAA, GA3, BAP, and macronutrients; and Root-up C [RC] was a combination of bamboo shoots, Aloe vera, and coconut water. Randomized Complete Block Design with 3 factors and 3 replications was used in this study. The first factor was Root-up, consisting of R_A, R_B, R_C, and Rooten-F (as comparison), second factor was Root Up Concentration consist of C5%, C10%, C15%, C20%, and C25%, and factor the third was the number of leaves on the shoot cuttings consist of N1, N2, and N3. Observation variables included when the roots appeared, the height increase buds, the increase of the number of leaves, the increase in diameter of the stem, and the length of the roots. A variant analysis was performed on the result of observation, followed by Honestly Significant Different Test of 5% level if there was a real difference between treatments. The difference in effect between control and treatment combinations was analysis by Orthogonal Contrast Test at 95% confidence level.

3. Results and discussion

3.1. Root-up vs. control (Rooten F)

The result of contrast orthogonal test between Root-up and Control (Rooten F) treatment had a very real effect on all observation variables, except for variable of stem diameter. Based on Figure 1 it appears that the Variable when shoots appear [A], the control treatment was faster than the Root-Up treatment, whereas the height increase of cuttings [B], Number increase number of Leaves [C], and Root Length [E] good when compared to control (Rooten F).

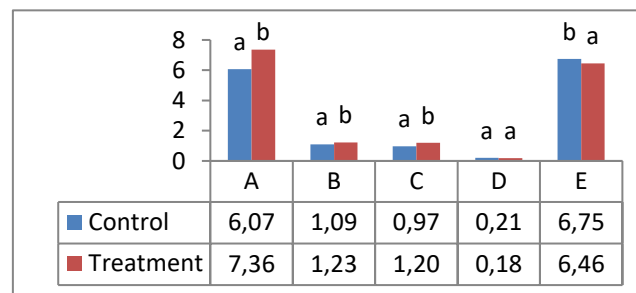


Figure 1. Contrast orthogonal test between root-up and control for all observed variables. The mean values accompanied by the same letter indicate differently was not really based on BNJ test at 5% level. A: Variable when shoots appear (day), B: Variable height increase of cuttings (Cm), C: Variable increase number of Leaves, D: Variable increase of Diameter (Cm) and E: Variable Root Length (Cm).

The Root-F control variable was faster than Root-Up because Rooten F contains two active auxin ingredients, NAA, and IBA which can help accelerate root removal in cuttings, while Root-Up contains only a single auxin namely NAA. It was in accordance with the results of research [13] who get when the root appears on the Rooten F treatment most quickly.

Variable of height increase of cuttings, increase the number of Leaves, and Root Length indicated that Root-Up treatment was better than control. Root-Up was a combination of NAA, GA3, BAP, which all three types of GRs can synergize to produce optimal growth. NAA serves to encourage root growth and growth of cuttings, GA3 serves for the growth of shoots, elongation of stems, and leaf growth, while the BAP function spur cell division and the formation and enlargement of plant cells and organs. The combination of the three [NAA, GA3, and BAP] helps in the process of accelerating growth, both in roots and stems, and accelerates in cell division. This indicates that the combination of synthetic and organic GRs materials used in the manufacture of GRs has a significant effect on the growth of cuttings, especially on the high variables of cuttings, number of leaves, and root length.

3.2. Days of roots appears

In the variables when the roots occur the interaction was not really between the studied acts, but separately only the treatment of Root-up concentration that significantly affected. The mean value of the Root-up concentration treatment was presented in Figure 2. From Figure 2, the Root-Up Treatment with 15% concentration showed when the roots appeared faster than the 5% concentration but differed from the other treatments.

Application of 15% Root-Up concentration turned out to have an optimum effect to stimulate the appearance of buds, although not significantly different with concentrations of 10%, 20%, and 25%. The effectiveness of GRs in plants was influenced by the concentration given because the different concentrations will cause different activities. In addition, the difference in GRs activity was also determined by the cuttings of the species used. This was consistent with the literature [14] which stated that exogenous GRs should be appropriate if too high would be detrimental whereas low

concentrations are ineffective. The results of research on sweet potato *in vitro* and *ex vitro* in the literature [15] and at potato cuttings [12] will accelerate the growth of shoots. According to literature [16], exogenous GRs applications in plants can function to spur the formation of phytohormones, thus promoting a biochemical activity. Phytohormones as organic compounds that act actively in small amounts are usually transformed into all parts of the plant so as to affect the growth or physiological processes of the plant.

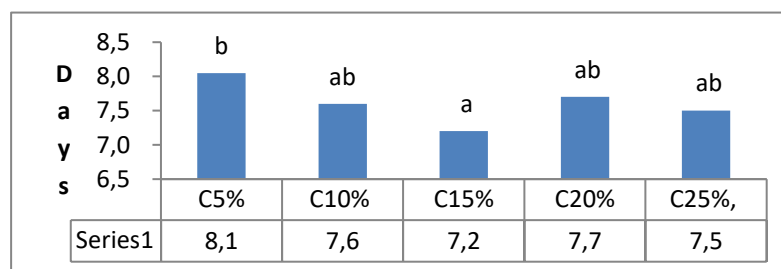


Figure 2. Average of days shoots appear due to differences in root-up concentration. The mean values accompanied by the same letter indicate differently was not really based on BNJ test at 5% level. C5%: Root-up concentration 5%; C10%: Root-up Concentration 10%, C15%: Root-up Concentration 15%, C20%: Root-up Concentration 20%, and C25%: Root-up Concentration 25%.

3.3. Shoot height increase

In the variable of shoot height increase there was an interaction between Root-up size and concentration at observation at day 30 after planting, and between Root-up concentration and leaf number at age of observation 14 days after planting. The mean values of Root-up and Root-up concentrations are presented in Fig. 3, and the mean values of Root-up concentration and the number of leaves in Figure 4.

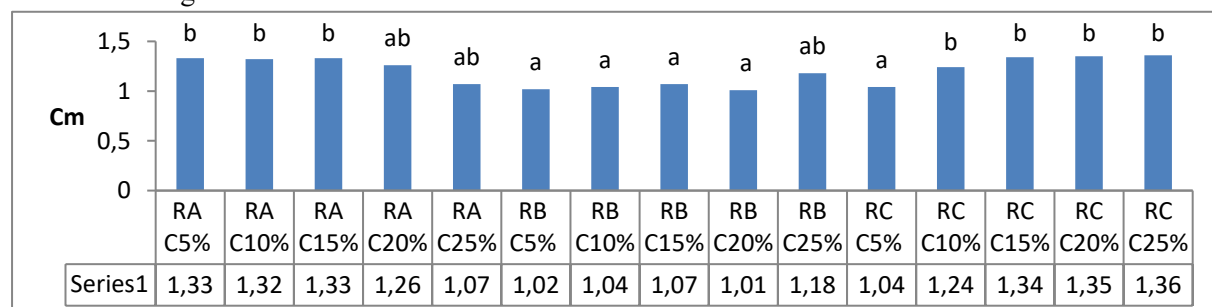


Figure 3. Mean shoot height increase due to interaction kind and concentration root-up. The mean values accompanied by the same letter indicate different is not real based on BNJ test at 5% level. RA-C5%: Root-up A-5% Concentration; RA-C10%: Root-up A-Concentration 10%; RA-C15%: Root-up A-Concentration 15%; RA-C20%: Root-up A-Concentration 20%; RA-C25%: Root-up A-Concentration 25%. RB-C5%: Root-p B-Concentration 5%; RB-C10%: Root-up B-Concentration 10%; RB-C15%: Root-up B-Concentration 15%; RB-C20%: Root-up B-Concentration 20%; RB-C25%: Root-up B-Concentration 25%. RC-C5%: Root-up C-Concentration 5%; RC-C10%: Root-up C-Concentration 10%; RC-C15%: Root-up C-Concentration 15%; RC-C20%: Root-up C-Concentration 20%; RC-C25%: Root-up C-Concentration 25%.

The content of auxin, gibberellin, and cytokines contained in Root-Up A and C are able to interact in stimulating the growth of shoot height. The addition of GRs from outside the plant can maximize the GRs work that is naturally present in the plant. In the nursery phase by the cuttings method, the use of GRs can directly improve the quality of the seedlings as well as reduce the number of seeds that grow abnormally [17]. Application of GRs from outside (exogenous) containing auxin can support the

activity of auxin in the cuttings, thus helping to speed the process of differentiation of cells to form new cells.

Root-Up concentrations of 15%, 20% and 25% on the number of leaves 1, 2, and 3 showed the same results. This indicates that the Root-Up concentration with the corresponding number of leaves can affect the increase in shoot height. The effectiveness of exogenous GRs given is strongly influenced by the concentration given, because different concentration will cause different activity, besides the existence of the number of leaf is also very important, considering the leaf acting to produce carbohydrate through a process of photosynthesis [5]. Carbohydrates derived from the leaves will be transferred to other cuttings to produce the energy needed in plant growth [11].

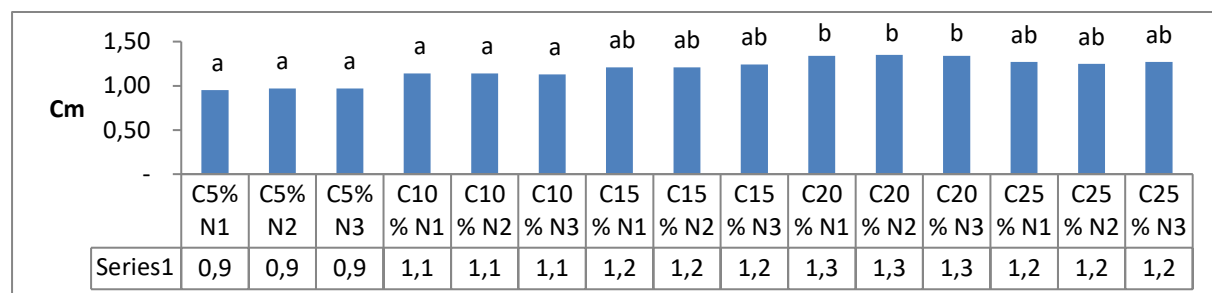


Figure 4. The average shoot height due to interaction of root-up concentration and number of leaf shoots. The mean values accompanied by the same letter indicate different is not real based on BNJ test at 5% level. C5% -N1: 5% Concentration -Number of Leaves 1; C5% -N2: 5% Concentration -Number of Leaves 2. C5% -N3: 5% Concentration -Number of Leaves 3. C10% -N1: 10% Concentration -Number of Leaves 1. C10% -N2: 10% Concentration -Number of Leaves 2; C10% -N3: 10% Concentration -Number of Leaves 3. C15% -N1: 15% Concentration -Number of Leaves 1. C15% -N2: 15% Concentration -Number of Leaves 2. C15% -N3: 15% Concentration -Number of Leaves 3. C20% -N1: 20% Concentration -Number of Leaves 1. C20% -N2: 20% Concentration -Number of Leaves 2; C20% -N3: 20% Concentration -Number of Leaves 3. C25% -N1: 25% Concentration -Number of Leaves 1; C25% -N2: 25% Concentration -Number of Leaves 2; C25% -N3: 25% Concentration -Number of Leaves 3.

3.4. Increase in leaves number

In the variable of leaf number increase, there was an interaction between type and Root-up concentration at 14 days after planting age, root-up and leaf number at 14 days after planting, and Root-up concentration and leaf number at age 28 day after planting. The mean values of Root-up and Root-up concentrations are presented in Fig. 5, the Root-up and the number of leaves in FIG. 6, and the Root-up and leaf concentration in Fig. 7.

In Figs. 5, 6 and 7, Root-up C with concentrations of 10% to 25% of shoots with 1, 2, and 3 leaf buds showed a higher leaf number than other treatments. Root-up C is a natural GRs which is a combination of extract bamboo shoots, aloe vera, and coconut water. Based on the results of laboratory testing of Environmental Biotechnology Laboratory, Indonesian Center for Biodiversity and Biotechnology (ICBB) showed that per-100 ml of bamboo shoot extract contain 8.116 ppm gibberellin. According literature [18], in addition to gibberellin, bamboo shoots contain protein, fat, carbohydrate, macronutrients (N = 7.56%, P = 0.86% and K = 15.58%) needed by plants. Gibberellin function to spur the growth of plants, by spurring cell division leads to stem lengthening and leaf development.

Rapid leaf growth will increase the rate of photosynthesis increases, increasing overall growth, including roots. The result of research [19] showed that bamboo shoot extract with dos 50 ml/seeds showed the highest yield for a seedling of *Albasia* seedlings. At Aloe vera, according to previous study [20] contained Auxin and Gibberellin hormones. In addition to these two hormones, Aloe vera amino acids, vitamins and minerals that are able to encourage the growth of cuttings [20]. The previous [21]

showed that, the application of Aloe vera gel could increased root growth of cuttings of cat's whiskers, while yields of 50% cilantro vanilla cuttings increased leaf growth, shoot dry weight, and root length. While in coconut water, the results of testing at the Laboratory of the Environmental Biotechnology Laboratory, Indonesian Center for Biodiversity and Biotechnology (ICBB) showed that per-100 ml coconut water contains cytokinin in the form of zeatin 3,122 ppm and kinetin 4,557 ppm, with chemical and nutrient complete (hormone, macronutrients, and micronutrients) so that when applied to the plant will have a positive effect on the plant. Coconut water is a liquid endosperm containing diphenyl urea so it can spur cell division. The results of the study showed that coconut water immersion can accelerate the growth of sleeping buds on *Ficus carica* seedlings, the growth of high cuttings [22], and the percentage grows 90% of pepper cuttings [23].

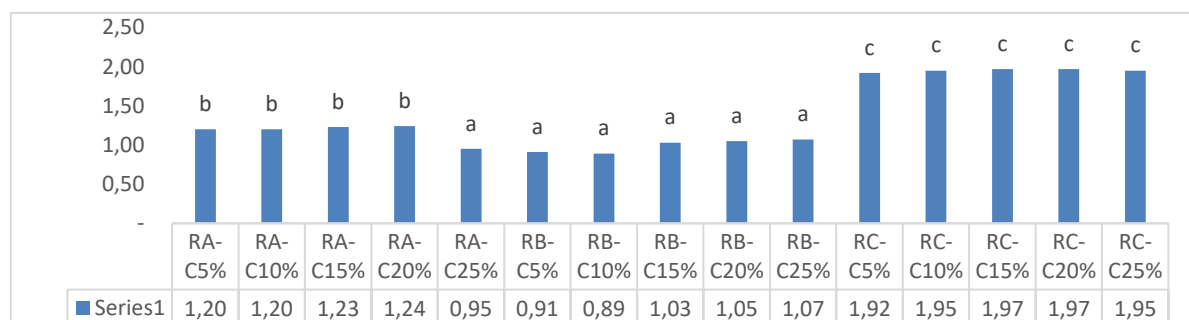


Figure 5. Mean of leaf number increase due to interaction kind and concentration root-up. The mean values accompanied by the same letter indicate differently is not really based on BNJ test at 5% level. Detail see Figure 3.

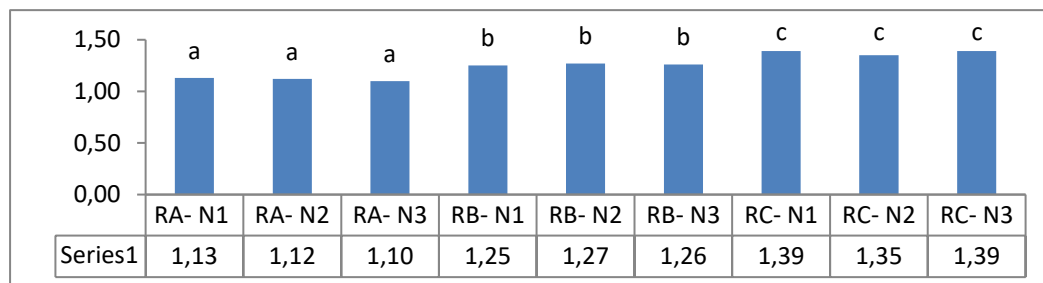


Figure 6. Mean of leaf number increase due to interaction kind and leaf amount. The mean values accompanied by the same letter indicate differently is not really based on BNJ test at 5% level. RA-N1: Root-up A-Leaf Amount 1; RA-N1: Root-up A-Leaf Number 2; RA-N1: Root-up A-Leaf Amount 3. RB-N1: Root-up B-Leaf Amount 1; RB-N1: Root-up B-Number of Leaves 2; RB-N1: Root-up B-Leaf Amount 3. RC-N1: Root-up C-Number of Leaves 1; RC-N1: Root-up C-Number of Leaves 2; RC-N1: Root-up C-Leaf Amount 3.

3.5. Stem diameter increase

On bar diameter variable there is no significant interaction in all treatment, also on each treatment. This is probably due to the not optimal growth of shoots cuttings studied so that the increase in diameter cannot be seen.

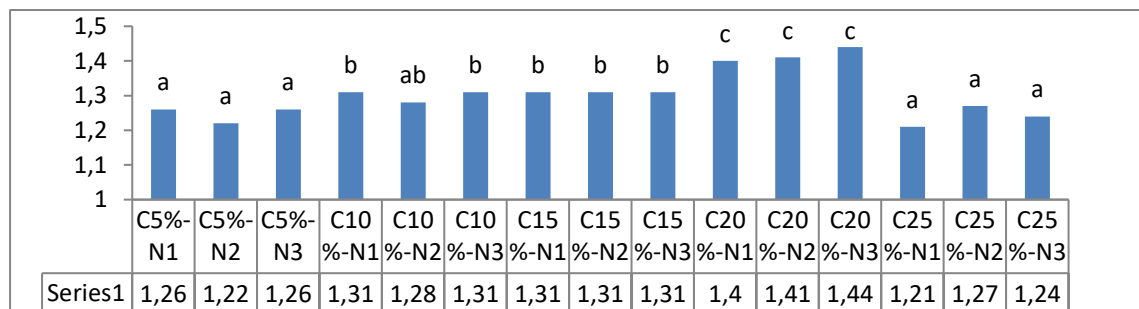


Figure 7. Mean of leaf number increase due to the interaction of root-up concentration and leaf number. The mean values accompanied by the same letter indicate differently is not really based on BNJ test at 5% level. Detail see Figure 4.

3.6. Root length

In the variable length of the root, there is a real interaction between the kind acts and the Root-up concentration. The mean root value of Root-up Type - Root-up Concentration is presented in Figure 8. It is seen that Root-Up C root length is relatively long compared to other Root-up. Root-Up C is a natural GRs consisting of a combination of bamboo shoot extract, Aloe vera, and coconut water.

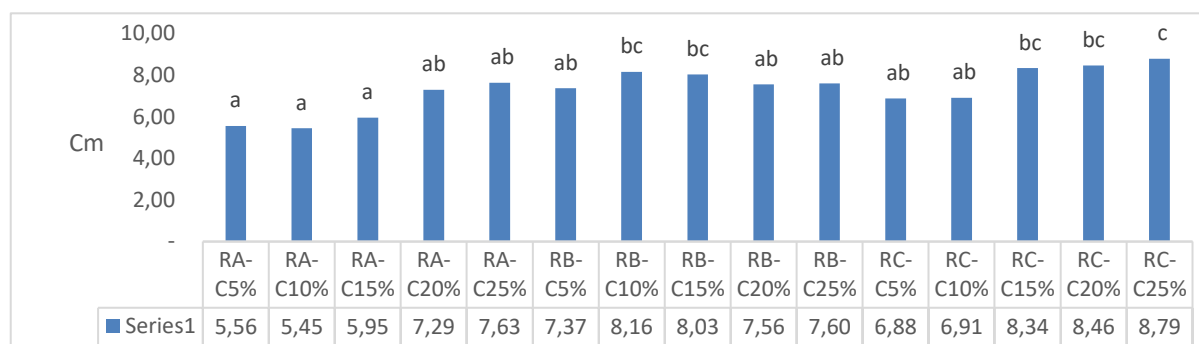


Figure 8. Mean root length due to interaction kinds and root-up concentrations. The mean values accompanied by the same letter indicate differently is not really based on BNJ test at 5% level. Detail see Figure 3.

Bamboo shoots extract contains gibberellin hormone, protein, fat, carbohydrate, macronutrients (N, P, and K) (ICBB). Aloe vera extract contains auxin and gibberellin hormones, amino acids, vitamins and minerals [16], while coconut water contains macronutrient hormone cytokines, and micronutrients [21]. The content of GRs and its other element on combination of these three sources can spur cell plant division, especially that leads to leaf development, then increasing photosynthesis. Higher photosynthesis will increase the plant growth rate, including root growth. This is in accordance with the results of research on potato cuttings [4].

4. Conclusions

Based on the results and discussion, it could be concluded that Root-up Treatment vs. Control (Rotten F) have a very significant effect on all observed variables, except stem diameter. On the Root-up treatment, Root-up Type - Root-up Concentration, interaction occurs between shoot height increase, number of leaves, and root length. Root-up C with a concentration of 10% - 25% indicates higher growth, better leaf count and root length; Root-up Type - The number of leaf buds cuttings, interaction occurs on the variable number of leaves, Root-up C with the number of leaves 1, 2, and 3 on the shoot cuttings showed the number of leaves better; Root-up concentrations - The number of leaf budding cuttings occurs interaction on the increase in shoot height and number of leaves. The root-up

concentration of 20% with leaf number 1, 2, and 3 on shoot cuttings showed a higher increase and higher leaf number. Based on this study, the use of Root-up C with a concentration of 10-20% could be used as a reference for the leaf bud proliferation.

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