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Propagation of *Cnidoscolus aconitifolius* using stem cuttings at different maturity stages and growing media

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Abstract

Chaya leaves (Cnidoscolus aconitifolius (Mill.) I.M. Johnst.) are leafy vegetables that contain many vitamins and minerals. Information about the intensification of chaya cultivation is still rare. Chaya propagated by stem cuttings. The maturity level of stem cuttings and planting media were expected to affect the success of plant propagation. This study aims to determine the maturity level of cuttings material that can grow well and deter-mine the type of media that can support the growth of chaya propagation. This research has been carried out from July to October 2022 in an off-campus experimental outdoor facility located in Inderalaya, South Suma-tra. This study was conducted using a randomized block design with 2 factors. The first factor was the level of maturity of stem cuttings material (upper, middle, and basal), and the second factor was the type of growing medium (control, chicken manure, and cow manure). The results showed that the use of cuttings from the mid-dle and basal has a better percentage of growth ability than the upper cuttings. Chaya plants used basal stem cuttings exhibited slower shoot grow but produced higher number of leaves, greater leaf area, canopy area, and biomass. The use of cow manure in a mixture of growing medium gave the best results on growth of chaya plants.

Keywords : leaf yield, manure, perennial vegetable, tropical climate, woody cutting

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1. Introduction

Chaya is a variety of cassava, with the economic value of this plant being its leaves, which are consumed as vegetables. This plant comes from the Yukatan peninsula of Mexico, this plant in its country of origin is better known as Mayan spinach or tree spin-ach while in Indonesia it is often referred to as Japanese papaya. Chaya entered the Asian region through malnutrition management programs. The nutritional content of chaya blade leaves compared to spinach is far supe-rior where: 78% more protein, 111% more fibre, 100% more iron and 242% more vita-min C [1]. In addition, chaya leaves have been found to be an important source of pro-tein, β-carotene, vitamins, ascorbic acid, cal-cium, potassium, and iron [2].

Chaya plants do not produce seeds be-cause pollen of infertile flowers [3]. Chaya propagation is carried out only vegetatively using stem cuttings. The success of cuttings in producing roots is influenced by many factors including, plant parts used for cut-tings, donor plant sources, plant age, cut-tings size, planting media and environmental factors [4], [5]. Research results [6], chaya propagation of different diameters does not show any difference at the beginning of growth but will look different after 11 weeks.

The best cuttings are able to produce balanced roots and shoots. This is related to the availability of energy to grow roots and shoots. The formation of roots on cuttings requires energy obtained from the cuttings themselves. Research results Simatupang et al. [7], Patchouli plant propagation using ba-sal and middle cuttings grows better than using cuttings of shoots. While Wiraswati and Badami [8] Argue, The growth of cat's whisker cuttings whose planting material comes from the base is difficult to take root because this part is generally too old and the skin begins to harden, So that root primordia are difficult to penetrate the cell wall.

In appropriate conditions, the cuttings will produce a new adventitious root system and further regenerate into

new plants. The role of roots as absorbers of nutrients and shoots as leaf producers who play an im-portant role in photosynthesis. In addition to the factor of the maturity level of the cut-tings material, the planting medium also af-fects the growth of cuttings. The function of the plant-ing medium is as a place for plant roots to grow and de-velop. Porosity and lightness of the substrate allow the growth of roots and shoots to be easier, This is due to good circulation of water and oxygen in the media [9]. On the other, media has the main function as a provider of nutrients and water used by plants after the root plants develop. Manure application can improved the physical and chemical properties of the soil [11]. The results of research by Odedina et al 2011 [12], showed the use of 10 tons / ha of manure on cassalva will provide more growth and yield. chicken and cow manure lots of available.

Studies on the intensification of chaya cultivation are still very limited, including research with respect to plant propagation, especially related materials and growing me-dia cuttings. This study was conducted to determine the physiological maturity level of stem cuttings and the in-fluence of media on chaya growth.

2. Materials and Methods

This research has been carried out in an ex-perimental garden in Permata Baru Village (104º46'44" E; 3º01'35"S) Ogan Ilir Regen-cy, South Sumatra, Indonesia, from July to October 2022.

2.1 Preparation of planting material and growing media

Planting material in the form of stem cuttings taken from chaya's garden that has been aged 6 months. Stem cuttings are grouped based on the position of the chaya stem part taken. groupings of planting material include Upper, Meddle, and Basal. Visually grouping can be dis-tinguished by the color of stem cuttings from green to dark brown. Planting material is cut to a length of 25 cm with 5-12 buds (figure 1). Planting using polybags with size 17,5 x 40 cm with media using top soil with the addition of or-ganic matter ratio 2: 1 according to treatment. Organic matter used cow manure and chicken manure.

Figure 1. Preparation of planting material (A, B) and chaya growing medium (C)

2.2 Research Design

This study was conducted with a randomized group design with 2 factors. The first factor is 3 kinds of origin of planting material stem cuttings (upper, middle, basal) and the second factor 3 composition of the growing medium (control, chicken manure, and cow manure). The study was conducted with 3 repetitions and each treatment set consisted of 4 plants so that 108 plants were maintained.

2.3. Data collection and analysis

Variables observed include the initial growth of stem cuttings in the form of percentage of growth power and living buds. As well as observing the growth and yield of chaya plants. Measurements are carried out continuously at 1-10 weeks after planting. Some of the paremeters observed include Bud length, number of leaves, Area of Canopy using Easy leaf area [10], SPAD value (Konica Minolta 502), leaf area gain with predictors of length and width of the middle lobe [6]. Yield parameters include root length, number of shoots, number of branches, diameter of shoots, Fresh weight and dry weight of pruning. Data yang terkumpul dianalisis menggunakan software analisis st The collected data is analyzed using R Studio statistical analysis software atistik R Studio.

3. Results and Discussion

3.1. Chaya growth in the early vegetative stage

The adaptability of chaya during the early vegetative period is indicated by per-centage of growth ability and surviving shoots (figure 2.). Each treatment showed insignificant differences, except for the per-centage of buds that survive with the treat-ment of the type of planting material. How-ever, based on the tendency of each treat-ment some treatments show a positive pat-tern of chaya adaptability at the beginning of the vegetative period [6].

Planting material from the middle is indicated to have the ability to survive and adapt to new growing environments. Each of these trend patterns is seen based on the number of living cuttings and buds present in the planting material. Meanwhile, this phenomenon also occurs in planting media, one of which shows a better tendency among others. Chicken manure is indicated as a substrate that is able to create a good growing medium so that chaya cuttings can grow and survive in a new environment. It is possible that the nurisi content of chicken manure is higher than other manure [11].

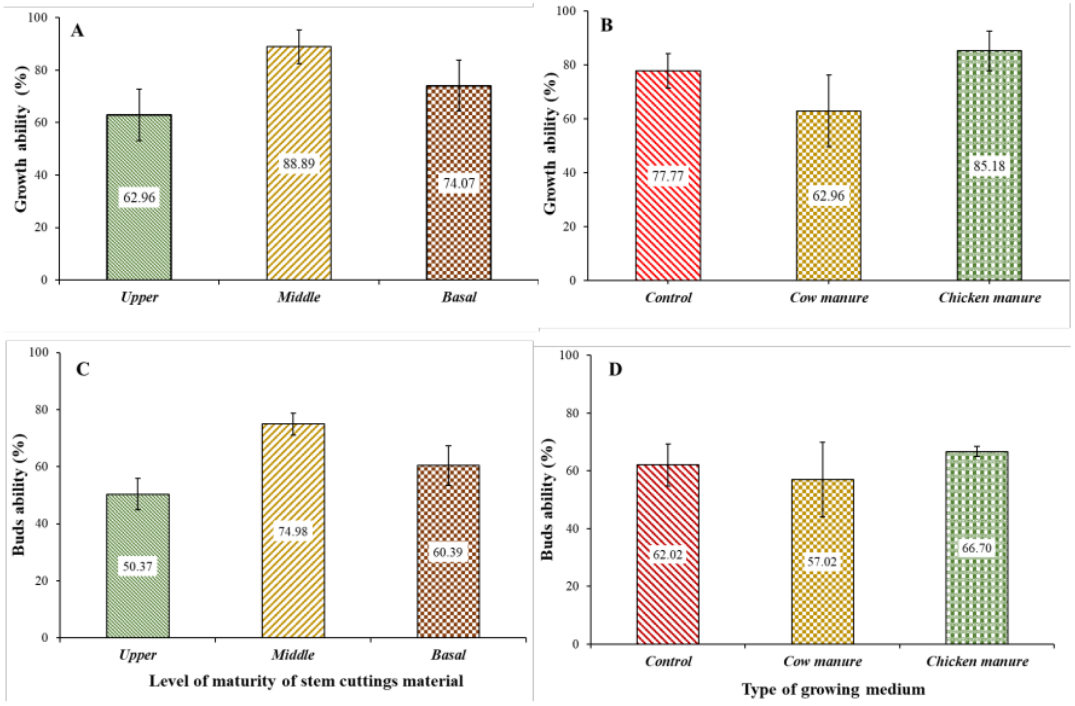

Figure 2. Percentage of growth ability (A-B) and Buds ability (C-D) in different planting material (left) and growing medium (right)

The material of the cuttings is an im-portant factor in plant propagation because it determines the growth yield of cuttings of chaya plants. According to Singh et al. [12], stem cuttings material is grouped into hard-wood cuttings, semi-hard cuttings, softwood cuttings and herbaceous cuttings. The ability to form adventitious roots on stem cuttings is related to the age and maturity of the par-ent tree. The percentage of live cuttings of the origin of the material of the middle stem cuttings is highest. The middle stem cut-tings are able to grow well, allegedly due to sufficient energy sources and active shoot growth points for growth. Basal cuttings ma-terialhas a lower growth power, as a result of which mature planting material with less active tissue [13]. The successful life of cut-tings depends on the formation of roots on the stem of planted cuttings

3.2. Growth of Chaya

The performance of cuttings after passing through the initial vegetative stage differs between treatments. All stem cuttings are experiencing an upward growth trend. Upper stem cuttings show better growth after passing through the early vegetative stage. This is indicated by the length of the shoots, the number of leaves and the area of the canopy (figure 3). Growing media affects growth gradually. Even so, the mixture of cow manure media has a better increase in the growth of plant canopy components. The canopy growth trend has occurred significantly after 8 weeks after planting (WAP). This is evidenced by an increase in the length of shoots, the number of leaves and the canopy area, respectively. In line with research conducted by [4] Plant propagation with media mixed with manure will increase the number of leaves, total leaf area and shoot length in Sterculia quadrifida.

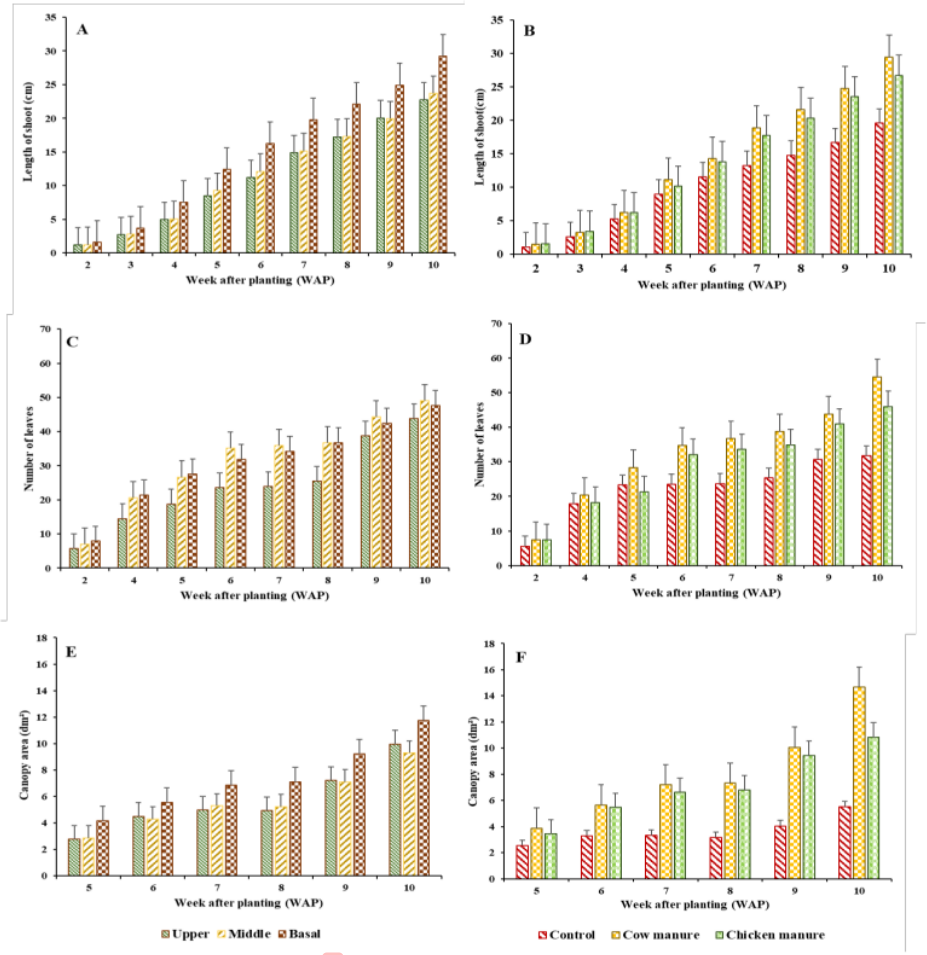

Figure 3. Chaya growth based on different level of maturity of stem cuttings material and type of growing medium

The chlorophyll content of chaya fluctuates differently between treatments. However, there were two chlorophyll peaks during the measurement. The first chlorophyll peak occurs when the chaya is 2 WAP old, while the other peak occurs at 5 WAP. However, the second chlorophyll peak is indicated to be higher than the first peak. On the other, chlorophyll content decreased after 6 MST (Figure. 4). Cuttings from the basal part have a higher chlorophyll content than other planting materials. A higher increase in chlorophyll content at the beginning of the observation occurred continuously until the end of the observation. The chlorophyll content in basal cuttings was significantly higher, particularly at 5 MST, which is the second chlorophyll peak. The chlorophyll content in the composition of the media looks to have a similar pattern. Despite this, a significant increase in chicken bedding occurs from the first week which makes a difference with the composition of other media. This leads to a higher chlorophyll content compared to other media mixtures and occurs at each peak.

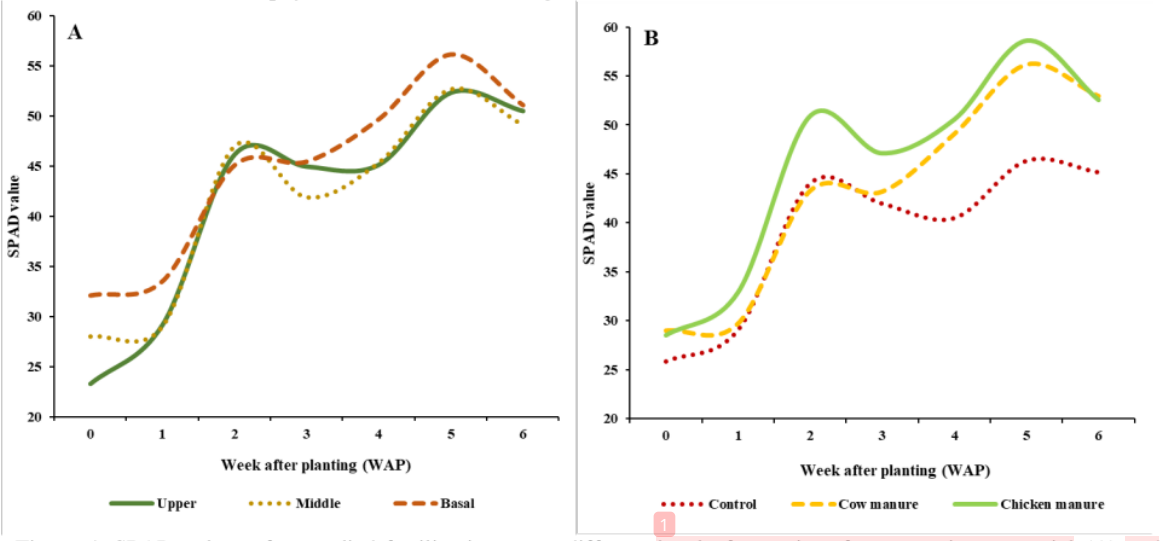

Figure 4. SPAD values after applied fertilization to on different level of maturity of stem cuttings material (A) and type of growing medium (B)

According to Simatupang et al.[7], differences in energy availability or food reserves that play a role in spurring the growth of shoots and roots. The difference in energy willingness is influenced by the size and physiological age of the cuttings material. Stem cuttings with two nodals on tomato plants will have a higher shoot length and number of leaves compared to one nodal [9]. Middle and basal stem cuttings are able to produce better growth than upper stem cuttings. The ability to grow roots on cuttings with an older physiological age tends to be better [14]. The maturity of cuttings material is related to endogenous hormones and nutrients in stem tissue. Scion cuttings have a higher rate of auxin synthesis, less tissue differentiation, and are more sensitive to dehydration [15]. Basal stem cuttings, despite their lower endogenous auxin content, have a greater capacity to provide the reserves of carbohydrates and nitrogen necessary for the formation and growth of roots and shoots [16].

Plant propagation requires good seeding media, the physical properties of media that are too pivotal are not good for the growth of seedlings from cuttings. Most types of woody plants require seedling media conditions that have sufficient porosity and water holding power to retain moisture [17]. Menurut Nugroho et al. [18], cow manure contains high fiber content so that it can make it easier for plant roots to grow and can increase the dry weight of the roots. Absorption of nutrients by plant roots will be more effective if the touch between the roots and the surface of the media occurs quite tightly. The level of leaf greenness is the plant's response to the willingness of plants to the nutrient content of the growing media, especially nitrogen [19]. This shows that the nutrient content of organic matter from chicken shrimp fertilizer is higher than cow shrimp fertilizer [20].

Leaf area increase tends to be similar between treatments. Leaves experience a significant increase in area at the beginning of leaf opening until the 11th day. Leaf area increase stops after entering the leaf age 12th day

(Figure 5). Leaves are a source of assimilation, produced through photosynthesis, and then translocated to other organs. The time it takes for leaf area growth can be used to estimate the age at which they can be harvested. Edible shoots of chaya are young leaves with the criteria of the upper 5 leaves [6]. Chaya leaf harvesting can be done every 2 to 4 weeks, as is done on cassava plants [21]. Harvesting The number of leaves per plant should be reasonable with consideration of growth and yield [22].

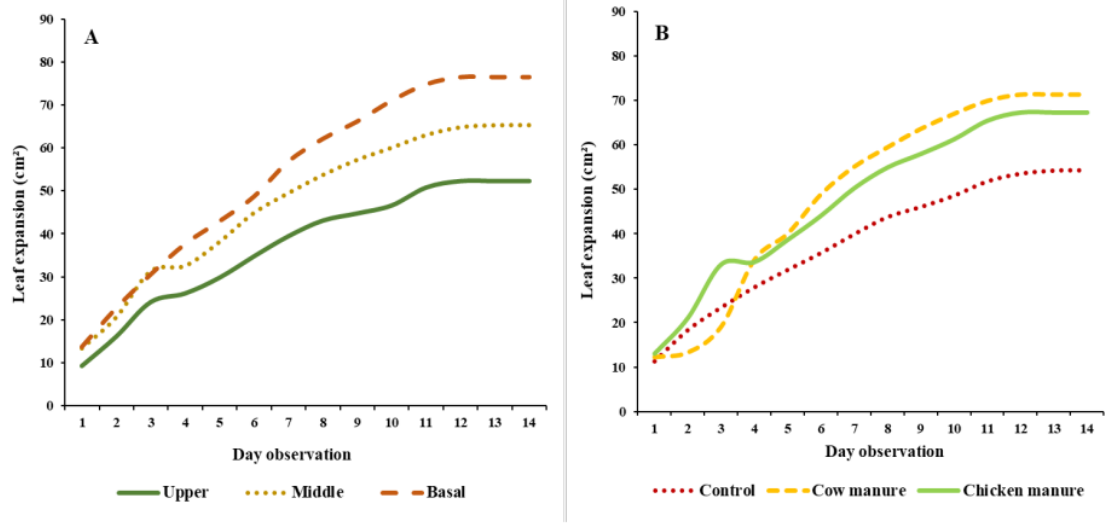

Figure 5. Increase of chaya leaf area with different level of maturity of stem cuttings material (A) and type of growing medium (B)

3.3. Destructive observation

The growth of planting material in each treatment is different (Table 1). Planting material from the middle and basal is better indicated than planting material from the upper. This indicates that the characteristics of the planting material in the section are adequate to trigger growth as a new individual. Meanwhile, cow manure and chicken manure can create subtrate conditions to be able to support plants to grow optimally. Several variables confirm the growing ability of such plants such as root length, number of shoots, number of branches and diameter of shoots.

Each plant has a different ability to meet metabolic needs as well as the alloca-tion of plant metabolic results. The ability to provide metabolic needs is reflected through the fresh weight of each plant organ. Plants derived from the middle and basal cuttings are indicated to experience better growth compared to plants from the upper. Mean-while, the ability to mix cow manure and chicken manure can create an environment that suits the needs of plants. The appropri-ate environment will allow the plant to grow well (figure 6). The ability of plants to provide metabolic needs will have implications for the allocation of metabolic results. This is evidenced by the dry weight of planting ma-terial from the middle and basal parts of plants with dry weight being more dominant than control.

Table 1. Plant growth parameters

	Length of root (cm)	Number of Shoots	Number of branch	Diameter of shoot (mm)
First factor				
Upper	70.76 a	9.33 a	8.39 a	28.62 a
Middle	105.91 b	9.44 a	14.94 bc	35.38 b
Basal	112.04 bc	7.28 a	13.89 b	39.40 bc
LSD $_{0.05}$	19.37	2.40	3.50	7.69
Second factor				
Control	87.06 a	5.61 a	10.33 a	33.30 a
Cow manure	101.36 a	11.22 bc	15.17 c	34.49 a
Chicken manure	100.30 a	9.22 b	11.72 ab	35.61 a
LSD $_{0.05}$	19.37	2.40	3.50	7.69

According to Dao et al [23], The growth of cuttings leaves depends depends on the nutriens reserves available in the cuttings. The nutrient content of stem cut-tings will be higher in the more mature parts. The role of

leaves in the rooting process shows growth will be maximized when cutting cuttings is active photosynthetically and results in assimilation for root development and elongation of root primordia in the absence of water stress [24]. Roots develop as an injury response involving a series of anatomical events along with several physiological, biochemical, and molecular changes. Adventitious roots can arise directly from primordia or through an intervening callus phase [25].

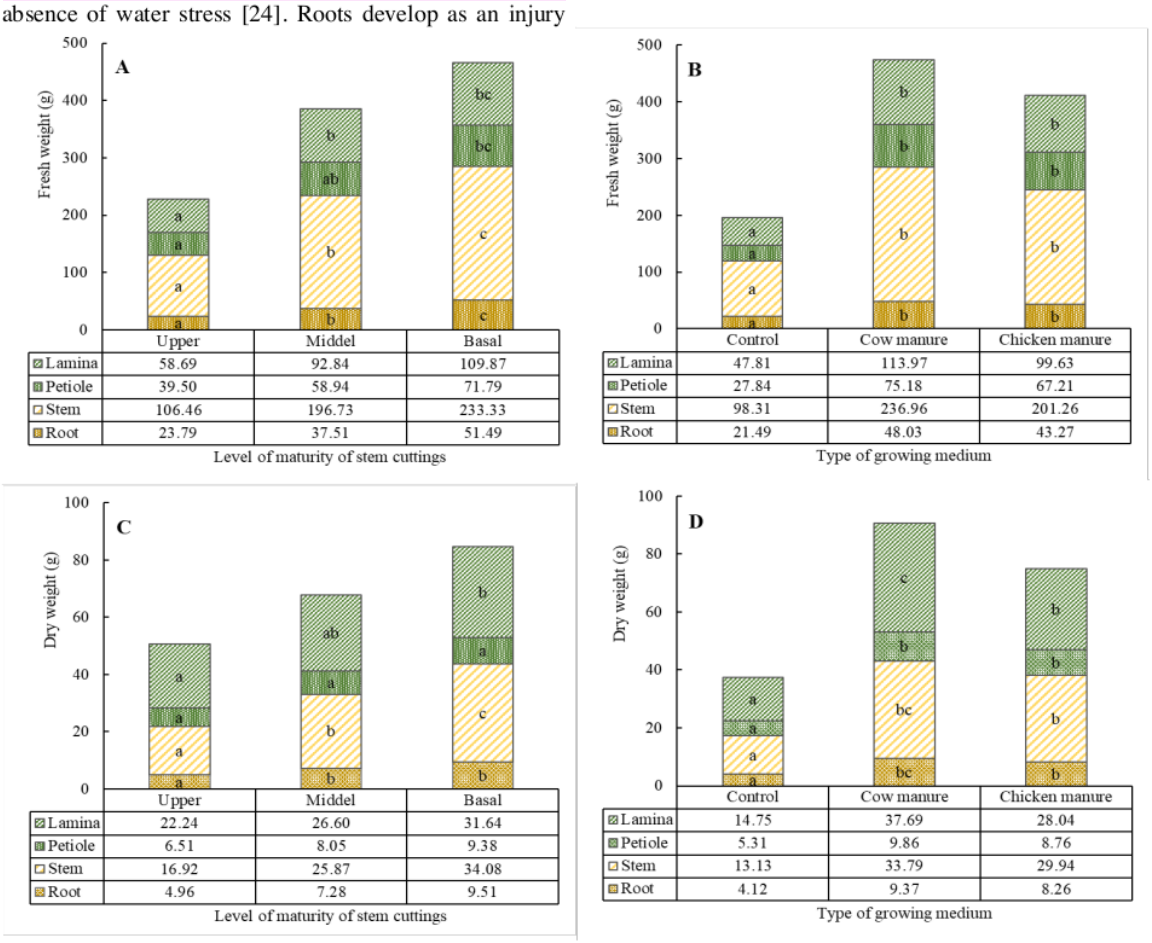

Figure 6. Fresh weight (A, B) and dry weight (C, D) chaya on different level of maturity of stem cuttings (left) and growing medium (right).

The difference in root length in cuttings material is due to a greater allocation of nutrients for root formation. [25] reported, that the length of the roots increases because the roots absorb sufficient amounts of water and nutrients. The nature of the media is very influential on rooting is porosity and bulk density. Highly porous media can become too loose and cause insufficient contact between the cuttings and the medium, resulting in loss of turgor [26]. Low porosity can lead to increased water-holding capacity of the medium and reduced oxygen availability to develop roots [27].

The fresh weight and dry weight of plants reflect the accumulation of organic compounds that plants successfully synthesize from inorganic compounds, especially water and carbon dioxide. The growth of shoots and roots as good certainly carries out photosynthesis and better nutrient absorption. The nutrients that the roots have absorbed contribute to the dry weight gain of the plant. Penelitian [28] states, that the weight of dry shoots of tomato cuttings is greatly influenced by the growing medium. This suggests that the medium is a rich source of all the basic nutrients i.e. nitrogen, phosphorus and potassium leading to higher vegetative growth. After development, young leaves will produce through photosynthesis, auxins and carbohydrates that will be translocated to the basal root system to induce rhizogenesis [29].

4. Conclusion

The results of the research carried out can be concluded, among others; 1). Stem cuttings material from the middle and basal has a better percentage of growth ability than the upper cuttings; 2). Chaya plants that use mature stem cuttings planting mate-rial have slower growth in shoot length and leaf count but produce greater leaf area, canopy area and biomass; 3). The use of cow manure in a mixture of growing medium gave the best results on growth of chaya plants.

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