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Performance Improvement of Young Pummelo Citrus (*Citrus maxima* (Burm.) Merr.) by Strangulation Application and Pinching

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ABSTRACT

Pummelo (*Citrus maxima* (Burm.) Merr.) is one of important horticulture commodity in Indonesia. Most of pummelo which is cultivated in Indonesia came from grafted seedling. There are some problem in using grafted seedling, namely: Limited number of plant material, the size of grafted seedling is not uniform and heavy grafted is caused damaging to mother plant. One of alternative seedling performance improvement of pummelo is by strangulation and pinching. This research conducted aimed to study the effect of combination of strangulation and pinching to change the performance of young pummelo. The treatment of strangulation and pinching on young pummelo showed significant difference to the variables observed. Interaction between strangulation and pinching showed significant difference on root and canopy dry weight. Combination treatment of double strangulation with pinching produced early bud emergence, more number of leaves, wider leaf area, elongation and larger stem diameter.

Key words: Pummelo (*Citrus maxima* (Burm.) Merr.), strangulation, pinching, canopy

INTRODUCTION

Pummelo (*Citrus maxima* (Burm.) Merr.) is one of important horticulture commodity in Indonesia. Pummelo is found with high genetic diversity in Indonesia. The Indonesian government has assigned pummelo as one of prime fruit among ten prime fruit. Nutrition content in pummelo is high. There are 89 g of water, 0.5 g of protein, 0.4 g of fat, 9.3 g of carbohydrate, 49 IU of vitamin A, 0.07 mg of vitamin B1, 0.02 mg of vitamin B2, 0.4 mg of niasin and 44 mg of vitamin C, per 100 g flesh (Niyomdham, 1997). In indonesia, pummelo is cultivated in some province which are Magetan, Sumedang, Pati, Kudus, Pangkajene and Kepulauan (Pangkep) and also Bireun (Aceh) (Susanto *et al*., 2013). Pummelo production is still unstable since 2004 until 2011, with range of total production was 63.801 t up to 105.928 t per year (Kementrian Pertanian, 2013).

Most of pummelo which is cultivated in Indonesia came from grafted seedling. There are some problem in using grafted seedling, namely: limited number of plant material, the size of grafted seedling is not uniform and heavy grafted is caused damaging to mother plant. The problems which is related to seedling availability could be solved by using shield budding to produce seedling (BPTP., 2003). Seedling improvement is needed in order to produced high quality of seedling with

spreading canopy. Canopy system of seedling with good formed will give maximum sun light absorption for photosynthesis, so that the plant become strong and high fruit productivity (Gilman and Black, 2011).

One of alternative seedling performance improvement of pummelo is by strangulation and pinching. Strangulation is physical treatment by strangulation on the stem with wire until a certain pressure and caused increase in leaf carbohydrate content. So far, research about strangulation has proved effective to increase flowering and fruiting in mature Pummelo plant (Yamanishi and Hasegawa, 1993; Yamanishi *et al*., 1994; Thamrin *et al*., 2009). Pinching is technique of the apical bud discard to stimulate the emergence of lateral shoots that will form the primary branches, thus improving the form and make the desired plant architecture (Aziz, 1998). Breaking the apical dominance by pinching will resulted more formation of lateral shoots number. (Wuryaningsih and Budiarti, 2008; Teper-Bamnolker *et al*., 2012) and also regulate the branches as needed to make the canopy form better (Islam *et al*., 2010).

There is no research about strangulation on young plants to manipulate the performance of the pummelo seedling. This research conducted aimed to study the effect of combination of strangulation and pinching to change the performance of young pummelo.

MATERIALS AND METHODS

Plant material: The Plants used were 150 seedlings which selected from shield budding Pummelo Cikoneng cultivar seedling 6 months old. Sand, soil and manure (2: 1: 1) is used as growing media and polybag with size 35×30 cm. Organic fertilizer granules were added on the surface of media with 0.5 kg per polybag. Some fertilizers are used for maintenance which are NPK Mutiara (15-15-15) (15 g L^{-1}), ZA (15 g L^{-1}), Gandasil and also insecticide Decis 2.5 EC (5 ml L^{-1}) and paranet 40%.

Experimental design: The experiment was designed using Randomized Complete Block Design (RCBD) with two factor. The first factor was strangulation and the second factor was pinching. Strangulation consists of three levels, namely: no strangulation (S0), strangulation single (S1) and strangulation double (S2). Pinching consists of two levels, namely: pinching (P1) and no pinching (P0). The treatment was replicated five times. Five plants were used in each experimental unit, so that 150 young pummelo plant were observed. Data were analyzed using SAS and the effect of treatment were detected using DMRT ($\alpha = 0.05$).

Strangulation and pinching treatments: Strangulation was conducted by wrapping the stem using a wire with 1 mm in diameter and pressing the wire to the stem as deep as the wire diameter. Strangulation method used was single and double strangulation. Strangulation was conducted at the same time to the main stem. Wire on the stem were released after 3 months of strangulation, by removing callus first. Pinching was conducted by cutting the apical bud using scissor, to stimulate formation of lateral shoots. Pinching was conducted two times, the first one was the same time with strangulation treatment and the second one was after strangulation.

Observation: Observations were made one week after treatment strangulation and continued until two months after the strangulation. Vegetative growth component observed is done once every two weeks with the observed variables include: (1) The diameter of the rod which is part of the trunk measured under treatment strangulation above stem by using a caliper, (2) The time the emergence of a new branch is calculated based on the release of the first secondary branch after the application of strangulation, (3) The number of buds and shoots a total each plant length. The

number of shoots was calculated based on the number of buds that form the branches. Total length of shoots plant is calculated by summing the entire length of shoots contained in the plant, (4) The number of leaves, (5) Leaf area, Measured leaf is fully developed leaves with the colors of the leaves are still green. Leaf area is done by using a Leaf Area Meter. Observations were carried out once a month, one month after strangulation, two months after strangulation, three months after strangulation, four months after the strangulation and five months after the strangulation at the end of the experiment (19 week after application), (6) The content of nutrients. Analyzed nutrient content is the nitrogen content of leaves and leaf carbohydrate content. Analysis of the carbohydrate content in the form of total sugars in the leaves using the method Semogy Nelson whereas nitrogen content using a semi-micro Kjeldahl (Yoshida *et al*., 1972), (7) The weight of the wet and dry weight of roots and canopy. Observations wet weight and dry weight of root and crown done destructively at the end of the study. The observation was made on 10 plants sample. Measurement of root dry weight and canopy made by weighing the wet and then dried in an oven at a temperature of 80°C for 24 h (Sitompul and Guritno, 1995), (8) The content of chlorophyll. Chlorophyll content analysis performed twice during the experiment. Samples were taken of the uppermost leaf that has grown from five plants of each experimental unit and performed in the morning. Chlorophyll content analysis was performed according to the procedure Sims and Gamon (2002) and (9) Measurement of the dry weight of the plant (roots and canopy) is done by weighing the wet weight, then dried in an oven temperature of 80°C for 24 h.

RESULTS

The treatment of strangulation and pinching on young pummelo showed significant difference to the variables observed. Interaction between strangulation and pinching showed significant difference on root and canopy dry weight (Table 1). Root dry weight and canopy are described biomass plants during phase life. Combination treatment with double strangulation and pinching gave the highest dry weight compare to other treatment (Table 2). The highest canopy dry weight

Table 1: Combination effect between strangulation+pinching in root dry weight and shoot dry weight with branches 19 weeks after treatment

Treatments	Root dry weight (g)	Shoot dry weight (g)
No strangulation+No pinching (S_0P_0)	32.22^{d}	105.56^{d}
No strangulation+Pinching (S_0P_1)	41.52^{c}	140.98^{b}
Single strangulation+No pinching (S_1P_0)	25.92^{d}	84.10^{e}
Single strangulation+Pinching (S_1P_1)	28.20^{d}	126.44^{c}
Double strangulation+No pinching (S_2P_0)	50.52^{b}	158.10^{a}
Double strangulation+Pinching (S_2P_1)	74.40^{a}	144.06^{b}

Digits followed by different letters mean different so the Duncan test α level of 0.05

Table 2: Combination effect of strangulation+pinching for some vegetative growth component with branches 19 weeks after treatment

Treatments	No. of leaves (leaves)	Plant height (cm)	Time emergence of a new branch	Branch height (cm)	Stem diameter (mm)	Leaves width (cm^2)
S_0P_0	103.60^{ab}	197.30^{ab}	7.80^{a}	34.90^{b}	16.52^{c}	93.09^{d}
S_0P_1	116.00^{a}	199.38^{a}	4.80^{b}	36.96^{ab}	17.15^{c}	101.86^{cd}
S_1P_0	109.80^{ab}	195.42^{b}	4.02^{b}	36.08^{b}	17.98^{b}	100.49^{d}
S_1P_1	103.60^{ab}	194.30^{b}	4.08^{b}	30.54^{c}	18.28^{b}	115.63^{bc}
S_2P_0	98.00^{b}	196.64^{b}	6.60^{a}	40.96^{ab}	18.52^{b}	125.22^{b}
S_2P_1	102.40^{ab}	198.08^{a}	3.60^{b}	45.22^{a}	19.65^{a}	165.47^{a}

Digits followed by different letters mean different so the Duncan test α level of 0.05

Table 3: Combination effect of strangulation+pinching for some vegetative growth component the average number of branches 19 weeks after treatment

Treatments	P0	P1	NP duncan α 0.05
S0	6.80^{ax}	7.00^{ax}	7.92
S1	8.00^{by}	7.00^{ax}	8.32
S2	7.40^{bx}	7.00^{ax}	
NP duncan α 0.05	7.92		

Digits followed by different letters mean different so the duncan test α level of 0.05

Table 4: Effect of strangulation and pinching against leaf nutrient content change

Treatments	C organic (%)	N content in leaf (%)	P content in leaf (%)	K content in leaf (%)	C/N ratio
S_0P_0	43.58^{b}	3.85^{d}	0.20^{bc}	3.04^{abc}	11.43^{a}
S_0P_1	49.84^{a}	4.08^{cd}	0.18^{c}	3.65^{a}	12.22^{a}
S_1P_0	40.60^{bc}	4.53^{ab}	0.19^{c}	3.63^{ab}	8.97^{b}
S_1P_1	41.47^{c}	4.27^{bc}	0.23^{ab}	3.04^{abc}	9.71^{b}
S_2P_0	41.26^{bc}	4.65^{a}	0.24^{a}	2.96^{c}	8.89^{b}
S_2P_1	44.14^{b}	4.60^{ab}	0.26^{a}	2.83^{c}	9.63^{b}

Digits followed by different letters mean different so the duncan test α level of 0.05

obtained from combination treatment of double strangulation without pinching. Pinching which is intend to reduce unnecessary sink was influence on plant biomass, both root and canopy.

The desired performance of pummelo seedling is growth well, canopy structure is compact and vigor. Interaction of strangulation and pinching treatment significantly affect to all vegetatif characters. In general, combination treatment of double strangulation with pinching was resulted the best performance of young pummelo compare to all combination treatments used in the experiment. Combination treatment of double strangulation with pinching produced early bud emergence, more number of leaves, wider leaf area, elongation and larger stem diameter.

In order to understand why the double strangulation and pinching treatment gave the best results, analysis of nutrient content and physiology were conducted. Significant result in interaction between strangulation and pinching affected to all of nutrient content components observed. The highest content of organic C obtained in the treatment without strangulation and with pinching. The highest of leaf N content yielded in combination treatment of single strangulation with pinching or without pinching. The highest of leaf P content obtained in combination treatment of double strangulation, either pinching and without pinching (Table 3).

Pummelo seedling which treated by combination treatment of double strangulation with pinching had higher levels of leaf N and P content, however leaf K content, organic C and C/N ratio was lower compare to other combination treatment (Table 4). Meanwhile, control plant had only C/N ratio was high but the other content was lower.

DISCUSSION

Strangulation treatment is intend to modify photosynthate flow. Strangulation in young pummelo plant give physical barrier which affect to transportation of photosynthate from canopy to the base area of root system. It can be seen as indicated by high accumulation of total carbohydrate in the canopy (Fig. 1). The advantage of this condition is photosynthate accumulation that occurs in the canopy can be used for crop canopy growth. Meanwhile pinching application intended to break the apical dominance. According Acquaah (2004), apical dominance will suppress the growth of axillary buds. Breaking apical dominance will trigger the growth of axillary buds.

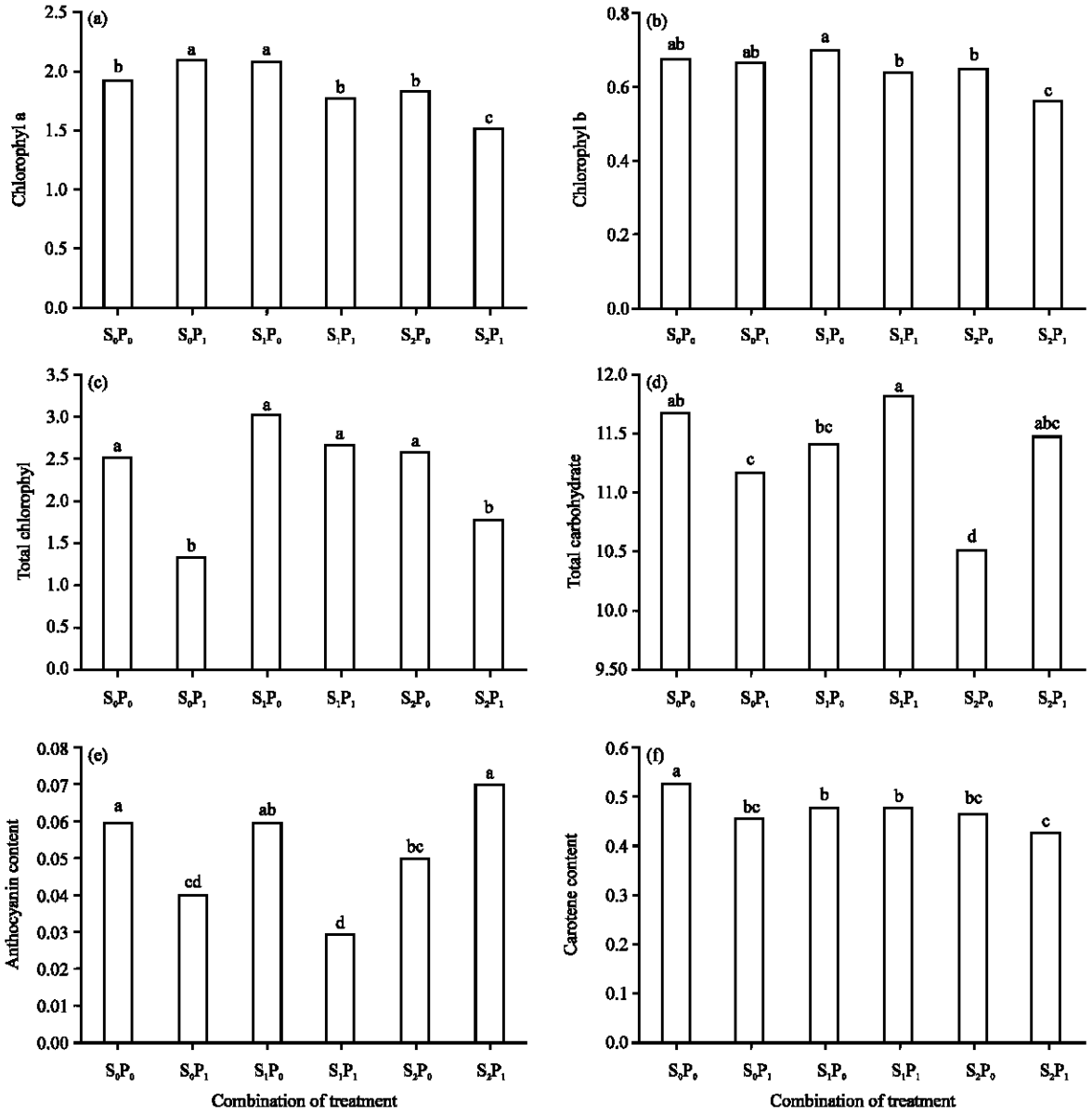

Fig. 1(a-f): Interaction of strangulation and pinching on leaves content, (a) Chlorophyl a, (b) Chlorophyl b, (c) Total chlorophyl, (d) Total carbohydrate, (e) Anthocyanin content and (f) Carotene content

Combination treatment of double strangulation with pinching had higher levels of leaf N and P content, however leaf K content, organic C and C/N ratio were low. Control seedling had high C/N ratio but the other content were low as described in Table 3. Nitrogen is one of important nutrient that plant needed, because of its role in promoting vegetative growth (Syekhfani, 1997). Nitrogen plays an important role as a component in the preparation of plant organs, as the element which involved in the process of photosynthesis, the plant cell life element, constituent of chlorophyll and other important organic compounds. Besides nitrogen, phosphorus is also a macro nutrient element which needed for various processes, such as photosynthesis, assimilation and

respiration. Phosphorus is structural component of molecular compound energy transporter ADP, ATP, NAD, NADH and the compound system of genetic information of DNA and RNA (Gardner *et al*., 1985). Embleton and Reinzt (1973) stated that P has a role in the plant growth (stem, root, branch and leaf). Phosphate is needed by plants for the formation of cells in root and shoot tissue which are growing and reinforce the stem, so that the plant is not easy to fall (Thompson and Troeh, 1978; Aleel, 2008).

CONCLUSION

The treatment of strangulation and pinching on young pummelo plant showed significant difference to the variables observed. Interaction between strangulation and pinching showed significant difference on root and canopy dry weight. Combination treatment of double strangulation with pinching production early bud emergence, more number of leaves, wider leaf area, elongation and larger stem diameter.

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