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RESEARCH ARTICLE

Gradual flowering and fruiting technology ("Bujangseta") through fertilizer management in siam (*Citrus nobilis* l.) Cv. Pontianak

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ABSTRACT

Fruit bearing of citrus species such Tangerine or Siam cv. Pontianak caused fruit yield and quality variation. Research was carried out in Banaran Experimental Garden under Indonesia Citrus and Subtropical Fruit Research Institute, Batu, East Java Indonesia, from November 2019 to September 2020. The objective of this study was to evaluate Bujangseta (BS) technology on the growth, physiology, flowering, and yields of Siam cv. Pontianak. 158 trees of 7-year-old 'Pontianak' Siam (*Citrus nobilis* L.) cultivar were divided into two blocks in which each block has been subjected to Bujangseta technology, and control, respectively. T Test was used to evaluate two treatments. The results showed that BS technology induced the leaf area, leaf pigments, fruit set, and total fruits/plant, whereas starch and sugar content of leaves decreased. Fruit harvesting on the BS and control (C) treatments during the period of January to August 2020 had been done 4 and 2 times, respectively. The total fruit weight/tree treated with BS significantly increased by 112% compared to C. The BS's fruits quality such as size, juice volume and total soluble solid were significantly better than control. Improvement of fertilizer application is recommended to improve the 'Bujangseta' technology in order to increase the gradual flowering and fruiting in Siam group throughout the year.

Keywords: Bujangseta; Citrus nobilis L; fertilizer; Siam cv. Pontianak; Tangerine

INTRODUCTION

Citrus is one of crops that is categorized as an alternate bearing crop. It means that the tree will produce hight yield in the season, and it is followed by light yield in the next season both in temperate and tropical condition. Samach & Smith (2013) and (Stander et al., 2017) reported that fruits produced during on season affect vegetative growth and floral induction as a result few flowers and fruit will be produced in the following year. Citrus species has three types of inflorescences, these are vegetative, generative, and mixed. The percentage of generative inflorescences was lower (15 %) during high yield (On Season) season than that under light yield (Off Season) season (85%), whereas vegetative shoots growth under "On" and "Off" season were 65% and 5 %, respectively (Shalom et al., 2012).

According to Patil et al. (2018), pruning was also used to produce fruit in off season. Acid lime tree pruned at bearing stage produced good healthy shoots that cause maximum fruit load. Verreynne & Lovatt (2009) also stated that fruit of the 'Pixie' mandarin reduce floral intensity of the return bloom by inhibiting budbreak, thus in arranging an alternate bearing on citrus, fruits on-crop trees should be harvested at maturity stage. Bending treatment with proper time of bending increased flowering shoot and fruit yield of guava during off season (Nandi et al., 2017) and apple cv. Fuji (Xing et al., 2016). Nevertheless, Iglesias et al. (2007) noted that behaviours of flowering time as well as response to the inductive conditions were also influenced by species and varieties.

Plant nutrition status is may involve in flowering process and fruit development. Mirsoleimani et al. (2014) revealed that bud responses of mandarin cv. Kinnow in the following season after fruit load are related to the nutrient level in shoots. Levels of K and P in leaf and shoot during "on crop" tend to decrease up to deficient levels. In addition, foliar spraying with potassium nitrate combined with girdling gave a positive result on total carbohydrate, total chlorophyll and chlorophyll a content in the leaves,

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which reflected on increasing fruit weight, number of fruits per tree and yield weight per tree (Mostafa & Saleh, 2006). Tariq et al. (2018) reported that K percentage in Nagpur mandarin leaves ranges 0.96 - 1.44% as a result of potash application at higher rates, whereas the optimum range of P in citrus leaves is 0.12% - 0.16 %.

More than 75 % of citrus production in Indonesia is dominated by Siam or known as Tangerine. The main Siam production centers are West Kalimantan, South Kalimantan, East Java, North Sumatera, and Bali. In general, there is no flowering season for Siam. It means that flowering occurs almost throughout the year and reach maximum stage during rainy season. Likewise, different stages of fruit and/or flower develop simultaneously in the same tree that may cause difficulty in determining fruit maturity and harvesting time (Supriyanto et al., 2019). Harvesting seasons of Siam ranged from April to August. Nevertheless, fruits with different age, size and quality are still harvested during the remaining months. This condition is always experienced by the farmers every year as result of over product and the price will fall sharply. This pattern may give a benefit for producing qualified fruits in every stage in order to harvest and provide qualified fruits continuously throughout the year. Hence, the manipulation of tree becomes important and is absolutely needed.

Gradual flowering and fruiting as well throughout the year technology known as "Bujangseta" has been started in Indonesia since 2015. This technology consisted of proper pruning, soil and foliar fertilizers, water management, and pests and diseases control. Implementation of this technology on three-year-old tree of Siam multiply harvesting time and fruit production per tree more than 100 % (from 2 to 5 times per year), and 26 %, respectively as compared to non "Bujangseta" (Supriyanto et al., 219; Purbiati & Isnaeni, 2019). Nevertheless, the continuous improvement of this technology is required especially for fertilizer application. The aim of this research was to evaluate the growth dan physiological responses, flowering and yield of Siam cv. Pontianak subjected to Bujangseta for four consecutive years.

MATERIALS AND METHODS

Location and plant materials

Research was conducted at Banaran Experimental Garden (950 m asl), Batu, East Java, Indonesia under Indonesian Citrus and Subtropical Fruit Research Institute from September 2019 to August 2020. Seven-year-old tree of Siam cv Pontianak planted with planting distance of 3 x 3 m on 2012 was used. Total number of trees were 158 trees that was divided into two blocks in which each block has been subjected to Bujangseta technology and non Bujangseta as a control since 2016.

Experimental design

Each block was consisted of three replications with 5 trees as a unit per replication. T Test was used to evaluate two treatments, these were Bujangseta (BS) and Non Bujangseta as a control (C). Components of BS and C were as follows:

BS: solid and liquid fertilizers were applied alternately. 0.5 kg NPK Nitrophoska (15-15-15) as a solid fertilizer was applied per tree four times every three month that it was started from October, January, April, and July, whereas liquid fertilizer consisted of 100 g NPK (15-15-15) + 25 gr ZA that was solved within 20 l of water and applied per tree 1.5 months after solid application for three times. 50 grams of Kieserite ($MgSO_4$) was also added per tree together with the liquid application.

C: NPK Nitrophoska (15-15-15) was applied three times; 1) 700g NPK + 400g ZA/tree was applied per tree after pruning and manure application on rainy season (November 2019); 2) 700g NPK was applied at three months after flowering when fruit diameter reached about 2 cm (March 2020); and 3): 700 g NPK was applied on fruit physiology maturity (May/June 2020). 50 gram/20 l of water of Kieserite was also added at 15 and 25 weeks after blooming. 20 l of water was also added on the control treatment simultaneously with liquid application on BS one.

Soil sampling and nutrient elements determination

Composited Soil samples obtained from four samples were taken from each orchard up to 20 cm. These soil samples were brought to laboratory, air dried, ground and passed through a 2-mm sieve and analyzed for physical and chemical characteristics. Various nutrient levels were also determined. In each treatment 5 sampling tree were chosen. A 200 g soil samples was collected under each tree crown at a 20 cm depth respectively, then mixed soil samples collected. A 500 g of mixed soil was brought to laboratory. Soil samples then was analyzed with following methodology: pH (H_2O); Khejdhal method for soil total nitrogen; available P was measured by the Bray 1 method; extraction 1 N NH_4OAc pH 7 for soil K, Na, Ca and Mg exchange also for CEC; the organic matter content was determined by the Walkley-Black method; soil salinity was be determined by electrical conductivity (EC); extraction 1 N NH_4OAc pH 4.8 for soil SO_4; and the DTPA micronutrient extraction method was used for estimating the potential soil availability of Zn, Cu, Mn, and Fe.

Leaf sampling and nutrient elements determination

Leaves samples were collected from 5 trees per replication from the same orchards where soil samples were collected.

Each leaves sample was a composite of four main branches, and five fully expanded leaves from non-fruiting terminals per branch were used as samples, they were at the 3rd and 4th leaf of these shoots sub-samples. Leaf samples were washed with distilled water and oven dried at 60 - 70°C to a constant weight. The oven-dried plant samples were ground and analyzed for various nutrients. The elements of P, K, Na, Ca, Mg, S, Fe, Zn, Cu, Mn, and B were measured by using wet ashing of HNO_3/$HClO_4$ digestion method.

Leaf chemical constituents (leaf pigments, starch and sugar content)

Chlorophyll a, b, and total Carotene on the leaf analyses were adopted from Sumanta et al. (2014). The determination of total sugar and starch contents were analyzed by Anthrone and acid hydrolyzed-Nelson method, respectively and read the absorbance using UV-Vis's spectrophotometer.

Vegetative growth

Leaf area and leaf thickness were estimated by leaf area meter (model KWF Law-A) with accurately of 0.01 cm^2 and Caliper Digital KRISBOW with accurately of 0.01 mm, respectively.

Flowering, fruit set, total number of fruits/a plant and grade of the fruits

Total number of flowers was observed five times from February – March, 2020, whereas the average of flower number was obtained from 10 branches per observation. Percentage of fruit set was also measured from the same branches. Fruit size data was recorded during 3rd week of February 2020-1st week of March, from three fruits of each replication. The fruit size (diameter) was recorded by manual vernier caliper. Fruit grades was categorized into five groups these were grade A (fruit diameter 8.0 – 12.9 mm); grade B (fruit diameter 13.0 – 25.9 mm; grade C (fruit diameter 26.0 – 38.9 mm); grade D (fruit diameter 39.0 – 49.9 mm); and grade E (fruit diameter >50 mm).

Yield, fruit physical and chemical characters

Total yield (kg) per tree was obtained from four harvesting times started from February, April, June and August 2020. Fruit weight, fruit size, fruit quality, and peel thickness were also measured during maximal harvesting time (August, 2020). TSS was measured by hand held refractometer at room temperature of 27 ºC and expressed in degree brix and taken from the composite juice extracted from citrus fruits to measure sugar concentration; pH value in the juice measured by pH meter with accuracy of 0.01; and Titrimetric method was used for determining the Vitamin C (mg/100 ml juice) content of juice.

Number of rainy days, rain intensity, and humidity measurement

Number of rainy day and rain intensity as well as humidity were observed per month started from February 2019 to December, 2020.

Statistical analysis

Differences in soil and leaf nutrient elements, vegetative and generative growth, yield and fruits quality between the Bujangseta (BS) and Control (C) treatments were tested using Student's t-tests. Differences were considered statistically significant at the levels ($p < 0.05$) using statistical analysis software Minitab 16.

RESULTS AND DISCUSSION

Rainy days, rain intensity, and humidity

Indonesia is located in the tropics condition that has two seasons these are dry and rainy season. Heavy rainfall, high humidity, high temperature, and low winds always occur almost every year. The wet season in Batu City (East Java Province) was from November to April (2019) and November to May in 2020. The annual rainfall in this area were 1232.9 and 1403.4 cc for year 2019 and 2020, respectively, while total of rainy days in 2019 and 2020 were 107 and 118 days/year, whereas the humidity average ranged from 89 to 97%, with temperature average ranged from 17.6 to 22.9ºC in 2019 (BPS Statistic Batu Municipality, 2020). According to Ritung et al. (2011), climate requirements for citrus are as follows: average of temperature ranged from 19 to 23 ºC, water availability (rainfall 1,200-3,000 mm/year), 2.5 - 4 dry months, and humidity range about 50-90%. Hence, both rain fall and temperature affected flushing, flowering pattern, and yield as well as fruit quality. According to Chelong & Sdoodee (2013), less rainfall and humidity may influence to fruit development, yield, and fruit quality of citrus.

Soil and leaf nutrient contents

Application of BS and C treatments did not significantly different on soil nutrient contents in 20 cm-soil layers ($p>0.05$) (data not shown); whereas C organic, N total, and Zn contents on the leaves of Siam cv. Pontianak treated by BS were significantly higher than that of C treatment, except for Cu (Table 1).

The optimal nutrient retention such as CEC > 16 cmol/kg, base saturation >20%, pH H_2O about 5.5-7.6, and C-organic >1.2% illustrated that the BS treatment was suitable (S1) for citrus plant growth. Apart from that, this treatment also induced an optimal value of available nutrients as well, namely a medium of N total (0.21-0.50%), high category of P_2O_5 (26-35 ppm), and a medium of K_2O (21-40 mg/100g). However,

Table 1: Effect of BS and C treatments on leaves nutrient content of Siam cv. Pontianak

Nutrient	Treatments		p value
	Bujangseta	Control	
C Organic (%)	38.53±0.9 a	32.3±7.37 b	0.03
N Total (%)	3.14±0.23 a	2.71±0.14 b	0.01
P (%)	0.16±0.01	0.17±0.02	0.83
K (%)	0.51±0.02	0.46±0.07	0.61
Na (%)	0.02±0.001	0.01±0.003	0.20
Ca (%)	0.84±0.11	0.81±0.16	0.88
Mg (%)	0.09±0.01	0.09±0.01	0.63
S (%)	0.18±0.003	0.17±0.01	0.06
Fe (ppm)	112.21±26.66	94.29±37.49	0.54
Zn (ppm)	125.95±15.33 a	89.69±3.01 b	0.02
Cu (ppm)	0,05±0,16 b	0,96±1,11 a	0.02
Mn (ppm)	75.73±40.78	86.2±32.89	0.72
B (ppm)	75.85±7.27	88.33±7.89	0.06

Statistical comparisons (Student's t-test) within a row only; different letters beside means denote significant differences between treatments at P<0.05. Data are means (±SD) from 9 samples at each treatment

lesser optimal nutrition in the control treatment was due to the total N content that less than 0.21% (Ritung et al., 2011).

Fertilization application in BS treatment may cause little effect on the content of K, Na, Ca, S, and Fe in the leaves. Based on the standard leaf nutrient content developed by Embelton et al. (1975), leaf nutrient content such as N and Zn treated by BS were categorized as high level, followed by P, Fe, Mn, and B that were in optimal level. Meanwhile, the remaining nutrients were very low. Higher total N concentration derived from BS treatment may due to difference in tree development phase as compare to control treatment. N content of 3.14% in leaf showed that trees were in flowering stadium with the less fruit, whereas under control condition, value of N was 2.71% and within fruit set stadium (Siswadi et al., 2011). It seems that CO, N, S, K in both soil and leaf treated by BS treatment were triggered to transport directly to the existing flower and fruits.

According to El-Ramady et al. (2014), the main elements such as C, H, O, N and S are needed to construct the building blocks of life that derived from amino acids, proteins, enzymes and nucleic acids. Hence, by increasing those elements, flowering and fruiting development become increase. This finding was in line with Hume et al. (1985) that yield of citrus was positively correlated with N levels in leaves, but it was negatively correlated with P and K levels. Likewise, fruit yields were also positively correlated with both leaf and soil Mg levels, which were closely related to soil Mg levels. In terms of Zn and Fe, those concentrations were higher in BS as compared to control treatment. The increased absorbed Zn in leaf was required for vegetative growth, flowering, and yield because Zn is involved in the synthesis of tryptophan which is a precursor of IAA, auxin production, nucleic acid synthesis, carbohydrate and lipid metabolisms as well production through its capability to influence the capacity for both water uptake and transport (Tsonev & Lidon, 2012; Kumar et al., 2017). Moreover, Zhang et al. (2014) revealed that Zn, Fe, dan Mn content in leaf of Satsuma mandarin trees grafted on trifoliate were depended upon the certain stage condition. At the full bloom period, Zn and Fe content in leaf were the highest, then tends to decrease during the young fruit period, and increased again until peak level at mature fruit period. On the other hand, Mn content in leaf increased notably at the fruit mature stage. Difference of leaf nutrient status reflected the stage of the tree in which BS treatment dominate during flowering stage whereas under control treatment condition reflects that the tree was under fruit set up to mature fruit stage.

Nutrient absorption in leaf is not only caused by genetic but also from the availability of soil nutrients that obtained from soil and foliar fertilizer application. Plants applied with foliar application of boron (B) and zinc (Zn) would significantly increase the K, Mn, Fe, B and Zn status of Feutrell's Early mandarin leaves (Khan et al., 2012). Erner et al. (1999) also mentioned that N concentration in the leaf was influenced by amount of N and Ca content in the soil, while K, Ca, and Zn separately were influenced by the concentration of N, K, Cu, Zn, Mn, and B; P and Ca; and P, Mg and Zn in the soil, respectively. Previous research done by Eticha et al. (2017) showed that by increasing Ca supply in the leaf, shoot and root growth as well as photosynthetic rate would increase.

Leaf growth

Growth of Siam cv Pontianak treated by BS treatment resulted in a 2 and 1.04-fold increase in leaf area and leaf thickness, respectively. The average of leaf area on BS treatment was significantly different with control one, but not for their leaf thickness. According to Khan et al. (2012), deficiency of Zn and B of plant that was foliar sprayed by micro nutrient such as Zn and B will significantly increase leaf size. This finding showed that both leaf area and leaf thickness were influenced by the status of nutrient in the soil. There was a regression equation for leaf size, $Y_{leaf\ area} = 10.4 - 0.642$ cmol kg^{-1} Ca + 9.20 cmol kg^{-1}Mg + 0.702 cmol kg^{-1} CEC - 4.15% C org (R^2 = 100.0%; p= 0.021), whereas, the leaf thickness regression equation was $Y_{leaf\ thickness} = -0.493 + 0.437$ cmol kg^{-1} Mg + 0.00676 cmol kg^{-1} CEC + 0.066% C org + 0.0019 ppm Mn (R^2 = 100.0%; p= 0.002). This equation reflected that Ca, Mg, Mn, C, and CEC involved on leaf development.

Leaf chemical constituents

Chlorophyll and carotene content in leaf

Chlorophyll is an important photosynthetic pigment to the plant, and act as a signal in controlling photosynthetic capacity of the plant per unit area of leaf, stress and nutritional deficiencies as well. The results showed that the concentration of chlorophyll a, b and total chlorophyl as well as total carotenoids of Siam cv. Pontianak leaves treated with BS were significantly higher than that of control (Table 2).

Chlorophyl content in leaf was depend on nutrient absorbed by tree on the leaf. Based on correlation analysis, chlorophyl a, b and total were significantly influenced by N, S, and Zn content, whereas carotene was influenced by Na and Zn in leaf (Table 3). The same result was also occurred on banana, N and Zn content absorbed in leaf was correlated with total chlorophyll content and leaf pigments level (Alberto et al., 2014). Ilyas et al. (2015) revealed that Kinnow tree treated with foliar application of Zn, Cu and B enhanced leaf nutrients that was in line with the significantly increased of chlorophyl (Chl) a, b, total and carotenoids concentrations. Based on equation, it seems that some nutrients contributed to chlorophyl and carotene production (Table 4).

Starch and sugar content of leaves

Concentration of simple organic molecules such as sugar and starch content on leaf treated by both BS and C treatment was not significantly different. These substrates were only significantly and negatively correlated with soil P_2O_5 with value of Pearson correlation (r) = -0.863* and -0.908* for leaf starch and sugar, respectively; the last was also negatively corelated with Cu (r = -0.846*) and Fe (r = -0.893*) elements. Starch and sugar content of leaf treated with BS may be more absorbed for fruit development as compared to control that less fruit development. Principally, carbohydrates storage is used to develop the flowers and fruit of citrus trees. In this phase, carbohydrates needs in the plants is high, because of the excessive flowers formation, hence it will affect the daily production of carbohydrates by the leaves (Goldschmidt, 1996). In addition, the greater consumption of carbohydrates that occurs at flowering phase in citrus plants will trigger both vegetative and flowering shoots development (Moreira et al., 2013). This finding showed that BS treatment affected the produce developed flowering and fruiting phase higher than that of control.

Flowering, fruit set and total number of fruits plant-1

Flowering period was evaluated for 5 months (February to March 2020). Different flowering patterns were showed by both BS and Control treatments. Flower bud formation, blooming, and fall petals of plant treated by BS was occurred earlier than that of control (Fig. 1), and after 5 months it produced flowering and fruit set percentage much higher than control. Due to less rain fall on May-June and August-October 2019, it was enough to stressing the tree, and when rainy season come on November 2019, flowering season was produced simultaneously thus harvesting time of trees treated with BS and Control was occurred in the same time on June 2020. The average of flowering/branch applied with BS and C treatments was 10.2 and 8.3, respectively, whereas for the average of fruit set percentage reached 9.8 and 3.7 %, respectively (Fig. 2).

Nishikawa (2013) mentioned that the protein encoding a flowering-related gene, known as *flowering locus t* (*CiFT*), plays an important role in triggering flowering production in citrus. It was apparently that this gene expression was

Table 2: Effect of BS on chlorophyll a, b, and total chlorophyll, and carotene content in leaves of Siam cv. Pontianak

Treatments	Chlorophyll a (µg/ml)	Chlorophyl b (µg/ml)	Total Chl (µg/ml)	Carotene (µg/ml)
Bujangseta	2,33±0.138 a	1,17±0.148 a	3.50±0.284 a	0,64±0.031 a
Control	1,87±0.272 b	0,87±0.868 b	2.74±0.425 b	0,56±0.066 b
p	0.00	0.00	0.00	0.00

Statistical comparisons (Student's t-test) within a row only; different letters beside means denote significant differences between treatments at P<0.05. Data are means (±SD) from 15 samples at each treatment

Table 3: Correlation of nutrients to chlorophyl a, b, carotene, and total chlorophyll in leaves of Siam cv. Pontianak

Leaf Nutrients	Chl-a	Chl-b	Carotene	Total Chl
CO	0.64	0.73	0.18	0.68
N	0.89*	0.89*	0.80	0.90*
P	0.03	0.09	0.14	0.05
K	0.36	0.28	0.71	0.33
Na	0.69	0.61	0.90*	0.66
Ca	0.05	0.13	0.37	0.09
Mg	0.31	0.46	0.08	0.38
S	0.83*	0.89*	0.50	0.86*
Fe	0.25	0.25	0.44	0.26
Zn	0.92*	0.94*	0.83*	0.93*
Mn	0.34	0.40	0.25	0.36
B	0.66	0.55	0.73	0.70

*)Correlation is significant at the P<0.05 level.
Chl=Chlorophyll

Table 4: The equation for leaf chlorophyl a, b and carotene

Y for	Equation	p-value	Adjusted R^2
Chlorophyll-a	- 2.05+93.0 cmol kg^1 Na+2.35 cmol kg^{-1} Ca+13.6 cmol kg^{-1} Mg-0.00669 ppm Mn	0.03	99.9%
Chlorophyll-b	2.67+22.9 cmol kg^{-1} K-0.032 ppm Fe-0.0117 ppm Zn-91.3 cmol kg^{-1} Mg	0.04	100.0%
Carotene	0.509+24.0 cmol kg^{-1} Na-0.0623 cmol kg^{-1} Ca-1.25 cmol kg^{-1} Mg-0.00134 ppm Fe	0.02	99.9%

due to response to re-hydration after drought periods or water stress condition as well as internal factors such as carbohydrate and N status in the plant. According to Huchche and Ladaniya (Ravishankar et al., 2014), peak level of flowering on citrus was during rainy season following periods of dry weather. In terms of flower induction process, it seems that environmental factors as well as climatic condition are involved. Under high winter temperatures, flowering of Valencia and Hamlin oranges tends to reduce (Valiente & Albrigo, 2004). In the tropic condition especially during dry season, the soil water deficit stress that due to high temperature contributed to flowering induction of Nagpur mandarin (Jhade et al., 2018). The same result was also mentioned by Koshita & Takahara (2004) and Micheloud et al. (2018).

Flowering intensity on citrus is mainly influenced by availability of water in the soil. Applying liquid fertilizer after solid one on 'Bujangseta' treatment may induce an optimal plants micro environment so that they could absorb the nutrients periodically. Hence, there may be several different stages of fruit and/or flower development within the same tree. Moreover, one of capability of plants to produce flower and fruit set was affected by the type of inflorescence. Flowers in leafy inflorescences type either in terminal or distributed among leaves along the shoot are commonly associated with higher fruit set; whereas for leafless inflorescences type, it may emerge first and contain a bouquet of flowers with low fruit set formation (Iglesias et al., 2007). Indeed, fruit percentage of citrus was also influenced by absorbed N by plant (Ennab, 2017).

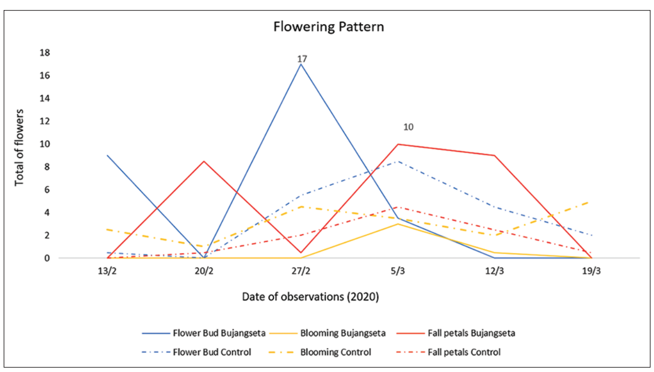

Fig 1. Flowering pattern of Siam cv. Pontianak treated with Bujangseta and Control

Phenological growth stage of Tangerine genetically is different to mandarin. Flowering and fruiting in Tangerine within one plant can reach several stages in the same time. Based on the BBCH-scale of citrus (Meier, 2001), these are stage 5 (Inflorescence emergence) up to stage 8 (Maturity of fruit). This finding showed that fruit stage of Siam cv. Pontianak observed from February to March 20. On March 20, the fruit stage reached stage 7 to 8. It means that this cultivar was in the stage of development of fruit up to fruit maturity. Fruit number treated by BS was 998 per 10 branches/tree, and significantly was higher than that of control (664) ($p<0.05$). This may be due to higher flowering number, and also could be explained as a result of increasing fruit set percentage.

Fruit yield and quality

Fruit yield plant^{-1}

By having different of flowering patterns, the harvesting time of BS and control treatment was also different. Trees treated by BS and control were able to harvest four and two times, respectively. Based on T test (p=5%), fruit weight/tree in each harvesting time was significantly different between BS and C as result of significantly different in total fruit weight of tree treated by BS (127.1kg) and C (59.9kg) or equivalent to 112.2% different (Fig. 3).

The important component of Bujangseta technology was fertilizer application and management as well. Based on a regression analysis, the equation of total fruit yield of Siam Pontianak was $Y_{\text{total production/plant}} = 311 - 2627\ \text{cmol kg}^{-1}$ Na - 22.5 cmol kg^{-1} Ca + 287 cmol kg^{-1} Mg + 37.3 cmol kg^{-1} K ($p< 0.05$, adjusted $R^2 = 99.8\%$). It indicated that leaf mineral nutrition status was the main cause of yield variation in this cultivar. Application of Mg ($MgSO_4$) with the composition of 20% MgO and 21% S, and K (Nitrophoska) with composition of 15% N; 15% P_2O_5; 15% K_2O plus 2 % S was able to increase fruit production. Eticha et al. (2017) reported that Ca content in the leaves and fruit yield, micronutrient uptake, and leaf cell wall material content as well have close correlations for each other. In terms of fruit grade, Bujangseta and control

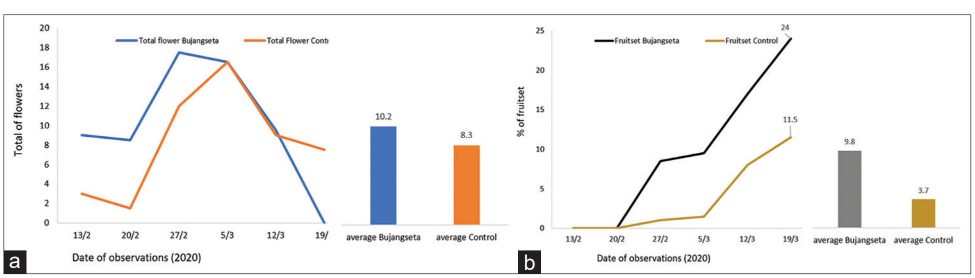

Fig 2. Number of flower/branch (a) and fruit set percentage (b) of Siam cv. Pontianak Treated with Bujangseta and Control treatments

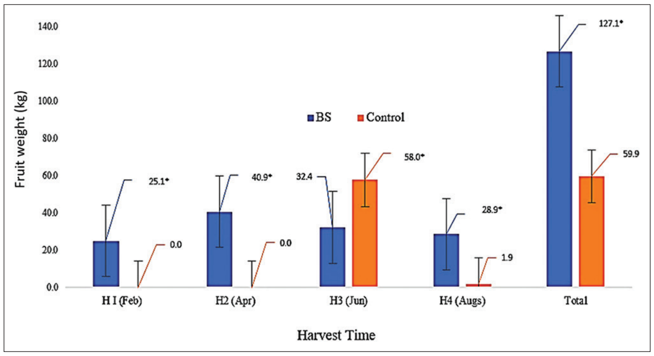

Fig 3. Fruit weight/tree under Bujanseta and Control (February – August 2020)
*Value that are significantly different of BS from the control treatment using student's t-test ($p < 0.05$). Error bars are standard errors of the mean

produced fruit with the grade class of A to E and C to E, respectively. Fruit grade of 85.7% derived from Bujangseta was classified into D to E with the diameter of ≥ 39 mm; whereas for control, 89.6 % under C to D with diameter of 26-50 mm. Moreover, Bujangseta treatment was still produce fruits in the following months because of higher fruit set production.

Fruit quality

Application of BS significantly improved fruit quality such as fruit weight and diameter, juice volume, TSS, and pH. Based on correlation analyses, fruit weight/fruit was correlated to C organic in the soil ($R^2 = 66.4\%$), skin thickness was correlated to Ca content ($R^2 = 83\%$) and N in the soil ($R^2 = 76.8\%$). Meanwhile, TSS was correlated to Mn ($R^2 = 66.7\%$), and pH in the soil ($R^2 = 72\%$); and Vit C was correlated to CEC in the soil ($R^2 = 77.5\%$). The value of TSS was affected not only Mg but also C organic in the soil that due to kieserite and manure application. It was proved by regression equation, $Y_{TSS} = 8.44 + 1.17$ cmol kg^{-1} Mg + 0.0647 cmol kg^{-1} CEC + 0.101% C Org - 0.201 cmol kg^{-1} K ($p < 0.05$, Adjusted $R^2 = 100\%$).

Production and fruit quality are influenced by many factors such as varieties, harvesting time, irrigation and mineral nutrition. In terms of macro nutrient, application of K and N increased fruit yield and fruit quality of citrus 'Cadoux' Clementine and Chinese Mandarin (Aular et al., 2017; Hamza et al., 2015; Ennab, 2017), Sweet lime (*Citrus limmetta*) (Aboutalebi, 2013), and mandarin Kinnow (Tariq et al., 2018). Moreover, the addition of organic fertilizer along with inorganic fertilizer (optimum NPK) did not increase plant growth, photosynthetic rates or fruit yields of Kiwifruit compared with only NPK fertilizer application, but significantly enhanced the fruit quality as a result of improving fruit chemical composition, such as soluble solids and reduced sugar (Zhang et al., 2020).

CONCLUSION

Leaf area of Siam cv. Pontianak treated with BS significantly increased by 2-fold compared to C treatment, whereas for leaf thickness, both BS and C gave the same respond.

Several nutrient contents such as C organic, N total, and Zn on the leaves of Siam cv. Pontianak treated by BS were significantly higher than that of C treatment. The same result was also occurred on chlorophyll a, b and total chlorophyl as well as total carotenoids contents.

Application of BS changed the flowering pattern and induced flower bud formation, blooming, and fall petals earlier. BS also produced higher flowering and fruit set percentage, fruit number/10 branches/tree, and total fruit weight.

Fruit quality such as juice volume, TSS, and pH was also improved by using BS treatment, whereas concentration of simple organic molecules such as sugar and starch content on leaf treated by both BS and C treatment was not significantly different.

Improvement of fertilizer application is recommended to improve the 'Bujangseta' technology in order to increase the gradual flowering and fruiting in Siam group.

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