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Efforts to Produce Siamese Orange Fruit All Year through Application of Flower-Inducing Substance and Calcium Fertilizer

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ABSCTRACT
This study aimed to produce Siamese orange fruits all year through the application of flower-inducing substance and calcium fertilizers. The research was conducted in Susut District, Bangli Regency, Bali Province, Indonesia, from February to September 2020. The experiment used a factorial randomized block design with 2 factors and 3 replications. The first factor was the dose of potassium nitrate as the flower-inducing agent consisting of 4 levels (0, 20, 40 and 60 g/tree), while the second factor, the dose of calcium fertilizer consisted of 3 levels (0, 250 and 500 g/tree). The results showed that the interaction between potassium nitrate and calcium doses had a significant effect on weight per fruit and fruit weight per tree. The highest weight per fruit and fruit weight per tree were obtained in the combination of potassium nitrate dose of 40 g/tree with a dose of calcium fertilizer 500 g/tree, namely 151.90 g and 59.49 kg, or an increase of 40.22% and 222.61% if compared to control with weight per fruit and fruit weight per tree were 108.33 g and 18.44 kg. Giving potassium nitrate at a dose of 40 g/tree increased the number of fruit and fruit weight per tree, thereby prolonging the fruit harvest period. The application of calcium fertilizer at a dose of 500 g/tree increased the number and yield of fruit per tree and increased fruit diameter significantly higher than the control.
KEY WORDS: *all year fruiting, calcium fertilizer, KNO_3, Siamese orange.*

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I. INTRODUCTION

Oranges are the third most important fruit commodity in Indonesia after bananas and mangos, both in terms of production quantity and consumption needs as well as of their trade value. Siamese orange (*Citrus nobilis* var. Microcarpa Hassk) is one of the most cultivated citrus types and dominates 60% of the national and regional citrus market [4]. In Bali Province, Siamese orange is a fruit of high economic value. It is needed in large quantities for tourism and domestic consumption.

The obstacle faced by Siamese orange farmers currently is that the production is seasonal, where at the main harvest time (on-season period) the plants produce a lot of fruits, but the quality is low with small sizes so that the selling price is low. On the other hand, outside the main harvest time (off-season period), the plants do not bear fruit, so there is no supply of fruit and farmers do not get income. This situation is not profitable from an agribusiness perspective. Therefore, it is necessary to overcome so that at on-season period the amount of production is not excessive but the quality of the fruit is prime, and at off-season the plants can still produce fruits so the fruit of Siamese orange be available all year.

The production potential of Siamese orange can reach 25 t/ha [15], however, according to [6] the production obtained by farmers in production canters of Siamese orange is only 2.9 t/ha. According to [17] the production of Siamese orange tree at the farm level is only 40-70 kg, much lower than its potential production. This occurred because the maintenance carried out by farmers is inadequate; especially fertilization that is not according to recommendations, both regarding the type of fertilizer and the time and method, and no action is taken that can stimulate the growth of flowers, such as giving flower-inducing compounds.

The low quality of fruit during the main harvest time occurs because farmers allow their plants to bear fruit without being accompanied by good and correct cultivation practices, especially the lack of balanced fertilization. [15] and [2] stated that citrus plants can produce well if they are fertilized with organic fertilizers and fertilizers containing N, P, K, Ca, and Mg nutrients with the right dosage and application time. The results of the study by [11] showed that giving calcium fertilizer in the form of dolomite increased the size and diameter of Siamese orange fruit. The size and diameter of Siamese orange fruit at a dose of 600 g/tree of calcium were higher than at a dose of 400 g/tree, but at a dose of 400 g/tree were significantly higher than that of controls (without calcium fertilizer). [16] found that application of Ca fertilizer in the form of gypsum 700 g/tree gave the highest fruit weight per tree, namely 28.58 kg, an increase of 66.36% compared to without

giving gypsum which was 17.18 kg. According [18], in adult plants even though the soil pH is neutral, giving low doses of dolomite (± 1 kg tree) is necessary to maintain the availability of Ca and Mg because the amount of Ca transported by fruit is relatively the same as the element of P. Dolomite is a lime compound which contains calcium (Ca) 8-12%, and magnesium (Mg) 18-22%.

Induction (stimulating) flowering so that fruit plants can bear fruit all year can be done by chemical agent, among others, by applying potassium nitrate (KNO_3), potassium chlorate ($KClO_3$), or ethepon [8, 19, 23]. KNO_3 is one type of flower-inducing substance that has been available in the market, which contains a combination of the elements N (nitrogen) and K (potassium) in the form of K_2O. Potassium contained in KNO_3 has an effect as a balancing act when plants have excess nitrogen. This fertilizer is very effective to use because the potassium (K_2O) content is quite large, namely 46% and the N content of 13% which can be applied through the soil [22].

Potassium nitrate (KNO_3) is the flower-inducing compounds that can be used to induce flowers. The ability of KNO_3 to break bud dormancy according to [19] are related to the role of K^+ ions in increasing the translocation of sucrose, increasing the rate of transport of sucrose to the apoplasts of leaf mesophyll cells, increased loading on the phloem and the direct effect of increasing osmotic pressure. Application of KNO_3 was reported by [9] and [10] that the substance can be used to stimulate off-season fruit production in mangoes because it can break dormancy of flower buds. In the Philippines, the use of potassium nitrate in mangoes has even been carried out since 1979 and from this discovery it has enabled the Philippines to produce mangoes of Pico, Carabao and Pahutan cultivars all year so that a continuous supply of mangoes can be done throughout the year [12]. The recommendation in using of KNO_3 for fruit trees is 50 g/tree, giving it can be done by sprinkling around the roots or spraying on the leaves [9].

II. RESEARCH METHOD

This research was conducted in the Siamese orange plantation owned by farmers in Susut District, Bangli Regency, Bali Province, Indonesia, from February to September 2020. The study used a randomized block design (RBD) which was arranged in a factorial with 2 treatment factors. The first factor was the application of the dose of potassium nitrate as the flower inducer (K) consisting of 4 levels, i.e. 0 g/tree (K_0), 20 g/tree (K_1), 40 g/tree (K_2) and 60 g/tree (K_3). While the second factor was the dose of calcium fertilizer in the form of dolomite (C) consisting of 3 levels, i.e. 0 g/tree (D_0), 250 g/tree (D_1), and 500 g/tree (D_2). Thus, there were 12 combination treatments and each of them was repeated 3 times so needed 36 sample trees.

Giving dolomite was carried out earlier than giving flower induzer substances by spreading it in the soil around the tree at a distance of 40-50 cm from the base of the stem, according to the treatment dose. The purpose of giving dolimite early was so that the plant growth healthy before it was induced to flower. Potassium nitrate as the flower-inducing agent was given 2 weeks after giving calcium fertilizer. Potassium nitrate according to the treatment dose was dissolved in one liter of water then sprinkled through the soil in a circle at a distance of 40-50 cm from the base of the tree. The sample trees were maintained intensively including pruning branches, twigs and leaves that were attacked by disease in order to reduce assimilate competition.

The variables observed included number of flowers per tree, number of fruits per tree, percentage of fruit-set, fruit weight per tree, weight per fruit, fruit diameter, leaf chlorophyll content, leaf relative water content, total sugar, reducing sugar, and sucrose content of leaves. Data were analyzed with variance according to the design used in research activity. If F test of the interaction was significant different, then it should be followed by Duncan test of 5%, whereas if F test of the interaction was not significant, the single factor tested by LSD of 5%.

III. RESULTS AND DISCUSSIONS

The results showed that the interaction between potassium nitrate and calcium fertilizer had only a significant effect on weight per fruit and fruit weight per tree. The highest fruit weight per tree was obtained on the combination of potassium nitrate dose of 40 g/tree with calcium fertilizer at a dose of 500 g/tree (K_2D_2), namely 59,49 kg, or an increase of 222.61% when compared to control (K_0D_0) with fruit weight per tree was 18.44 kg. The high fruit weight per tree in K_2D_2 was supported by the increase of weight per fruit, whereas the highest weight per fruit was obtained in K_2D_2 (151.90 g), or an increase of 40.22% compared to K_0D_0 (108.33 g) (Table 1). The increased of fruit weight per tree and weight per fruit in K_2D_2 was due to the influence of potassium nitrate and calcium fertilizers working together in influencing plant metabolisms, especially in the process of flowering and fertilization. Potassium nitrate is a flower inducer that is effective in overcoming generative bud dormancy, which is indicated by the induced buds that can develop further to produce flowers. Meanwhile, calcium fertilizer in the form of dolomite has a function apart from being a neutralizer for soil pH as well as providing nutrients, especially Ca and Mg. The two elements, Ca and Mg, have the same function in preventing flowers and fruit drop so that the flowers and fruits that are formed higher [11, 16].

Table 1. Weight per fruit and fruit weight per tree on the interaction between potassium nitrate and calcium fertilizer

Variables	Weight per fruit (g)			Fruit weight per tree (kg)		
Treatments	Calcium fertilizer (D)			Calcium fertilizer (D)		
Potassium nitrate (K)	D_0	D_1	D_2	D_0	D_1	D_2
K_0	108.33 g	115.30 cd	119.80 def	18.44 d	23.41 bcd	23.67 bcd
K_1	116.30 def	125.30 c	129.33 f	38.61 bc	33.57 bcd	39.17 bc
K_2	121.10 ef	137.87 b	151.90 a	30.19 bcd	41.37 bc	59.49 a
K_3	121.50 cde	136.73 b	143.00 b	44.21 ab	38.98 bc	40.98 bc

Note: Numbers followed by the same letter in the same column and lane and diagonally showed no significant difference in Duncan's test of 5%.

On the single factor the dose of potassium nitrate, the number of flowers per tree in K_1, K_2, and K_3 was significantly higher than that of in K_0. In addition, the percentage of flowers that developed into fruit (*fruit-set*) in K_1, K_2, and K_3 was also significantly higher than that of in K_0. Both of them caused the number of fruits per tree in K_1, K_2, and K_3 to be significantly higher than in K_0 (Table 2). The higher number of flowers and number of fruits per tree in K_1, K_2, and K_3 were associated with higher leaf relative water content and leaf chlorophyll content at these treatment levels compared to K_0. The increased in chlorophyll content and leaf water content causes the photosynthetic process increase because chlorophyll and water play very important roles in the photosynthetic process so that more assimilates are produced [5]. The increased in the photosynthesis process in the K_1, K_2 and K_3 levels was evident from the higher content of total sugar, reducing sugar, and sucrose of leaves (Table 3). The increase in total sugar, reduction sugar and sucrose content of leaves caused the allocation of photosynthetic to the fruit organs increase, thereby increasing fruit diameter (Table 2), weight per fruit and fruit weight per tree (Table 1). The increased in the weight per fruit and number of fruits per tree in this study caused the span of the harvest period for the provision of potassium nitrate to be longer so that if the regulation of potassium nitrate treatment was carried out properly, the Siamese orange could bear fruit all year. The ability of KNO_3 to induce flower according to [7] was related to the role of K^+ in increasing the translocation of sucrose, increasing the rate of transport of sucrose in leaf mesophyll cells, and increasing osmotic pressure. KNO_3 with essential nutrients, namely potassium (K) and nitrogen (N), was reported by [9] that the substance can be used to produced off-season fruits of mangoes because it can break flower bud dormancy. [6] found that guava giving KNO_3 concentration of 1.5% by spraying the leaves during the enlargement phase of the fruit had a significant effect on improving fruit quality as indicated by the increase in vitamin C content, total dissolved solids, storage time, and the level of damage of fruit. The same thing was obtained by [4] on tomatoes. Based on this description, it can be concluded that giving KNO_3, besides being able to increase harvest continuity, can also improve fruit quality of Siamese orange.

On the single factor the dose of calcium fertilizer, the higher the dose of calcium fertilizer, the higher number of flowers per tree and percentage of fruit-set, but statistically the dose of D_2 was not significantly different from the dose of D_1. The higher number of flowers per tree and the increasing percentage of fruit-set in D_2 and D_1 caused the number of fruits per tree in D_2 and D_1 to be significantly higher than control (D_0) (Table 2). This showed that the application of calcium fertilizer in the form of dolomite can increase the number of flowers and reduce the number of fallen fruits so that the number of fruit harvested per tree increases. This condition is related to the increase in chlorophyll content and the relative water content of leaves with calcium application, and this caused the photosynthesis process increase as indicated by the increase in the total sugar, reducing sugar and sucrose content of leaves (Table 3). Calcium plays a very important role in relation to cell wall integrity [14, 24]. According to [21] calcium is the most important nutrient for maintaining cell wall integrity and cell membrane elasticity in fruit trees. Fruit trees that are deficient in calcium cause cell membranes to be weak and leaky, the fruit is easy to soften and rot, susceptible to pests and diseases, and cannot stand long storage. The results of the research by [20] showed, apples that received adequate calcium fertilization, rotten fruit and were attacked by *botrytis cinerea* fungus were lower than those of control.

Table 2. Number of flowers per tree, percentage of fruit-set, number of fruits per tree, fruit diameter, relative leaf water content, and leaf chlorophyll content in the treatment of potassium nitrate and calcium fertilizer

Tretaments	Number of flowers per tree (unit)	Percentage of fruit-set (%)	Number of fruits per tree (unit)	Fruit diameter (cm)	Relative leaf water content (%)	Leaf chlorophyll content (SPAD)
Potassium nitrate (K)						
K_0	236.11 c	89.83 b	186.33 c	6.08 d	80.32 b	82.33 d
K_1	272.11 b	95.63 a	245.00 b	6.33 c	87.06 a	84.55 c
K_2	345.55 a	96.34 a	325.66 a	6.81 a	88.66 a	87.90 a
K_3	341.78 a	95.29 a	318.44 a	6.57 b	88.03 a	85.88 b

LSD 5%	34.10	2.90	49.35	0.15	5.76	0.06
Calcium fertilizer (D)						
D_0	232.92 b	88.92 b	200.75 b	6.23 b	80.54 b	80.11 c
D_1	273.75 ab	94.92 a	256.83 ab	6.57 a	82.54 ab	86.07 b
D_2	294.75 a	96.25 a	279.42 a	6.58 a	87.86 a	90.01 a
LSD 5%	55.55	3.34	56.98	0.18	6.65	0.09

Note: The number followed by the same letter in the same column showed a significantly different level of LSD test at 5%.

Table 3. Total sugar, reducing sugar, and sucrose content of leaves on potassium nitrate and the dose of calcium fertilizer treatment

Treatments	Total sugar content of leaves (%)	Reducing sugar content of leaves (%)	Sucrose content of leaves (%)
Potassium nitrate (K)			
K_0	15.69 d	5.83 d	9.86 c
K_1	19.86 c	7.41 c	12.45 b
K_2	26.75 a	10.98 a	15.77 a
K_3	22.97 b	9.85 b	13.12 b
LSD 5%	1.67	0.66	1.55
Calcium fertilizer (D)			
D_0	17.69 c	5.98 c	11.71 c
D_1	22.85 b	7.73 b	15.10 b
D_2	28.50 a	9.52 a	18.98 a
LSD 5%	1.72	0.88	1.93

Note: The number followed by the same letter in the same column showed a significantly different level of LSD test at 5%.

IV. CONCLUSION

The highest weight per fruit and fruit weight per tree was obtained in the combination of potassium nitrate at a dose of 40 g/tree with calcium fertilizer at a dose of 500 g/tree, namely 151.90 g and 59.49 kg or an increase of 40.22% and 222.61% if compared to the control with weight per fruit and fruit weight per tree 108.33 g and 18.44 kg. Giving potassium nitrate at a dose of 40 g/tree increased the number of fruit and fruit weight per tree, thereby prolonging the fruit harvest period and indicated that Siamese orange can be done for fruiting all year. The application of calcium fertilizer at a dose of 500 g/tree increased the number and yield of fruit per tree and increased fruit diameter significantly higher than the control (without calcium fertilizer).

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REFERENCES

[1]. Dirjenhorti (Direktortat Jenderal Hortikultura). (2018). Volume dan nilai ekspor-impor hortikultura indonesia periode 2013-2017. Departemen Pertanian, Jakarta. http://www. hortikultura.deptan.go.id.
[2]. Garhwal, P. C., Yadav, P. K., Sharma, B. D., Singh, R. S. and Ramniw, A. S. (2014). Effect of organic manure and nitrogen on growth yield and quality of citrus in sandy soil of hot arid region. African J. of Agric. Res., 9(34), 2638-2647.
[3]. Januwiata, I. K., Dunia, I. K. dan Indrayani, L. (2014). Analisis saluran pemasaran usahatani jeruk di Desa Kerta Kecamatan Payangan Kabupaten Gianyar Tahun 2013. ejournal.undiksha, 4(1), 15-21.
[4]. Kazemi, M. (2012). Effect of gibberellic acid and potassium nitrate spray on vegetative growth and reproductive characteristics of tomato. Journal of Biology and Environmental Science, 8(22), 1-9.
[5]. Luis, A. G., Fornes, F., and Guardiola, J. L. (2005). Leaf carbohydrate and flower formation in citrus. J. Amer. Soc. Hort. Science, 120(2),222-227.
[6]. Mandal, G., Dhaliwal, H. S. and Mahajan, B. V. C. (2012). Effect of pre-harvest application of naa and potassium nitrate on storage quality of winter guava (*Psidium Guajava*). Indian Journal of Agricultural Sciences, 82 (11), 985-989.
[7]. Marschner, H. (1997). Mineral nutrition in higher plants. London: Academic Press Inc, LTD.
[8]. Mehouachi, J., Tadeo, F. R., Zaragoza, S, Primo-Millo, E. and Talon, M. (2006). Effects of gibberellic acid and paclobutrazol on growth and carbohydrate accumulation in citrus flowering. Journal of Hort. Science, 71(5), 747-754.
[9]. Poerwanto, R., Harjadi, S. S. and Efendi, D. (1997). Pengaturan pembungaan mangga Gadung 21 di luar musim dengan paklobutrazol dan zat pemecah dormansi, Hayati 4(2),41-46.
[10]. Poerwanto, R. (2003). Peran manajemen budidaya tanaman dalam peningkatan ketersediaan dan mutu buah-buahan. Orasi Ilmiah Guru Besar Tetap Ilmu Hortikultura, Fakultas Pertanian, IPB. 13 September 2003. 86 hal.
[11]. Purbiati, T., Sugiyarto, M. dan Susanto, D. A. (2014). Pengkajian penjarangan buah pada tanaman jeruk Siam. Perpustakaan Balijetstro. Diakses pada 20 November 2019.
[12]. Tome, R. P. and Bondad, N. D. (1991). Growth and floering of "Carabao" mango with paclobutrazol and potassium nitrate. Phillipp Agric., 74(3), 367-374.

[13]. Romdhon, M. M, Andani, A., and Nasari, W. F. (2018). Comparative advantage of Siamese orange (*Citrus Nobilis*) farming in District of 50 City, West Sumatera. Agritropica: Journal of Agricultural Science, 1(2), 62-67. DOI: https://doi.org/10.31186/J. Agritropica, 1(2), 62-67.
[14]. Sahu, P. K., Dikshit, S. N. and Sharma, H. G. (2014). Effect of chemical fertilizers, organics and biofertilizers on growth, yield, and soil nutrient status in guava. International Journal of Research in Environmental Science and Technology, 4(4), 111-113.
[15]. Srivastava, A. K. 2009. Integrated nutrient management: Conscept and apllication in citrus. Tree and Forest Science and Biotechnology. National research Center for Citrus, Maharashtra, India. 27p.
[16]. Sulistiawati, A. N. P. 2018. Fisiologi pembungaan dan produksi buah jeruk Siam (*Citrus nobilis* var. microcarpa L.) di luar musim. Disertasi. Pascasarjana Fakultas Pertanian Universitas Udayana, 56-72.
[17]. Supartha, I. W., Kesumadewi, A. A, Susila, W, Gunadi, I. G. A and Suardi, D. P. O. (2015). Profil jeruk Gianyar tahun 2015. Kerjasama Pemerintah Kabupaten Gianyar dengan Universitas Udayana.
[18]. Sutopo. (2011). Rekomendasi pemupukan untuk tanaman jeruk. KPRI Citrus. Pusat Pesanan Benih Jeruk Indonesia. Balitjestro. http://balitjestro.litbang.pertanian.go.id/. Diakses 11 Januari 2014.
[19]. Thirugnanavel , A., Amutha, R., Rani, W. B., Indira, K., Mareeswari, P., Muthulaksmi dan Parthiban, S. (2007). Studies on regulation of flowering in acid lime (*Citrus aurantifolia* swingle.). Research Journal of Agriculture and Biological Sciences, 3(4), 239-241.
[20]. Tobias, R. B., Conway, W. S., Sams, C. E., Gross, K. C. and Whitaker, B. D. (2003). Cell wall composition of calcium-treated apples inoculated with *Botrytis Cinerea*. Journal of Phytochemistry, 32 (1), 35-39.
[21]. Weir, R. G. and Creswell, G. C. (1995). Plant nutrient disorder 2: Tropical Fruit and Nuts Crop. Inkata Press, Australia.
[22]. Widiastoety, D. (2007). Pengaruh KNO_3 dan (NH4)2SO4 terhadap pertumbuhan bibit anggrek Vanda. Jurnal Hortikultura, 18 (3), 307-311
[23]. Wilkie, J. D., Sedgle, M. and Olesen, T. (2008). Regulation of floral initiation in horticultural trees. J. of Experimental Bot., 59 (12), 3215–3228.
[24]. Yadav, M. K., Ram, R. B., Kumar, V., Meena, M. L., and Singh, H. D. (2014). Impact of micronutrients on fruit set and fruit drop of winter season guava (*Psidium guajava* L.) cv. Allahabad Safeda. Indian Journal of Science and Technology, 7(9), 1451-1453.