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Effect of Mono Potassium Phosphate and Calcium Fertilizer on Yield and Sweetness of Siam Orange Fruit on Off-Season Production

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Abstract
The aim of the study was to determine the effect of mono potassium phosphate and calcium fertilizers on yields and sweetness of Siam oranges. Research was conducted in Belantih Village, Bangli Regency during the off-season period of Siam orange production from December 2021 to July 2022. The study used a randomized block design with 2 factors and 3 replications. The first factor was the dose of mono potassium phosphate fertilizer (M) consisting of 4 levels, i.e. 0 g/tree (M_0), 5 g/tree (M_1), 10 g/tree (M_2) and 15 g/tree (M_3), while the second factor was the application of calcium fertilizer in the form of dolomite (D) consisting of 4 levels, i.e. 0 g/tree (D_0), 250 g/tree (D_1), 500 g/tree (D_2) and 750 g/tree (D_3). The results showed that the interaction between mono potassium phosphate and dolomite fertilizer had no significant effect on all observed variables. In the mono potassium phosphate fertilizer treatment, the highest harvested fruit weight per tree (9.01 kg) and the highest fruit sweetness (9.58 ^{o}Brix) was obtained at a dose of 15 g/tree, or an increase of 48.43% and 25,56%, respectively,than those of control with fruit weight per tree and sweetness level of only 6.07 kg and 7.63 ^{o}Brix. Dolomite fertilizer dose of 750 g/tree gave the highest weight of harvested fruit per tree (10.06 kg) and the sweetness of fruit(9.21 ^{o}Brix) or an increase of 45.16% and 20.08% compared to the control.
Keywords: *calcium, off-season, potassium phosphate, Siam orange, sweetness*

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I. INTRODUCTION

Siam orange is a type of citrus that is most widely cultivated in Indonesia. Siam orange plantations dominate around 85% of all citrus plantations in Indonesia, followed by tangerines at 8%, pomelo oranges at 55% and other types of citruses at 3%. Indonesia's Siam orange production is the 3rd largest in the world after China and Spain, while pomelo oranges are number 9 in the world [1]. The weight per fruit of Siam oranges is quite heavy with a weight per fruit of around 75.6 g, so that the average fruit yield per tree is around 7-8 kg and the main harvest (on season production) is usually done in May-August [2].

In Bangli Regency, Bali Province, Siam oranges are one of the regional superior commodities, so it is not surprising that Siam oranges dominate the plantations or fields of local residents. Siam orange is a type of citrus that is easily adaptable both in the lowlands and highlands such as the geographical conditions of the Kintamani area [3]. The need for Siam oranges especially for Bali is still lacking, this is due to the uneven (seasonal) harvest of citrus fruits which causes price spikes where only a small amount of fruit is harvested during off-season production and the price is cheap during the main harvest season (on-season production) due to the abundant availability of fruit [4].Apart from being seasonal, farmers also let the plants bear fruit without proper maintenance, especially fertilization which is less balanced so that the fruit produced is small, with low fruit quality. This problem can be overcome by applying balanced fertilization cultivation technology to induce flowering so that it can produce off-season fruit. Srivastava [5] stated that citrus plants can produce well if given organic and inorganic fertilizers containing the nutrients N, P, K, Ca and Mg with the right dosage and application time. For optimum citrus plant growth, in addition to N fertilization, it must be balanced with P and K fertilization. Phosphorus deficiency causes plant growth to become stunted, easy to fall off, flower growth is disturbed, and fruit quality is low, while excess phosphorus causes plants to flower too quickly so that the generative phase is more dominant than the vegetative phase, leaves are abnormal, widened, and brown in color. Meanwhile, potassium is an essential nutrient which is classified as the third main nutrient after N and P [6].The main function of potassium for citrus plants is to help root development, strengthen stems so that plants do not collapse easily, increase resistance to pests and diseases, improve fruit quality due to better shape, taste, firmness and color. K deficiency causes stunted citrus plants, disturbed flowering, imperfect fruit growth and

easy to fall off, small fruit yield, poor quality and cannot be stored. Calcium (Ca) plays a very important role in relation to the integrity of the cell wall, namely protecting cells from toxins, slowing tissue aging, increasing resistance to unfavorable environments, and extending the shelf life of fruit. Fruit trees that lack calcium cause cell membranes to become weak and leaky, fruit to become soft and rotten, susceptible to pests and diseases, and cannot be stored for long. Meanwhile, magnesium (Mg) functions in the photosynthesis process because it helps the formation of chlorophyll which is important in photosynthesis, it also supports plant permeability so that it helps the respiration process; increase plant resistance or immunity to pests and diseases; the formation of nutrients in plants (sugars, carbohydrates, fats, proteins and oils); increase plant productivity (because it can prevent the fall of flowers and seeds) [7]. Calcium and magnesium nutrients can be obtained through the application of dolomite.

Dolomite is a type of natural mineral rock whose main components are calcium and magnesium. Pure dolomite theoretically contains 30.4% CaO and 21.9% MgO, with the chemical formula $CaMg(CO_3)_2$ [8]. Sutopo [9] stated that for mature plants, even though the soil pH is neutral, low doses of dolomite (± 1 kg/tree) need to be applied to maintain the availability of Ca and Mg because the amount of Ca transported by the fruit is relatively larger, the same as P. Purbiati*et al*. [10] stated that the addition of Ca fertilizer in the form of dolomite could increase citrus fruit yields and also tended to increase fruit diameter and fruit weight. Treatment of 500 g Ca per tree gave the highest fruit size and fruit diameter followed by treatment of 400 g Ca per tree and significantly higher than without Ca fertilizer application.The results of research by Astiari*etal*.[11] on Siam orange plants aged 6 years with calcium fertilization in the form of dolomite at a dose of 500 g/tree gave the highest fruit yield weight (13.53 kg/tree) with the lowest percentage of fallen fruit (3, 57%) and significantly higher than control (without calcium fertilizer) with fruit yield weight (8.57 kg/tree)and fallen fruit (3, 57%). Mono Potassium Phosphate is a crystalline fertilizer and white powder containing two relatively high macronutrients, namely 52% phosphate (P) and 34% potassium (K). Mono Potassium Phosphate fertilizer provides great benefits for plants, some of which are able to increase plant growth and development, accelerate the process of flower growth, can stimulate the formation and growth of healthy fruit, prevent fruit and flower drop, longer shelf life and fruit freshness, rarely spoil fruit, and good quality. Mono Potassium Phosphate fertilizer is easily soluble and absorbed by plants, very easy for farmers to use and does not require special equipment; can be spread in the plantation area, sprayed with an ordinary sprayer, and with a sprinkling system to the base of the tree (soil drenching), can be used on various types of plants; and does not leave sediment on the ground. The recommended dose for using Mono Potassium Phosphate fertilizer is by sprinkling it around the plants at a dose of 5-10 g/plant, but not too close to the base of tree trunk. Based on the description above, the purpose of this study was to determine the effect of the application of mono potassium phosphate and calcium fertilizer on the yield and sweet taste of Siam oranges in off-season production.

II. RESEARCH METHOD

This research was carried out in Belantih Village, Kintamani District, Bangli Regency from November 2021 to July 2022. The research location is at an altitude of 1266 m above sea level, temperature between 20-25 ^oC, and rainfall is quite high between 14 - 20 mm [13]. This study used a Randomized Block Design arranged in a factorial with 2 factors and 3 replications. The first factor was the dose of mono potassium phosphate (M) fertilizer which consisted of 4 levels, i.e.: M_0 (0 g/tree), M_1 (5 g/tree), M_2 (10 g/tree) and M_3 (15 g/tree). While the second factor was dose of calcium fertilizer sourced from dolomite (D) which consisted of 4 levels, i.e.: D_0 (0 g/tree, D_1 (250 g/tree), D_2 (500 g/tree) and D_3 (750 g/tree).Thus, there were 16 combination treatments, each of treatment was repeated 3 times so that 48 citrus trees were needed. The variables observed in this study were leaf Relative Water Content (RWC), leaf chlorophyll content, total sugar, reducing sugar, and sucrose of leaves content, number of fruits per tree, percentage of fruit fallen per tree, weight per fruit, fruit diameter, fruit weight per tree and total dissolved solids.

III. RESULT AND DISCUSSION

The results of the analysis of variance showed that the interaction between the dose of monopotassium phosphate and the dose of dolomite fertilizer ((MxD) did not have a significant effect on all observed variables, whereas in the single treatment, the dose of monopotassium phosphate (M) and dolomite fertilizer (D) had a very significant effect on all observed variables (Table 1).

Treatment of mono potassium phosphate fertilizer with a dose of 15 g/tree (M_3) gave the highest fruit yield per tree, namely 7.01 kg, an increase of 53.39% when compared to the control (M_0), which was only 4.57 kg (Table 2). The increase in the weight of harvested fruit per tree in the M_3 treatment was supported by an increase in the number of fruits harvested per tree; weight per fruit and fruit diameter. The higher number of fruits in the M_3 treatment was closely related to the leaf RWC, which was 86.08% compared to M0 which was only 76.68% (Table 3). The application of monopotassium phosphate fertilizer is thought to increase the water status in plant tissues because monopotassium phosphate fertilizer contains the elements P and K. Both of these

elements are very necessary for the growth of Siam orange plants. One of the functions of the elements P and K is both in the process of forming roots and stimulating root growth and root development in the soil so that the function of roots as absorbers of water and nutrients functions properly which will support increased plant growth above ground.

Table 1. The significance of the effect of monopotassium phosphate and dolomite fertilizer doses and their interactions with the observed variables

No.	Variable	Treatments		
		(M)	(D)	(MxD)
1	Percentage of fruit fall per tree (%)	**	**	ns
2	Relative water content of leaves (%)	**	*	ns
3	Leaf chlorophyll content (*SPAD*))	**	*	ns
4	Total sugar content of leaves (%)	**	**	ns
5	Leaf reducing sugar content (%)	**	**	ns
6	Leaf sucrose content (%)	**	**	ns
7	Number of harvested fruits per tree (fruit)	**	**	ns
8	Fruit diameter (cm)	**	*	ns
9	Weight per fruit (g)	**	*	ns
10	Fruit weight per tree (kg)	**	**	ns
11	Total dissolved solids (^{o}brix)	**	*	ns

Description: ns = Not significant (P> 0.05)
* = Significantly influential (P<0.05)
** = Very significant effect (P<0.01)

Table 2. Average number of harvested fruit per tree, weight per fruit, fruit diameter, weight of harvested fruit per tree and total dissolved solids due to the effect dose of mono potassium phosphate and dose of dolomite fertilizer treatment

Treatment	Number of harvested fruits per tree (fruit)	Weight per fruit (g)	Fruit diameter (cm)	Weight of harvested fruit per tree (kg)	Total dissolved solids (^{0}brix)
Dose of MonopotassiumPhosphate (M)					
M_0 (0 g/tree)	59.50 d	80.32 a	5.68 d	6.07 d	7.63 b
M_1 (5 g/ tree)	59.83 c	99.16 b	6.11 c	6.10 c	7.63 b
M_2 (10 g/tree)	64.83 b	104.02 a	6.31 b	7.10 b	8.00 b
M_3 (15 g/tree)	70.92 a	107.61 a	7.59 a	9.01 a	9.58 a
LSD 5%	1,96	4.05	0.17	0.27	0.39
Dose of Dolomite (D)					
D_0 (0 g/tree)	58.67 c	87.20 b	6.07 c	6.93 d	7.67 c
D_1 (250 g/ tree)	61.25 b	100.48 a	6.18 bc	7.56 c	7.88 bc
D_2 (500 g/tree)	63.83 a	101.25 a	6.25 b	9.01 b	8.08 b
D_3 (750 g/tree)	65.33 a	102.17 a	7.29 a	10.06 a	9.21 a
LSD 5%	1,96	4.05	0.17	0.27	0.39

Note: The average value followed by the same letter in the same treatment and column, means that it is not significantly different at the 5% LSD test level.

The highest fruit weight per tree obtained at M_3 was closely related to the leaf chlorophyll content which was also the highest at that treatment level. The highest leaf chlorophyll in mono potassium phosphate fertilizer dose of 15 g/tree (M_3) (66.30 SPAD) was significantly different from the control (M_0) (53.79 SPAD) (Table 3). The higher content of leaf chlorophyll causes the process of photosynthesis to increase as indicated by the higher content of carbohydrates on M_3, reflected in the increased levels of total sugar, reducing sugar and sucrose conent of leaves as well as total dissolved solids. Table 3 showed that the content of total sugar, reducing sugar, and leaf sucrose content and total dissolved solids in plants that were given mono potassium phosphate 15 g/tree (M_3) fertilizer was 22.65%; 11.68%; 10.97% and 9.58 ^{0}brix, respectively, significantly higher than the control.Increases in total leaf sugar, leaf reducing sugar and leaf sucrose content were positively correlated with increases in fruit weight harvested per tree, number of fruits harvested per tree and weight per fruit compared to control. Higher total sugar content in leaves can reduce fruit fall. The percentage of fallen fruit in M_3 was only 3.10% compared to the control, which was 12.86% (Table 3). Table 3 also shows that the highest total dissolved solids were obtained in M_3 and significantly higher than M_2, M_1 and M_0. The higher total

dissolved solids at M_3 compared to the other treatment levels indicated that the sweetness level of the fruit at M_3 was the best and this was supported by the highest allocation of photosynthate to the fruit at the M_3, this was possible because the total sugar content of the leaves was the highest at M_3.These data showed that mono potassium phosphate 15 g/tree fertilization treatment can improve metabolic processes and fruit growth thereby supporting increased productivity and sweetness of Siam orange on off-season production. Ashraf et al.[7] and [14] stated that potassium fertilizer can accelerate the growth and development of roots in the soil, increase the size of the fruit, add sweetness, extend the shelf life of the fruit, lighten the color of the fruit skin so that the color is more attractive, and strengthen. citrus scent. This result was also supported by [15,] which stated that with good overall plant growth and development, the process of flower and fruit formation was not hampered so that the quantity and quality of fruit became higher.

Table 3. Percentage of fallen fruit per plant, RWC, leaf chlorophyll content,sugar content, reducing sugar and sucrose content of leaves due toeffect dose of mono potassium phosphate and dose of dolomite fertilizer treatment

Treatment	Percentage of fallen fruit per plant(%)	Relative water content of leaves (%)	Leaf chlorophyll content (%)	Total sugar content of leaves (%)	Reducing sugar content of leaves (%)	Sucrose content of leaves (%)
Dose of MonopotassiumPhosphate (M)						
M_0 (0 g/tree)	12.86 b	76.18 c	59.70 b	14.29 d	7.13 c	7.45 c
M_1 (5 g/ tree)	10.09 bc	80.85 b	61.75 b	14.79 c	7.23 c	7.56 c
M_2 (10 g/tree)	7.08 b	83.74 ab	67.54 a	19.87 b	10.95 b	8.92 b
M_3 (15 g/tree)	3.10 a	86.08 a	70.40 a	22.65 a	11.68 a	10.97 a
LSD 5%	1.97	4.26	4.26	0.44	0.48	1.73
Dose of Dolomite (D)						
D_0 (0 g/tree)	9.55 c	78/06 b	61.89 b	13.59 c	6.63 d	6.96 d
D_1 (250 g/ tree)	8.77 c	81.27 ab	62.79 b	14.75 c	7.63 c	7.12 c
D_2 (500 g/tree)	8.14 b	81.73 ab	65.26 ab	17.75 b	8.11 b	9.64 b
D_3 (750 g/tree)	6.67 a	83.26 a	67.36 a	23.40 a	10.42 a	12.98 q
LSD 5%	1.97	4.26	4.26	0.44	0.48	1.73

Note: The average value followed by the same letter in the same treatment and column, means that it is not significantly different at the 5% LSD test level.

In thedose of dolomite fertilizer treatment, the highest harvested fruit weight per treewas obtained in the treatment of 750 g/tree (D_3) which was 7.56 kg, or an increase of 53.34% compared to the control (D_0) which the harvested fruit weight per tree was only 4.93 kg (Table 2). The increasing weight of harvested fruit per tree in the D_3 was supported by the increase in the number of harvested fruits per tree, weight per fruit and fruit diameter(Table 2). Higher number of harvested fruits per tree and weight per fruit on $D_3$was closely related to the higher RWC of leaves. RWC of leaves at D_3(86.08%) was significantly higher than that of on control (76.18%). The increase of RWC of leaves cannot be separated from the function of calcium contained in dolomite as stated [16] and [17] that besides functioning as a fertilizer, calcium also functions to neutralize soil pH so that the absorption of water and certain elements in the soil can be increased.

In the dolomite fertilizer dose treatment, the highest harvested fruit weight per tree was obtained at the 750 g/tree (D_3), which was 7.56 kg, or an increase of 53.34% compared to the control (D_0), which the harvested fruit weight per tree was only 4.93 kg (Table 2). The increase in fruit weight per tree at D_3 was supported by the higher number of fruits harvested per tree, fruit weight and fruit diameter (Table 2). The high number of fruits harvested per tree and the weight per fruit at D_3 is closely related to the high RWC of the leaves. The RWC of leaves at D_3 (86.08%) was significantly higher than that of the control (76.18%). The increase in leaf RWC is thought to be very closely related to the function of calcium contained in dolomite as stated by [16] and [17] that besides functioning as fertilizer, calcium also functions to neutralize soil pH so that the absorption of water and certain nutrients in the soil can increase.By increasing the internal water content of plant tissues and chlorophyll content (table 3) causes the photosynthesis process to increase so that the photosynthate produced is higher, which is indicated by the higher carbohydrate content in the leaves. The carbohydrate content as a result of the higher photosynthesis process is evident from the higher content of total sugar, reducing sugar, sucrose content in the leaves so that this can support faster fruit enlargement and increase total dissolved solids. Table 3 shows that the total sugar, reducing sugar, leaf sucrose content and total dissolved solids in D_3 were 23.40%; 10.42%; 12.98% and 9.56 ^{0}brix, respectively, much higher than the controls which were only 13.59%; 6.63%; 6.96% and 7.67 ^{0}briks. Increasing the sugar content in leaves can support an increase in total dissolved solids due to higher

leaf chlorophyll content and the photosynthate produced is positively correlated with an increase in fruit weight harvested per tree, number of fruits harvested per tree and fruit weight per tree in off-season Siam orange production. In addition, the application of dolomite level D_3 gave the highest total dissolved solids and was significantly different from D_2, D_1 and D_0. This showed that the level of fruit sweetness at D_3 is the highest and significantly sweeter than the other treatment levels. The data from this study indicated that the dolomite treatment offers hope that it can be used to increase the productivity and sweetness of Siam oranges on off-season production.

IV. CONCLUSION

The interaction between dose of mono potassium phosphate and dose of dolomite fertilizer had no significant effect on all observed variables. In the dose of mono potassium phosphate fertilizer treatment, the highest harvested fruit weight per tree (9.01 kg) and the highest fruit sweetness (9.58 ^{o}Brix) was obtained at a dose of 15 g/tree, or an increase of 48.43% and 25,56%, respectively,than those of control with fruit weight per tree and sweetness level of only 6.07 kg and 7.63 ^{o}Brix. Dolomite fertilizer dose of 750 g/tree gave the highest weight of harvested fruit per tree (10.06 kg) and the sweetness of fruit(9.21 ^{o}Brix) or an increase of 45.16% and 20.08% compared to the control.

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V. COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declared that there is no conflict of interest.

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