Improving the quality fruit of Citrus cv. Siam out off-season through the application of fertilization and pruning

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Abstract. This study aims to determine the efforts to improve the quality of Siamese citrus fruits during the growing season through fertilization and pruning. This experiment used a factorial randomized block design consisting of 2 factors. The first factor is fertilization, namely: P₀ (manure/control), P₁ (manure, N, P, K, and Ca) and P₂ (manure, N, P, K, Ca, Zn and Cu). While the second treatment is pruning, namely: M₀ (without trimming), M₁ (trimmed young shoots) and M₂ (trimmed young shoots, twigs, and leaves affected by disease and shaded). The results showed that the interaction between fertilization and pruning treatment had no significant effect on all observed variables. P₂ treatment can improve fruit quality, which is reflected by the weight of the fruit harvest per tree (3442.76g); weight per fruit (173.58g) and total dissolved solids (9.48°brix) or increase by 99.79%; 35.69% and 30.22% compared to P₀ which is 1673.13g; 127.92g and 7.28°brix. In the M₂ treatment can improve fruit quality, which is reflected by the weight of fruit harvest per tree (3638.77g), weight per fruit (173.58 g) and total dissolved solids (9.63°brix) or increase by 40.91%; 19.56% and 25.55% when compared with treatment M₀ which is 2582.34g; 145.92g and 7.67°brix.

1. Introduction
Siam Citrus is one of the most cultivated citrus species and dominates 60% of the national and regional citrus market [1]. At present the availability of Siamese citrus fruits on the market is seasonal. At the time of the harvest (on-season), the plants produce a lot of fruit, but the quality of the fruit is low, the size of the fruit is small so the selling price is low. When harvesting, farmers often leave citrus fruits in trees (not harvested) because they are cheap. Therefore, arrangements are needed so that during the harvest the amount of production is not excessive but the quality of the fruit is good. The low quality of fruit at the time of harvest occurs because farmers allow their plants to bear heavy fruit without being accompanied by the application of intensive cultivation, especially the lack of balanced fertilization and no pruning of leaves and unproductive branches such as those that are shaded and those affected by the disease. Then there was intense competition between organs in fighting photosynthates. Shaded leaves and those affected by the disease are leaves of "parasites" so that its function as "source" to supply the needs of "low" sinks [2]. The inadequate supply of photosynthates causes the fruit to fall, and this is caused by limited production and photosynthetic allocation to fruit, thus the number of harvested fruits is small and fruit quality is low [3]. Other impacts, after harvesting the fruit ends the plant languishes,
is weak and is physiologically "sick" because when fruiting is burdened with large and small fruits but not fertilized and maintained properly.

Based on the facts of the field like that, at the time of the “off-season” research needs to be done on the application of appropriate and balanced fertilization technology accompanied by unproductive leaf and branch pruning. Citrus plants can produce well when fertilized with organic fertilizers and fertilizers containing nutrients N, P, K, and Ca with the right dosage and time of application [4,5]. Nitrogen-deficient oranges cause dwarf growth, yellowish leaves and a limited root system, whereas if nitrogen is given excessively it will result in dominant vegetative growth so that the plants slowly bloom and bear fruit, the stems are easily broken, reduce crop quality and resistance to pests and diseases is low [4, 6, 7]. For optimum growth, N fertilization must be balanced with fertilizing other elements, especially P and K. The lack of phosphorus causes the growth of plants to become stunted, easy to fall down, disrupted flower growth, and low fruit quality, while excess phosphorus causes plants to flower too quickly and dominate the generative phase of the vegetative phase, leaves are abnormal, widened, and brownish in colour. The main function of potassium for citrus plants is to foster root development, strengthen stems so that plants do not fall easily, increase resistance to pests and diseases, improve fruit quality due to better shape, taste, hardness, and colour [6]. Lack of K causes dwarf citrus plants, flowering is disrupted, fruit grows imperfect and easily declines, fruit yields are small, quality is poor and cannot be stored [8]. The results of the research by [5], showed that fertilizing oranges with N, P and K each of 500, 250 and 200 g/plants had an effect on improving fruit quality, prolonging shelf life, delaying damage to ascorbic acid, and increasing the fruit sugar content.

In addition to fertilization with N, P, and K fertilizers, fruits should also be fertilized with Ca [9,10], and micro fertilizers containing zinc (Zn) [7] and copper (Cu) [11]. The quality of citrus fruit increased by fertilizing zinc sulfate (zinc sulfate) 0.5% [8], whereas the quality of guava fruit increased after being fertilized with calcium nitrate and micro fertilizer containing copper sulfate (cupric sulfate) [11]. Giving Ca fertilizer and micro fertilizer is said to be able to maintain the quality during storage and the shelf life is longer. The lowest deciduous fruit and the best quality of fruit were obtained by giving 0.5% copper sulfate through leaves. Calcium (Ca) plays a very important role in relation to cell wall integrity [9,10].

Pruning aims to control the size, control the shape, diversity of plants and regulation of flower production, quantity, and quality. The physiological response or response of plants that experience physical regulation by pruning can be seen in the growth rate and response of generative organ formation. Pruning will increase the ratio of C/N ratio in the body of the plant. A high ratio of C / N ratio results in a build-up of carbohydrates, which ultimately stimulates the formation of flowers and fruit, and the use of solar radiation by plants is more efficient so that photosynthesis is obtained per unit of leaf area is greater than plants that are not pruned. Pruning also aims to reduce competition in the struggle for assimilation between leaves and productive twigs with unproductive leaves, shoots, and twigs [12].

2. Materials and methods
The research was conducted in Kerta Village, Payangan District, Gianyar Regency from March to October 2017. The study used factorial Randomized Block Design (RBD) consisting of 2 factors. The first factor is fertilization consisting of 3 levels, namely fertilization following the farmer's method, namely only with manure/control (P0), fertilizing with manure, N, P, K, and Ca (P1), and fertilizing with manure, N, P, K, Ca, Zn and Cu (P2). While the second factor is trimming consisting of 3 levels, namely: M0 = Without pruning, M1 = Trimmed young shoots and M2 = Trimmed young shoots, twigs, and leaves that are attacked by disease and shaded. The combination treatment was repeated 4 times so that 36 sample trees were needed. Variables observed: percentage of flowers into fruit / fruit-set per tree, percentage of young fruit falling per tree, leaf chlorophyll content, nutrient content of N, leaf P, KAR content of leaves, sugar content total, reducing sugars and leaf sucrose, weight per fruit, number of harvested fruits, fruit diameter, harvested fruit weight per tree and total dissolved solids. Data were analyzed statistically with variance according to the design used. If the F test shows significant
interaction, then to compare the values between treatments, the DMRT average test (Duncan multiple range test) is used, whereas if the F test is only a single factor that has a significant effect, further testing uses the LSD Test.

3. Results and discussion

Based on the results of the analysis of variance, it was found that the interaction between fertilizer and trimming treatment had no significant effect on all observed variables. While the fertilization and pruning treatment had a significant effect on all variants of the observed. The average value of variables observed because of the effects of fertilization and pruning are presented in Table 1 to Table 2. Fertilization treatment with manure, N, P, K, Ca and micro fertilizers Zn and Cu (P2) gave the highest number of fruit harvests per tree 256 fruits or increased by 95.79% compared to the control treatment of 130.75 pieces per tree (Table 2). The increase in the number of fruit harvests per tree in P2 treatment was due to the increase in fruit-set formed which was 11.62%, higher than the control of 7.35% (Table 1). The high percentage of fruit-set in P2 caused the harvested fruit weight per tree to be higher by 3442.76 g compared to P1 and control ie 2853.55 g and 1673.13 g (Table 2). The number of fruits per tree, fruit diameter and weight per fruit in P2 treatment was obtained higher, i.e. 256.00 pieces; 6.90 cm and 191.08 g compared to controls, namely 130.75 pieces; 6.06 cm and 127.92 g. Increasing the weight per fruit in P2 treatment is supported by the increasing sugar level in citrus fruits which are reflected by the total dissolved solids of 9.48°brix compared to the control of 7.28°brix. The increase in harvested fruit weight per tree was associated with an increase in leaf relative water content (KAR) of 92.09%, higher than the control (Table 1). Increasing KAR leaves shows that the provision of complete fertilizer can increase the ability of plants to absorb water so that the internal water content of plant tissue increases, also due to the ability of plants to reduce transpiration. The complete application of fertilizer was also able to increase leaf N nutrient uptake (1.81%) and leaf P nutrients (0.20%) compared to controls i.e. 1.35% and 0.11%. Increased nutrient content of N and P leaves causes metabolic processes to be better than controls. This is reflected in the increase in leaf chlorophyll content, which is 54.28 SPAD, higher than the control, which is 48.24 SPAD (Table 1). The higher content of leaf chlorophyll in P2 treatment causes photosynthesis to work well as indicated by the higher content of carbohydrate in plants, especially the total sugar content of leaves, reducing sugars and leaf sucrose which is 15.26%; 4.95% and 11.62% higher than the control, 11.59%; 2.98% and 7.35%. The increase in total sugar content of leaves as a result of higher leaf chlorophyll content and leaf N and P nutrient content in P2 treatment correlated positively with increasing fruit weight and the number of harvested fruits per tree, fruit diameter, weight per fruit and total dissolved solids compared to controls. This shows that the P2 treatment gives hope to be used to increase the production and quality of Siamese citrus fruit because it can increase the percentage of fruit-set and increase the number and weight of fruit per tree.

In mangosteen plants, the total sugar content of leaves on shoots with deciduous flowers was significantly lower than the total sugar of the leaves on shoots whose flowers did not fall [2]. This shows that the low percentage of fruit-set in sugar bark plant Sand or the fall of flowers on mangosteen plants is associated with the low supply of photosynthates by leaves. Reports that the inadequate supply of photosynthates causes the fruit to fall and this is caused by limited assimilate production and/or the allocation of assimilates to low fruit [13]. States that assimilation does not directly determine the interest rate because it is also very determined by the level of competition between fruit "sinks" or between fruit and shoots and the proximity of the location between "sink" and "source" (proximity) [14]. The high total sugar content in the leaves can reduce the fall of fruit, this is reflected in the percentage of deciduous fruit in P2 treatment obtained the lowest that is 4.23% compared to the control ie 16.07% (Table 1). Complete fertilization can increase the quantity and quality of fruit produced so that the weight per fruit increases and the selling price of citrus fruits is more expensive. The treatment of young shoots, twigs, and leaves that were attacked by disease and shaded (M2) gave a percentage of fruit-set which was 85.05% higher than in plants that were not trimmed (control), namely 76.25% and in young shoots trimmed (M1) which is 79.61% (Table 1).
The higher fruit-set percentage in M2 causes more fruit yields, namely 222.42 with higher fruit diameter and weight per fruit, which is 6.86 cm and 173.58 g and higher total dissolved solids 9.63°brix compared to the control i.e. 170.92 pieces; 6.39 cm, 145.92 g and 7.67°brix (Table 2). Increasing the number of fruits, fruit diameter and weight per fruit produced causes the weight of the fruit harvest per tree to be higher. The harvested fruit weight per tree in M2 reached 3638.77 g, whereas those that were not pruned and young shoots cut only the weight of the harvested fruit 2582.34 g and 3155.55 g or pruning young shoots, twigs, and leaves affected by the disease and shaded give harvest fruit weight per tree 40.91% and 15.31% higher than controls and M1. The results of this study indicate that pruning of young shoots, twigs and leaves that are affected by disease and shaded is very important to do, unlike what is usually done by farmers where the branches and leaves that are attacked by disease and shade are left so that they become competitors for nutrients, water, and photosynthesis for the development of flowers and fruit from the parent plant. Increased fruit weight in M2 is caused by greater weight per fruit. So trimming young shoots, twigs, and leaves that are attacked by disease and shaded can increase the quantity of fruit as well as improve the quality of fruit produced because the higher weight per fruit determines the selling price in consumers is more expensive.

The increase in yield and yield per tree in M2 was caused by an increase in the relative water content of leaves (93.08%), leaf chlorophyll content (51.98 SPAD), leaf N nutrient content (1.68%) and leaf P nutrient content (18%), compared to plants that are not pruned, namely 84.15%; 49.88 SPAD; 1.28% N leaves and 0.09% P leaves (Table 1). His causes more optimal photosynthesis activity as evidenced by the increase in total sugar content, reducing sugar and leaf sucrose, which is 14.23%; 4.49% and 10.48% compared to plants that were not pruned at 9.46%; 2.64% and 7.66% (Table1 and 2). The low photosynthate that is received by flowers on non-pruned citrus plants is associated with higher competition in fighting for the results of photosynthesis among various organs. Branches and leaves that are attacked by disease and shaded if not immediately discarded, the organ is a competitor and competes with each other so that physiologically reduces the ability of flowers or fruit to get photosynthate. Reports that the inadequate supply of photosynthates causes deciduous fruit, caused by limited photosynthate production and photosynthetic allocation to low fruit [12]. In plants that are not pruned/controlled, more deciduous fruits are reflected by the percentage of deciduous fruit (11.71%) and 10.22% at M1, higher than M2 which is 7.68% (Table 1).

**Table 1.** Effect of fertilization and pruning on the percentage of a fruit-set percentage, the percentage of young deciduous fruit, leaf chlorophyll content and relative water content leaf, leaf N nutrient content, leaf P nutrient content, and total leaf sugar content.

| Treatment | Percentage Fruit-Set (%) | Percentage of Young Fall Fruit (%) | Leaf Chlorophyll content (SPAD) | Relative Water Content (KAR) Leaf (%) | Nutrient content of N leaves (%) | Nutrient content of P leaves (%) | Content Total Sugar Leaf (%) |
|-----------|---------------------------|-----------------------------------|---------------------------------|-------------------------------------|-------------------------------|-------------------------------|-----------------------------|
| Fertilization (P) | | | | | | | |
| P0 | 64.31 b | 16.07 a | 48.24 c | 86.33 c | 1.35 b | 0.11 c | 13.59 c |
| P1 | 82.77 a | 9.31 b | 50.51 b | 89.92 b | 1.65 a | 0.16 b | 21.75 b |
| P2 | 83.83 a | 4.23 c | 54.28 a | 92.09 a | 1.81 a | 0.20 a | 27.40 a |
| LSD 5% | 7.75 a | 1.94 | 1.82 | 0.02 | 0.21 | 0.03 | 1.13 |
| Pruning (M) | | | | | | | |
| M0 | 76.25 b | 11.71 a | 49.88 b | 84.15 b | 1.28 b | 0.09 c | 17.76 c |
| M1 | 79.61 b | 10.22 a | 51.18 b | 90.01 a | 1.53 a | 0.14 b | 20.87 b |
| M2 | 85.05 a | 7.68 b | 51.98 a | 93.08 a | 1.68 a | 0.18 a | 23.65 a |
| LSD 5% | 7.75 a | 1.94 | 1.82 | 0.02 | 0.21 | 0.03 | 1.13 |

Description: The average value followed by the same letter in the same treatment and column, means that there is no significant difference in the level of LSD test 5%.
Table 2. Effects of fertilization and pruning on reducing sugar content variables leaves, leaf sucrose content, number of harvested fruits per tree, diameter per fruit, weight per fruit and weight of fruit harvest per tree.

| Treatment | Leaf Reduction Sugar Content (%) | Sucrose content Leaf (%) | Number of fruit harvested per tree (fruit) | Diameter per Fruit (cm) | Weight per Fruit (g) | Fruit harvest weight per tree (g) | Total dissolved solids (°Brix) |
|-----------|---------------------------------|--------------------------|------------------------------------------|------------------------|---------------------|---------------------------------|-------------------------------|
| Fertilization (P) |                                  |                          |                                          |                        |                     |                                 |                               |
| P0        | 4.93 c                          | 8.66 c                   | 130.75 c                                 | 6.06 b                 | 127.92 c            | 1673.13 c                     | 7.28 c                        |
| P1        | 6.63 b                          | 14.61 b                  | 203.33 b                                 | 6.58 a                 | 157.83 b            | 2853.55 b                     | 8.00 b                        |
| P2        | 8.42 a                          | 19.06 a                  | 256.00 a                                 | 6.90 a                 | 191.08 a            | 3442.76 a                     | 9.48 a                        |
| LSD 5%    | 0.44 a                          | 1.64 a                   | 27.86 a                                  | 0.38                   | 10.35 a             | 4.20 a                         | 0.70                          |
| Pruning (M) |                                  |                          |                                          |                        |                     |                                 |                               |
| M0        | 5.88 c                          | 12.15 c                  | 170.92 c                                 | 6.39 b                 | 145.92 c            | 2582.34 c                     | 7.67 c                        |
| M1        | 6.88 b                          | 13.95 b                  | 199.75 b                                 | 6.80 a                 | 157.33 b            | 3155.55 b                     | 8.42 b                        |
| M2        | 9.23 a                          | 16.22 a                  | 222.42 a                                 | 6.86 a                 | 173.58 a            | 3638.77 a                     | 9.63 a                        |
| LSD 5%    | 0.44 a                          | 1.64 a                   | 27.86 a                                  | 0.38                   | 10.35 a             | 4.20 a                         | 0.70                          |

Description: The average value followed by the same letter in the same treatment and column, means that there is no significant difference in the level of LSD test 5%.

4. Conclusion
The interaction between fertilizing and pruning treatment has no significant effect on all observed variables. Fertilization treatment with manure, N, P, K, Ca and Zn and Cu fertilizers can improve fruit quality, which is reflected in the increase in fruit harvest weight per tree (3442.76 g); weight per fruit (173.58 g) and total dissolved solids (9.48°Brix) or increase by 99.79%; 35.69% and 30.22%, when compared with controls, namely 1673.13 g; 127.92 g and 7.28°Brix. The treatment of pruning, twigs, and leaves that are attacked by disease and shaded can improve the quality of the fruit as reflected in the increase in harvested fruit weight per tree (3638.77 g); weight per fruit (173.58 g) and total dissolved solids (9.63°Brix), or increase i.e. 40.91%; 19.56% and 25.55% when compared with treatments without pruning, namely 2582.34 g; 145.92 g and 7.67°Brix

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