

Growth Response and Photosynthetic Activity of Tejakula Tangerine (*Citrus Reticulata* CV. Tejakula) On the Application of Different Fertilization Package



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ABSTRACT: Optimization of vegetative growth and photosynthetic activity of Tejakula tangerine requires appropriate nutrition, which can be met with a combination of fertilization. This study aims to find a combination of fertilization packages between organic fertilizers, macro and micro fertilizers, mycorrhizal biofertilizers and probiotic POC fertilizers that can provide the best growth response and photosynthetic activity in Tejakula tangerine plants. The study was conducted using a Randomized Block Design (RAK) with one treatment factor of the fertilization package consisting of three levels, namely: 1. Organic fertilizer (P_o), 2. Organic fertilizer + macro and micro fertilizers (P_h), 3. Organic fertilizer + macro and micro fertilizers + mycorrhizal biofertilizer + probiotic POC fertilizer (P_c). Each treatment was repeated ten times, so that 30 experimental plant units were obtained. The results of the analysis of variance showed that the fertilizer package treatment had a very significant effect on the variables of the increase in the number of primary branches and leaf color, and had a significant effect on the variables of the increase in plant height, increase in stem diameter, leaf thickness and leaf chlorophyll content, but had no significant effect on the variables of the ratio of leaf length and width, relative water content (RA) of leaves and the microclimate of the research site. The P_c fertilizer package affected the growth of Tejakula tangerine very significantly on leaf color (3.88 BWD units), had a significant effect on the increase in plant height (72.10 cm) and the increase in the number of leaves (1.211 strands) and provided the highest photosynthesis rate (4.97%).

KEYWORDS: Photosynthesis, Tejakula tangerine, macro and micro fertilizer, organic fertilizer, fertilization package

INTRODUCTION

Horticulture is one of the subsectors that has an important role and has bright potential to be developed in Indonesia. With the support of the climate and soil in Indonesia, horticultural crops are able to grow and develop well so that abundant yields are obtained as one of the agricultural potentials that can improve the economic sector [1]. The development of horticulture as an important subsector of agriculture is evidenced by data from the Coordinating Ministry for Economic Affairs of the Republic of Indonesia [2].

Tejakula tangerine (*Citrus reticulata* cv. Tejakula) is a local variety of citrus that is commonly cultivated by people in Tejakula District, Buleleng Regency, Bali Province. Differences in fertilization technology used in Tejakula tangerine cultivation will affect plant growth and development. Citrus plants that are in the vegetative phase need fertilization optimization so that the nutrients in the fertilizer can be absorbed and utilized to optimize the growth of citrus plants [3].

Fertilizers that are generally used for citrus fertilization are organic fertilizers and inorganic fertilizers. Organic fertilizers when applied to citrus plants will be absorbed for a long time because of their slow release nature [4]. While the use of inorganic fertilizers can increase leaf green substances (chlorophyll) leaves that can affect plant photosynthesis [5]. This research was conducted to find fertilization packages between organic fertilizers, inorganic fertilizers, biological mycorrhiza and probiotics that are able to increase the growth response and photosynthetic activity of Tejakula tangerines in different fertilization package applications.

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RESEARCH METHODS

This research was conducted from February to August 2024. Research activities were carried out in Tembok Village, Tejakula District, Buleleng Regency, Agronomy and Horticulture Laboratory, Faculty of Agriculture, Udayana University, Soil Science Laboratory, Faculty of Agriculture, Udayana University, and Agricultural Product Technology Laboratory, Faculty of Agricultural Technology, Udayana University. This study used the method of Randomized Group Design (RGD) 1 factor with 3 levels, namely: 1. organic fertilizer package (P_o), 2. organic fertilizer package + macro and micro (P_h), 3. organic fertilizer package + macro and micro fertilizer + mycorrhizal biofertilizer + probiotic POC (P_c) which was repeated 5 times. Data were analyzed using Anova (Analysis of Variance). From the results of the analysis of variance, if it is found that the observation of the treatment has a real or very real effect on the parameters observed, it is continued with the 5% BNT test.

The implementation of the research includes the selection of experimental material plants, making probiotic liquid organic fertilizer, making mycorrhizal biofertilizer, fertilization implementation, fertilization treatment application, plant maintenance and data collection. Probiotic POC was made by mixing the necessary materials, namely 1 kg of kepok banana peel, 1 kg of goat manure, 2.5 l of green young coconut water, 2.5 l of rice washing water, 0.5 kg of brown sugar, 0.1 l of EM4 starter and Aquades. The preparation of mycorrhizal biofertilizer is carried out by combining the type/genus of mycorrhizal spores with spore carrier media with a composition of 100 g of volcanic sand carrier media sprinkled with 50 spore consortia from the genus glomus, acaulospora and scutellospora obtained from spore propagation from exploration results on citrus plantations in Tejakula District. The implementation of fertilization begins with cleaning the area around the plant and making rows around the tree. Fertilizers were sprinkled and shaken into the rows around the sample plants according to the treatment level with a fertilizer application interval of 2 times, namely at the beginning of the study and 2 months after the first fertilization. Especially for mycorrhizal biofertilizer, it was sprinkled at the base of the plant and given only once during the first fertilization. Plant maintenance was carried out in the form of weeding, maintenance pruning, and pest and disease control

RESULTS

Increase in plant height, stem diameter and number of primary branches

The highest increase in plant height and stem diameter obtained in the (P_c) treatment was significantly different from the (P_o) treatment, but not significantly different from the (P_h) treatment. The value of plant height increase was P_c (72.12 cm), P_h (67.20 cm) and P_o (54.80 cm), respectively. While the value of stem diameter increase is P_c (1.54 cm), P_h (1.54 cm) and P_o (1.03 cm). Fertilizer application with P_c level gave the highest increase in plant height and stem diameter increase of 24.01% and 33.11% respectively compared to P_o which had the lowest value (Table 1).

Table 1. Growth response and photosynthetic activity to the variables of plant height increase (cm), stem diameter increase (cm) and number of primary branches increase (cm)

Treatment	Plant height increase (cm)	Stem diameter increase (cm)	Primary branch number increase (fruit)
P_o	54,80 b	1,03 (1,25) b	25,60 b
P_h	67,20 a	1,54 (1,43) a	38,70 a
P_c	72,12 a	1,54 (1,44) a	36,20 a
BNT 5%	11,05	0,36	4,32

Note: Numbers followed by the same letter in the same treatment and column show no significant difference in the least significant difference test (BNT) at the 5% level. The numbers in parentheses are the result of transformation.

Leaf length to width ratio, leaf thickness and leaf color

The fertilizer package treatment did not significantly affect the ratio of leaf length and width. The P_o fertilizer package treatment tends to have the highest ratio value with a value of 1.81 cm, which is not significantly different from all other fertilizer package treatment levels. The P_h fertilizer package treatment tends to have the lowest ratio value with a value of 1.79 cm (Table

Package treatment significantly affects leaf thickness. The P_o fertilization package treatment has the highest value with an average leaf thickness of 0.27 mm, which is not significantly different from the leaf thickness value of the P_c fertilization package treatment with an average leaf thickness of 0.26 mm. The average value of the P_c treatment is not significantly different from the P_h fertilization package, where the treatment has the lowest average leaf thickness of 0.25 mm (Table 2).

The fertilization package treatment has a very significant effect on leaf color. P_c fertilization package treatment has the

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highest value with an average leaf color value of 3.88 units, which is not significantly different from the leaf color of P_h fertilization package treatment with an average value of 3.81 units. The average value of the P_h treatment is significantly different from the P_o fertilization package treatment, the P_o treatment has the lowest average value of leaf color at 2.19 units (Table 2).

Table 2. Growth response and photosynthetic activity to variables of leaf length and width ratio (cm), leaf thickness (cm), leaf color (BWD unit)

Treatment	Leaf length to width ratio (cm)	Leaf thickness (mm)	Leaf color (BWD units)
P_o	1,81 a	0,27 a	2,19 b
P_h	1,79 a	0,25 b	3,81 a
P_c	1,80 a	0,26 ab	3,88 a
BNT 5%	0,07	0,01	0,14

Note: Numbers followed by the same letter in the same treatment and column show no significant difference in the least significant difference test (BNT) at the 5% level. The numbers in parentheses are the result of transformation.

Relative water content (RWC) and chlorophyll content of leaves, percentage of light entering the canopy

The fertilizer package treatment did not significantly affect the relative water content (RWC) of the leaves. The P_c fertilizer package treatment tends to have the highest RWC value with 78.55%, which is not significantly different from all other fertilizer package treatment levels. The P_o fertilizer package treatment tended to have the lowest RWC value with 76.55% (Table 3).

The fertilization package treatment significantly affects the leaf chlorophyll content. P_h fertilization package treatment has the highest value with an average leaf chlorophyll content of 58.39 SPAD units, not significantly different from the value of leaf chlorophyll content of P_c fertilization package treatment with an average leaf chlorophyll content of 56.16 SPAD units. The average value of the P_c treatment was not significantly different from the P_o fertilization package, the P_o treatment had the lowest average leaf chlorophyll content of 52.35 SPAD units (Table 3).

The fertilizer package treatment did not significantly affect the percentage of light entering the canopy. The P_h package treatment tends to have the highest percentage value of light into the canopy with 72.78%, which is not significantly different from all other fertilizer package treatment levels. The fertilizer package treatment P_c tended to have the lowest percentage value of light into the canopy with 71.71% (Table 3).

Table 3. Response of growth and photosynthetic activity to variables of leaf relative water content (RWC) (%), leaf chlorophyll content (SPAD units) and percentage of light entering the canopy (Lux).

Treatment	Relative water content (RWC) of leaves (%)	Chlorophyll content of leaves (SPAD units)	Percentage of light entering the canopy (Lux)
P_o	1,81 a	0,27 a	2,19 b
P_h	1,79 a	0,25 b	3,81 a
P_c	1,80 a	0,26 ab	3,88 a
BNT 5%	0,07	0,01	0,14

Note: The means followed by the same letter at the same column are not significantly different according to LSD (Least Significant Different) test at alpha 5%.

Leaf P and K nutrient

The results of leaf P nutrient analysis showed different results in each fertilizer package given. The P_o fertilization package treatment has the highest leaf P nutrient content of 0.347%, followed by the P_c package treatment which has a leaf P nutrient content of 0.180%. The P_h fertilization package has the lowest leaf P nutrient content of 0.158%.

The results of the analysis of leaf K nutrient show that leaf K nutrient content has different values in each fertilization package given. The P_o fertilization package treatment has the highest value of 1.336%, followed by the P_c fertilization package treatment which has a value of 0.547%. The P_h fertilization package has the lowest value of 0.529% (Table 4).

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Table 4. Growth response and photosynthetic activity to variable leaf P and K nutrient (%)

Treatment	Leaf nutrients (%)	
	P	K
P _o	0,347	1,336
P _h	0,158	0,529
P _c	0,180	0,547

Note: The figures above were not statistically analyzed, but were analyzed in the laboratory.

Total sugar content

The treatment of fertilization packages shows the results of total sugar analysis that the total sugar content has different values. The P_c fertilization package treatment has the highest value of 4.97%, followed by the P_o fertilization package treatment which has a value of 4.34%, and the lowest result is in the P_h fertilization package treatment which has a value of 4.04% (Table 5).

Table 5. Effect of growth response and photosynthetic activity on total sugar content variables (%)

Treatment	Total sugar (%)
P _o	4,34
P _h	4,04
P _c	4,97

Note: The figures above were not statistically analyzed, but were analyzed in the laboratory.

Stomatal position on leaves and pest infestation

Tejakula tangerine plants include plants that have stomata with a position below the surface of the leaf. The type of plant that has stomata below the leaf surface is called Hypostomatus and this type of plant leaf is called a xerophytic leaf. This type of leaf is owned by plants that live in hot areas, aiming to reduce evaporation or transpiration.

The results of observations made on the experimental unit found mealy bug infestation. The symptoms of this pest attack are the presence of a white waxy layer on the surface of the citrus leaves and the surrounding leaves are perforated which causes the leaves to become perforated. Perforated leaves will cause the plant to become bald. The result of bare plant leaves is to interfere with the process of plant growth and development. The level of this pest attacked in several experimental plant units. In the observations made, 6 plant units were infested with details of 2 plants at the P_o level, 1 plant at the P_h level and 3 plants at the P_c level.

DISCUSSION

The treatment of organic fertilizer + macro and micro fertilizer (P_h) fertilization package produced the highest increase in plant stem diameter of 1.54 cm and the highest increase in the number of primary branches of 38.70 pieces or provided an increase of 24.01% and 33.85% respectively compared to the organic fertilization package treatment (P_o) which had the lowest value. The fertilization package treatment of organic fertilizer + macro and micro fertilizers + mycorrhizal biofertilizer + probiotic POC fertilizer (P_c) produced the highest plant height increase of 72.12 cm or provided an increase of 24.01% from the (P_o) treatment which had the lowest value. In line with research conducted by [6] that the combination of organic and inorganic fertilizers can increase the diameter of the chili stem at 42 HST compared to the use of organic or inorganic fertilizers alone. The use of a combination of organic fertilizers + macro and micro fertilizers must pay attention to the dose given to plants in order to provide optimal growth results. Giving the right dose and fertilizer will optimize plant growth and development, especially in the vegetative phase [7]. The high increase in stem diameter in the P_h treatment is influenced by the support of other variables, namely the number of primary branches, the number of leaves and leaf chlorophyll.

Leaf chlorophyll content is one of the important factors in plant growth and development. High leaf chlorophyll is related to the rate of photosynthesis which is a benchmark in the process of plant production. The stem diameter will continue to increase in size to facilitate the process of photosynthate and nutrient transportation that passes through the plant stem through xylem and phloem vessels [8]. Optimal photosynthate transportation will encourage optimal growth rates of stems, roots, and leaves in plants. High leaf chlorophyll content in the P_h (58.39 SPAD units) and P_c (56.16 SPAD units) treatments indicates that the uptake of N nutrients in plants is optimally absorbed. This can increase the ability of plants to photosynthesize, so as to increase the photosynthetic yield of plants for optimal plant development. According to [9] nutrient N functions for the formation of protein

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and chlorophyll in plants. High leaf chlorophyll content is also influenced by leaf color. Whether or not N nutrients are absorbed optimally in plants can be seen through the color of the leaves. The greener the leaf color, the higher the leaf chlorophyll content, which means that nutrients, especially N, can be absorbed optimally by plants and the photosynthesis process can run well. The treatment of P_c fertilization package has the highest leaf color value of 3.88 BWD units compared to other treatments.

Sunlight is absorbed by plants through chlorophyll to be utilized in the photosynthesis process. In this case the leaves have an important role in capturing sunlight. The ratio of leaf length and width and leaf thickness are related to the ability of leaves to absorb sunlight. The ratio of leaf length and width determines the leaf surface area exposed to sunlight, while leaf thickness is related to the adaptability of plants to high light intensity, and the thicker the leaves can protect tissue damage to the leaves due to excess radiation [10]. The ratio of leaf length and width and the highest leaf thickness was obtained in the organic fertilizer package treatment with consecutive values of 1.81 cm and 0.27 mm higher than other treatments. This shows that plants in the P_o treatment adapt to their environment by thickening the leaves and the leaves become more pointed. This aims to reduce the process of evaporation or excessive transpiration in plants through leaves [11]. Tejakula tangerines are plants that have stomata below the surface of the leaves or often called Hypostomatis with xerophytic leaf types. The xerophytic leaf type is widely owned by plants that live in hot environments and low humidity [12].

Photosynthesizing plants produce products or energy called photosynthates. The results of photosynthesis in the form of photosynthate are utilized by plants for plant growth and development [13]. ATP in plants is produced through the process of respiration. Nutrients involved in the formation of ATP are leaf P and K nutrients. P nutrients have a role in helping synthesize ATP which is essential for energy metabolism in plants [14]. Meanwhile, K nutrients function in helping regulate turgor and membrane potential and are needed during the formation of ATP during the respiration process [15]. In line with the results of the research conducted, the highest leaf P and K nutrients were found in the P_o treatment at 0.347% (high) and 1.336% (low), respectively. The low content of leaf P and K nutrients in the P_h and P_c treatments indicates that photosynthate can be well distributed to all vegetative organs of the plant which is characterized by an increase in stem diameter, primary branches and a fairly high number of leaves. P nutrients function to help the formation of plant roots and shoots in the vegetative phase [16], and according to [17] K nutrients help plants in the vegetative phase for leaf formation and resistance to plant diseases.

The effectiveness of photosynthesis carried out by plants can be seen from the variable total sugar in the leaves. The highest total sugar content in the leaves in the P_c treatment was 4.97% and the lowest in the P_h treatment was 4.04%. The high total sugar content indicates that the plants in the P_c treatment can maximally carry out photosynthesis. Total sugar as a result of photosynthesis is used to metabolize and is used for vegetative and generative growth in plants [18]. High total sugar content is also supported by sunlight that can be captured by plant leaves. The percentage of light entering the canopy is an indicator that plants in the field are exposed to good sunlight to support their photosynthetic activities. The plants in the research location received sufficient and evenly distributed sunlight in all treatments, the highest in the P_h treatment at 72.78% and the lowest in the P_c treatment at 71.71%. Sunlight has an important role in the photosynthesis process because it can provide the energy source needed by plants [13].

The success of the photosynthesis process in plants is not only influenced by chlorophyll in the leaves, but also supported by the role of water. When the water available in the plant is less than its needs, it will cause the rate of photosynthesis to be inhibited. Increased water availability in plants will increase the relative water content in the leaves [19]. The relative water content of leaves is one indicator of the formation of leaf chlorophyll in addition to N nutrients [20]. The highest leaf relative water content was obtained in the P_c treatment with a value of 78.55% compared to other treatments. This was due to the P_c treatment which contained additional mycorrhizal fertilizer with sand carrier media. In line with research conducted by [21]. mycorrhizal fertilizer with sand carrier media gives the results of higher leaf relative water content compared to without mycorrhizal fertilizer and other carrier media. Mycorrhizal fertilizers function in holding water in the soil so that water can be absorbed optimally by plants [22]. The relative water content of the leaves illustrates the plant's resistance to drought in the field of cultivation.

Pests as growth disruptors attacked several samples of experimental plants. Pests tended to be more prevalent in the P_c fertilizer package treatment. Plants in the P_c treatment found 3 pest attacks compared to P_h and P_o which contained 1 and 2 pest attacks. This is because the P_c treatment plants are morphologically very lush plants and sufficient food sources, thus supporting the life of these pests. The pests that attacked the experimental plants were Mealy Bug or mealy bug, this was due to the high humidity at the research location, which is a weekly average of 71.6 and food sources on citrus leaves that support the life of mealy bug pests [23].

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CONCLUSIONS

Different fertilization treatments gave different vegetative growth of Tejakula tangerine. Fertilization package P_c, gives the highest increase in plant height (72.12 cm), the highest leaf color (3.88 BWD units) and the highest total gula content (4.97%), while fertilization package P_h gives the highest increase in stem diameter (1.54 cm), the most primary branches (38.70 pieces), the highest leaf chlorophyll content (58.39 SPAD units).

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