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Yield response and fruit quality of Tejakula Tangerines (*Citrus reticulata* cv. Tejakula) on application of different fertilizer types

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Abstract

Tejakula tangerine (*Citrus reticulata* cv. Tejakula) is one of the local citruses from Tejakula District, Buleleng Regency which is almost extinct due to CVPD (*Citrus Vein Phloem Degeneration*) disease. Until now, the Bali Provincial Government continues to strive to restore this horticulture, but has experienced obstacles, namely the quantity and quality of fruit produced is still lacking. This study was conducted to find a fertilization combination between organic fertilizer, AB Mix, mycorrhizal biofertilizer and probiotic POC that can increase yield, fruit quality and photosynthetic activity of Tejakula tangerine plants. The study used a Randomized Group Design (RAK) 1 factor with 4 replications consisting of 6 levels, namely fertilization with organic fertilizer, fertilization with organic fertilizer + inorganic fertilizer, fertilization with organic fertilizer+ AB Mix, fertilization with organic fertilizer+ AB Mix+ mycorrhizal biofertilizer, fertilization with organic fertilizer + AB Mix+ probiotic POC and fertilization with organic fertilizer + AB Mix+ mycorrhizal biofertilizer+ probiotic POC. Fertilization using a combination of organic fertilizer+ AB Mix+ mycorrhizal biofertilizer + probiotic POC gave the best results on yield response, fruit quality and photosynthetic activity when applied to Tejakula Citrus cultivation. This is indicated by the high values of the number of fruits formed per tree (361.50 fruits), the number of harvested fruits per tree (358.75 fruits), fruit weight per tree (45.53 kg), fruit flesh moisture content (90.59%), fruit water content (88.99%), vitamin C content (105.60 mg) and leaf chlorophyll content (68.46 SPAD).

Keywords: Photosynthetic Activity; Unjuicy Fruit; Tejakula Tangerine; Fruit Quality; Yield Response

1. Introduction

Tejakula tangerine is one of the national superior tangerine species whose production centers are in North Bali, precisely in Tejakula District. Demand for Tejakula tangerines was very high in the 1970s but due to the CVPD (*Citrus Vein Phloem Degeneration*) endemic that hit in the 1980s, this tangerine production decreased due to mass plant eradication. Before the CVPD disease, Tejakula tangerine production was so high that it was able to help improve the economy of the farming community. Therefore, the Bali Provincial Government continues to strive for the recovery of this plant by propagating CVPD disease-free tangerine seeds. Re-cultivation of Tejakula tangerines has been successful but the quantity and quality of fruit produced is still not optimal. Fruit production is considered still low and the quality of the fruit produced is still not in accordance with the desired criteria, so efforts are needed to improve the quality and quantity of citrus fruit through fertilization. Fertilization can be done by combining various types of fertilizers such as organic fertilizers, inorganic fertilizers, biological fertilizers, and probiotic POC. This study aims to find a fertilization combination between organic fertilizer, AB Mix, mycorrhizal biofertilizer and probiotic POC that can increase the yield and quality of Tejakula tangerine fruit.

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2. Materials and methods

This research was conducted in Tejakula tangerine orchards owned by farmers in Tejakula Village, Tejakula District, Buleleng Regency and in the Agronomy and Horticulture Laboratory of the Faculty of Agriculture, Soil Science Laboratory of the Faculty of Agriculture, Analytical Laboratory of Udayana University and Chemistry and Microbiology Laboratory of the Faculty of Agricultural Technology, Udayana University which was conducted from February to June 2024. The study used a randomized group design (RAK) 1 factor with 4 replications. The treatment consisted of 6 levels so that 24 sample plants were needed as experimental units. Fertilization levels tested include: Po: Farmer's fertilization as a control, i.e. fertilization with organic fertilizer; Pa: Fertilization using organic fertilizer+ inorganic fertilizers Urea, TSP and KCl; Pk: Fertilization using organic fertilizer + AB Mix; Pm: Fertilization using organic fertilizer + AB Mix + mycorrhizal biofertilizer; Pp: Fertilization using organic fertilizer+ AB Mix+ POC probiotics; Pc: Fertilization using organic fertilizer+ AB Mix + mycorrhizal biofertilizer+ probiotic POC.

The tools used include buckets, jerry cans, sprayers, measuring cups, pruning shears, scissors, knives, blenders, cups, hand refractometer, Chlorophyl Meter SPAD, Atomic Absorption Spectroscopy (AAS), ovens, brown envelopes, penetrometers, cooler boxes, ice packs, scales, label paper, airtight plastic, tissue, prep glass, microscope, pH meter and mobile phones. The materials used in this study were Tejakula tangerine plants, mycorrhizal biofertilizer prototypes, probiotic Liquid Organic Fertilizer (POC), cow manure, inorganic fertilizer, AB Mix, distilled water, filter paper, amylum solution, and materials for fruit quality analysis. The implementation of the study included the selection of sample plants, making mycorrhizal biofertilizer, making Probiotic POC, giving treatments, maintaining plants, and observing/collecting data. The selected plants must come from the same ownership garden with the same maintenance history and have been 5 years old and have already borne fruit. Mycorrhizal biofertilizer was made by combining 50 spore isolates into 50 grams of volcanic sand carrier media. Probiotic POC was made by combining ingredients such as 1 kg of kepok banana peel, 1 kg of goat manure, 2.5 liters of rice washing water, 2.5 liters of light green coconut water, 0.5 kg of brown sugar, and 100 ml of EM4 and then anaerobic fermentation. The treatment was adjusted to the level of treatment determined. Before giving the treatment, the sample plants were first cleaned of weeds and then loosened around the crown. Plant maintenance is carried out by irrigating, pruning, controlling weeds and controlling pests and diseases. Plant maintenance is adjusted to GAP (Good Agriculture Practices) in citrus plants. Observations and data collection were carried out by observing important variables that are components of the quality and quantity of plant yields such as leaf chlorophyll content, leaf relative water content, number of fruits formed per tree, number of harvested fruits per tree, harvested fruit weight per tree, percentage of the number of breathable fruits, percentage of breathable fruit weight, fruit moisture content, fruit pulp moisture content, total soluble solids, and vitamin C content. Observation data obtained were analyzed using Anova analysis of variance. If the Anova analysis of variance showed a significant effect on the parameters observed, then further tests with Duncan were carried out.

3. Results

3.1. Leaf Chlorophyll Content and Leaf Relative Water Content

The highest leaf chlorophyll content was obtained in the Pc treatment and significantly different from the Po and Pm treatments but not significantly different from Pa, Pk and Pp. The chlorophyll content of the leaves was Pc (68.46), Pa (67.76), Pk (67.06), Pp (66.33), Pm (64.16) and Po (63.71), respectively. The highest leaf relative water content was obtained in the Pm treatment and significantly different from Po but not significantly different from the other treatments where the values were Pm (79.48), Pc (79.17), Pk (78.57), Pa (77.69), Pp (75.36) and Po (68.27) respectively.

Table 1 Effect of Fertilizer Type Treatment on Leaf Chlorophyll Content and Leaf Relative Water Content

Treatment	Leaf Chlorophyll Content (SPAD)	Relative Water Content (KAR) of Leaves (%)
Po	63,71 c	68,27 b
Pa	67.76 ab	77,69 a
Pk	67.06 abc	78,57 a
Pm	64.16 bc	79,48 a
Pp	66.33 abc	75,36 a
Pc	68,46 a	79,17 a

Notes: Numbers followed by the same letter in the same treatment and column indicate not significantly different at the Duncan Multiple Range Test (UJBD) level of 5%.

3.2. Number of Fruits Formed, Number of Harvested Fruits per Tree and Weight of Harvested Fruits per Tree

The highest number of fruits formed, number of harvested fruits and weight of harvested fruits per tree were obtained at the Pc level where the value of the number of fruits formed was Pc (361.50), Pp (266.25), Pm (223.50), Pa (189.75), Pk (180.50) and Po (75.50) respectively but Pc was not significantly different from Pp, Pm, Pa and significantly different from Pk and Po. The number of harvested fruits per tree were Pc (358.75), Pp (260.50), Pm (218.50), Pa (187.00), Pk (172.25) and Po (73.00) respectively where Pc was significantly different from Pk and Po and not significantly different from Pp, Pm and Pa. The weight of harvested fruit per tree was Pc (45.53), Pp (32.81), Pm (24.42), Pa (23.50), Pk (19.09) and Po (8.09) respectively where Pc was significantly different from Pp but significantly different from Pm, Pa, Pk, and Po.

Table 2 Effect of Fertilizer Type Treatments on Number of Fruits Formed, Number of Harvested Fruits per Tree and Weight of Harvested Fruits per Tree

Treatment	Number of Fruit Formed (Fruit)	Number of Harvested Fruit per Tree (Fruit)	Weight of Harvested Fruit per Tree (Kg)
Po	75,50 (8,51) c	73,00 (8,37) c	8,09 (2,86) c
Pa	189.75 (13.69) abc	187.00 (13.60) ab	23,50 (4,87) b
Pk	180.50 (13.12) bc	172.25 (12.79) bc	19.09 (4.32) bc
Pm	223.50 (14.65) ab	218.50 (14.49) ab	24,42 (4,93) b
Pp	266.25 (15.82) ab	260.50 (15.65) ab	32.81 (5.60) ab
Pc	361,50 (18,98) a	358,75 (18,91) a	45,53 (6,76) a

Notes: - Numbers followed by the same letter in the same treatment and column indicate not significantly different at the UJBD level of 5%.

Numbers outside the brackets show the original data while numbers inside the brackets shows the transformed data to $\sqrt{x}+ 0.5$ because the original data does not spread normally.

3.3. Percentage of Number of Unjuicy Fruit, Percentage of Unjuicy Fruit Weight and Total Dissolved Solids

The highest percentage of the number and weight of unjuicy fruits was obtained at the Po level where the percentage value of the number of unjuicy fruits respectively were Po (8.33), Pp (7.29), Pk (6.25), Pm (6.25), Pa (3.13) and Pc (1.04) where Po was significantly different from Pc and not significantly different from Pp, Pk, Pm and Pa. The percentage of weight of ujuicy fruit was Po (16.74), Pk (13.84), Pp (13.60), Pm (7.97), Pa (7.96) and Pc (5.03) where Po was not significantly different from the other treatments. The highest value of total soluble solids was obtained in Pm where the consecutive values were Pm (7.43), Pc (7.32), Pp (7.06), Pk (6.81), Pa (6.72) and Po (6.66) and Pm was not significantly different from Pc and Pp and significantly different from Pk, Pa and Po.

Table 3 Effect of Fertilizer Type Treatment on Percentage of Number of Unjicy Fruits, Percentage of Unjuicy Fruit Weight and Total Dissolved Solids

Treatment	Percentage of Number of Unjuicy Fruit (%)	Percentage of Unjuicy Fruit Weight (%)	Total Dissolved Solids (^{o}Brix)
Po	8,33 (76,35) a	16,74 (81,64) a	6,66 b
Pa	3.13 (72.88) ab	7,96 (76,12) a	6,72 b
Pk	6.25 (74.99) ab	13,84 (79,68) a	6,81 b
Pm	6.25 (74.94) ab	7,97 (76,02) a	7,43 a
Pp	7.29 (75.61) ab	13,60 (79,67) a	7.06 ab
Pc	1,04 (71,43) b	5,03 (74,13) a	7,32 a

Notes: Numbers followed by the same letter in the same treatment and column indicate not significantly different at the UJBD level of 5%.

Numbers outside the brackets show the original data while numbers inside the brackets shows the transformed data to $\sqrt{x}+ 0.5$ because the original data does not spread normally.

3.4. Fruit Moisture Content, Fruit Flesh Moisture Content and Vitamin C Content

Fruit water content was obtained in Pc where the values were Pc (88.99), Pa (88.26), Pm (88.21), Pp (88.05), Pk (87.94) and Po (86.92) respectively but Pc was significantly different from Po and not significantly different from Pa, Pm, Pp, and Pk. The highest fruit pulp moisture content was obtained in Pc where the values were Pc (90.59), Pm (89.99), Pa (89.99), Pp (89.97), Pk (89.83) and Po (87.10) respectively but Pc was significantly different from Po and not significantly different from Pm, Pa, Pp and Pk. The highest vitamin C content was obtained in Pc where the values were respectively Pc (105.60), Pm (96.80), Pa (96.80), Pk (95.33), Pp (93.87) and Po (82.13) but Pc was significantly different from Po and not significantly different from Pm, Pa, Pk and Pp.

Table 4 Effect of Fertilizer Type Treatment on Fruit Moisture Content, Fruit Flesh Moisture Content and Vitamin C Content

Treatment	Fruit Water Content (%)	Fruit Flesh Moisture Content (%)	Vitamin C Content (mg)
Po	86,92 b	87,10 b	82,13 b
Pa	88.26 ab	89,99 a	96.80 ab
Pk	87.94 ab	89,83 a	95.33 ab
Pm	88.21 ab	89,99 a	96.80 ab
Pp	88.05 ab	89,97 a	93.87 ab
Pc	88,99 a	90,59 a	105,60 a

Notes: Numbers followed by the same letter in the same treatment and column show no significant difference in Duncan's Multiple Range Test (UJBD) at the 5% level.

4. Discussion

Giving a combination of fertilizers at the Pc level in the form of the use of organic fertilizers, AB Mix, mycorrhizal biofertilizer and probiotic POC provides the best citrus results in terms of quantity and quality of fruit. This can be seen in the high number of fruits formed, the number of harvested fruits per tree and the weight of harvested fruits per tree at the Pc level which indicates that there is the most fruit formation at Pc and followed by optimum fruit filling which has implications for the high number and weight of harvested fruits at that level. The use of complete fertilizers in the form of a combination of organic fertilizers, inorganic fertilizers, mycorrhizal biological fertilizers and POC Probiotics is thought to be able to meet the needs of nutrients needed by citrus plants considering that each nutrient has a role that cannot be replaced by other nutrients [7]. Organic fertilizers given to all sample plants aim to improve chemical, biological and improve some soil physical properties such as soil permeability, soil pore space and help form soil granular structure [3, 9]. According to Fathidarehnijeh et al. [2] a nutrient solution in the form of AB mix containing complete nutrients if applied at the optimum concentration will show better results than fertilizers containing incomplete nutrients even though they are applied according to plant needs. Biofertilizers in principle do not contain nutrients directly but contain microorganisms that are able to provide the nutrients needed by plants [6]. Murrobi [5] suggests that probiotic microbes have 3 roles, namely biofertilizer (nutrient provider), bioprotectant (control and protection against pathogens) and biostimulant (growth stimulator). The provision of nutrients from various fertilizers and their absorption assisted by mycorrhiza and probiotic microbes make the fulfillment of nutrients for plants so that the physiological processes in plants become optimum. One of the physiological processes affected is photosynthesis. Photosynthesis in plants is also closely related to the high relative water content of leaves at the Pc level and is also supported by the high value of leaf chlorophyll content where water acts as a photosynthetic substrate and chlorophyll as a pigment that is able to capture photon energy from light as an energy source in photosynthetic reactions [4]. The high photosynthetic activity in plants is closely related to the translocation of photosynthate from the leaves to the fruit of the plant during the fruit filling process. This is in line with the research of Wigunanda et al., [10] which states that there is a positive correlation between leaf chlorophyll content and leaf relative water content to the high quantity of yield in plants.

The provision of fertilization packages at the Pc level in addition to being able to provide a good quantity of yield is also able to provide the best quality of fruit on Tejakula tangerines. This can be seen from the low percentage of the number and weight of breathable fruit on Pc which is also supported by the high value of fruit moisture content, fruit pulp moisture content, vitamin C content and total soluble solids. The low percentage of the number and weight of breathable fruits reflects the optimum osmotic regulation of cells in plants so that they are able to manage water conditions in plant tissues, especially in the fruit so as to produce juicy fruit. Different things can be seen in Po where if the plants are only fertilized using organic fertilizers alone without any other fertilizers combined, resulting in low quantity and quality of citrus fruits produced. High vitamin C levels indicate that there is biosynthesis of glucose contained in the fruit, maximum vitamin C levels occur when the fruit is ripe which is marked by a change in color, so that vitamin C biosynthesis will show its optimum condition [8]. The high total soluble solids in Pc is caused by the breakdown of water-insoluble polysaccharide components such as cellulose and pectin, which are the main components of cell walls, into water-soluble saccharides such as glucose, sucrose, and fructose [1]. Total soluble solids also usually indicate a sweeter flavor in the measured fruit.

5. Conclusion

The fertilization package at the Pc level in accordance with the research data shows its effectiveness in increasing the quantity of yield and quality of Tejakula tangerine fruit. The collaboration between cow manure organic fertilizer, AB Mix Kryptonium fertilizer, Mycorrhizal Biofertilizer and Probiotic Fertilizer makes nutrients for plants available while being able to be absorbed directly or indirectly due to the association between plants and mycorrhizal and probiotic microbes.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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