Magna Scientia Advanced Biology and Pharmacy

eISSN: 2582-8363

Cross Ref DOI: 10.30574/msabp

Journal homepage: https://magnascientiapub.com/journals/msabp/

(RESEARCH ARTICLE)

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Application of liquid organic fertilizer rice water waste and magnesium sulfate on flowering and fruiting of Siamese citrus in the off-season

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Magna Scientia Advanced Biology and Pharmacy, , 2024, 12(01), 084–091

Publication history: Received on 21 May 2024; revised on 02 July 2024; accepted on 05 July 2024

Article DOI: https://doi.org/10.30574/msabp.2024.12.1.0042

Abstract

The purpose of this study was to determine the effect of liquid organic fertilizer application of rice water waste and magnesium sulfate on flowering and fruiting of siamese citrus outside the season, which was conducted in Bayung Gede Village, Kintamani District, Bangli Regency, from September 2023 to April 2024. This study used a Randomized Block Design consisting of 2 factors arranged factorially. The first factor tested was liquid organic fertilizer of rice water waste (B) with 4 concentration levels, namely B0 = 0 ml/l; B1 = 5 ml/l; B2 = 10 ml/l and B3 = 15 ml/l. While the second factor is the application of magnesium sulfate fertilizer (M) with 4 dosage levels namely M0 = 0 g/tree; M1 = 5 g/tree; M2 = 10 g/tree and M3 = 15 g/tree, each of which was repeated 3 times so that 48 plants were needed. Based on the results of the study, the interaction between the concentration of liquid organic fertilizer of rice water waste and the dose of magnesium sulfate fertilizer significantly affected the variables of the number of harvested fruits and the weight of harvested fruits per tree, very significant effect on fruit diameter and not significant effect on other variables. The highest number of harvested fruits per tree, fruit diameter and harvested fruit weight per tree were obtained at the interaction between liquid organic fertilizer of rice water waste at a concentration of 15 ml/l with magnesium sulfate fertilizer dosage of 15 g/tree, namely 86 fruits; 6.97 cm and 12.03 kg or an increase of 84.27%; 78.72% and 89.15% when compared to without liquid organic fertilizer of rice water waste with no magnesium sulfate fertilizer, namely 46.67 fruits; 3.90 cm and 6.36 kg.

Keywords: Dose; Citrus; Concentration; Waste; Fertilizer

1. Introduction

Citrus is a horticultural commodity that can grow and produce in low and highlands, and can also grow on rice fields and moorlands. Citrus is one of the fruits that produce high vitamin C [1]; [2] and [3]. In addition to being a source of vitamins and minerals, Siamese citrus also has a fairly high economic value both in fresh and processed form. Therefore, citrus is favored by all levels of society so that the need for citrus continues to increase [4] and [5]. Siamese citrus is a small part of the many citrus species that have been widely recognized and cultivated which are members of the tangerine group which has the scientific name Citrus nobilis [6]; [7].

Good and correct cultivation of citrus plants requires processes such as tillage, seed selection, fertilization, control of plant pest organisms, which need to be carried out on an ongoing basis so that the results obtained can be optimal. Nutrient management through fertilization is crucial to optimize crop production [8]; [9]; [10]. According to [11], soil fertility can be improved through fertilization which aims to provide nutrients needed by plants, both with artificial fertilizers and organic fertilizers applied through the soil.

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Organic fertilizers are fertilizers composed of living matter, such as weathering of plant, animal, and human remains. Organic fertilizers can be solid or liquid and are used to improve the physical, chemical, and biological properties of soil. Organic fertilizers contain more organic matter than the nutrient content [12]; [13]. Sources of organic matter can be compost, green manure, manure, crop residues (straw, stover, corn cobs, sugarcane stover, and coconut husks), livestock waste, industrial waste that uses agricultural materials, and municipal waste (garbage). The use of organic fertilizers can improve soil structure and encourage the development of soil microorganism populations [14]; [15]. Organic matter physically promotes granulation, reduces plasticity, and increases water holding capacity. Organic fertilizers can be solid or liquid [16]; [17].

Rice washing water has been considered as household waste that is not considered its existence has many benefits for plants. The benefits of rice washing water include: helping several hormones in plants so that they can stimulate the growth of leaf shoots, carry food to all cells in the leaves and stems, contain starch substances, inhibit pathogen growth, reduce transplant shock, as a source of energy, help the photosynthesis process, prevent plant wilting, and accelerate flower growth [18] and [19].

According to [20] and [21] that rice washing water contains many nutrients including 0.80% vitamin B1; 0.70% vitamin B3; 0, 90% vitamin B6; 0.50% manganese; 0.2944% Ca; 0.252% Mg; 0.027% S; 0.0427% Fe; 0.043% B1 and contains N 0.015%; P 10.31% and K 0.02% [22]. The elements N, P and K play an important role for plant growth and development because they are essential nutrients for plants. However, the limited availability in the soil makes N, P and K elements often a limiting factor that can inhibit plant growth and development. Therefore, to meet the needs of these nutrients, additional nutrients are needed, which are generally in the form of organic fertilizers and inorganic fertilizers [23]; [24].

Rice washing water needs to be fermented first so that it becomes a liquid organic fertilizer that can be absorbed by plants quickly and effectively [25]. [26] states that rice washing water is also useful for growing media when sprinkled through the soil. The benefits include: in general, it can improve the physical, chemical and biological properties of the growing media, making the soil structure looser due to the presence of organic materials in the growing media. Organic matter in the growing media will always be decomposed and the availability of plant nutrients due to the presence of decomposer microorganisms. [27] states that in addition to high nutrient content, it turns out that rice washing water also contains several antagonistic bacteria that can fight bad/pathogenic bacteria. How to apply rice water waste POC: for leaf fertilizer: Take 10 ml of fermented rice water waste POC and dissolve it in 1 liter of water. Spray to all parts of the plant, especially the bottom of the leaves. Spray leaf fertilizer every 2 weeks [28].

Magnesium sulfate (MgSO4) fertilizer is a compound fertilizer containing 26% magnesium oxide (MgO) and 21% sulfur (SO4) which is suitable for use in horticultural and plantation crops. Easily soluble in water so that it can be applied by dribbling, sowing, or through drip irrigation. The recommended dose of magnesium sulfate fertilizer in horticultural crops is 5-10 g / tree which is given by leaking (sprinkled around the roots) and sprayed on all parts of the plant. Besides by leaking magnesium sulfate can also be given through the soil by immersing it into the soil around the roots at a dose of 20-30 g / tree. Magnesium sulfate is very suitable for tropical climates, very easy to apply as a basic or supplementary fertilizer, helps improve the quality of crops, important nutrients in the formation of chlorophyll, sugar, protein, carbohydrates, oil and fat. Especially plays a role in the process of photosynthesis and respiration, also increases plant resistance to drought and disease [29]. [30]; [31] state that the element magnesium serves to prevent shedding of flowers and fruit ovules. The most common symptom as a result of magnesium nutrient deficiency in plants is chlorosis: where the leaves turn yellow due to disruption of chlorophyll formation, yellow stripes appear on the leaves, mucus appears on young leaves, leaves become small and brittle with curled leaf margins. Meanwhile, sulfur (S) is an essential nutrient for improving leaf quality, plant oil content, and resistance to low temperatures. Unreasonable fertilization, especially the excessive use of N and K fertilizers, can also inhibit the absorption of magnesium by the roots due to competition between ions, as a result the potential for magnesium deficiency becomes higher [32]. The results of research [33] found that the treatment of magnesium sulfate fertilizer by immersing through the soil can increase the yield reflected by the weight of harvested fruit per tree is highest at a dose of 45 g/tree, which is 10.17 kg, an increase of 30.05% when compared with no magnesium sulfate fertilizer, which is only 7.82 kg.

2. Materials and method

The research was conducted in Bayung Gede Village, Kintamani District, Bangli Regency from September 2023 to April 2024. The design used in this study was a factorial Randomized Group Design with 2 treatment factors. The first factor is the application of liquid organic fertilizer rice water waste (B) with 4 levels; B0 = 0 ml/l, B1 = 5 ml/l, B2 = 10 ml/l, B3 = 15 ml/l. While the second factor is the application of magnesium sulfate fertilizer (M) with 4 dosage levels, namely M0 = 0 g/tree; M1 = 5 g/tree; M2 = 10 g/tree and M3 = 15 g/tree, each of which was repeated 3 times so that 48 plants were needed. The citrus plants used in this study were ± 4.5 years old with a spacing of 3 x 3 meters, which had uniform

growth, based on plant age, plant height ranged from 180 - 220 cm, stem diameter ranged from 6 - 8.5 cm and healthy plant conditions. Liquid organic fertilizer of rice water waste was given in the morning with concentrations according to the treatment (0, 5, 10 and 15 ml / water), by dissolving it first in 1 liter of water and then spraying it on all parts of the plant, which was given once every 1 month during the study with the same concentration in each treatment each time. While magnesium sulfate fertilizer was also given once every 1 month during the study at a dose of 0, 5, 10 and 15 g/tree, which was first dissolved in 5 liters of water and then leaked through the soil, with the same dose in each treatment for each application.

3. Result and Discussion

Based on the results of statistical analysis, it can be explained that the interaction between the treatment of the concentration of liquid organic fertilizer of rice water waste and the dose of magnesium sulfate fertilizer (BxM) has a significant effect on the number of harvested fruits per tree, the weight of harvested fruits per tree and a very significant effect on the variable fruit diameter and has no significant effect on the variable number of flowers formed per tree, the number of fruits formed per tree, the percentage of fallen fruits per tree, weight per fruit and total soluble solids. The treatment of liquid organic fertilizer of rice water waste and magnesium sulfate fertilizer had a significant effect only on the variable number of flowers per tree and on the variables of number of fruits formed, percentage of fallen fruits per tree, number of harvested fruits per tree and fruit diameter, weight per fruit and harvested fruit weight per tree had a very significant effect.

The highest harvested fruit weight per tree was obtained at the interaction between liquid organic fertilizer of rice water waste at a concentration of 15 ml/water with magnesium sulfate fertilizer at a dose of 10 g/tree (B3M2) which was 12.03 kg or an increase of 89.15% when compared to without liquid organic fertilizer of rice water waste with no magnesium sulfate fertilizer (B0M0) which was 6.36 kg (Table 2). The high weight of harvested fruit per tree in the interaction between liquid organic fertilizer of rice water waste at a concentration of 15 ml/water with magnesium sulfate fertilizer at a dose of 10 g/tree (B3M2) was supported by the increase in weight per fruit, fruit diameter, number of harvested fruits per tree, number of formed fruits per tree and number of flowers per tree. The highest number of harvested fruits per tree and fruit diameter were obtained in the interaction between liquid organic fertilizer of rice water waste at a concentration of 15 ml/water with magnesium sulfate fertilizer at a dose of 15 g/tree (B3M3), namely 86 fruits and 6.97 cm, an increase of 82.27 % and 78.72% compared to without liquid organic fertilizer of rice water waste with no magnesium sulfate fertilizer (B0M0), namely 46.67 fruits and 3.90 cm (Table 3 and Table 4). The increased weight of harvested fruit per tree in B3M3 compared to B0M0 is due to the effect of liquid organic fertilizer of rice water waste and magnesium sulfate fertilizer working together in affecting plant growth, especially in the process of flowering and fruiting. It can be said that the increase in citrus fruit yield is inseparable from the function of nutrients contained in rice water waste liquid organic fertilizer, including 4.1% C-organic; 4.8% N; 16.8% P; 4.2% K; 0.7% CaO and 2.5% MgO (results from laboratory analysis). The elements of N, P and K contained in the liquid organic fertilizer of rice water waste which are macro elements are needed by plants. The three elements, namely N, P and K, have a very important role in plant growth and production where these elements interact in supporting each other. Supported by [33] and [34] which states that the elements of N, P and K in plants have a relationship with each other, where the nutrient N functions as a constituent of amino acids (proteins), nucleic acids, nucleotides and chlorophyll. This will make plants greener, overall plant growth faster and increase the protein content of the crop. Nutrient P functions as a storage and distribution of energy for all plant metabolic activities. The positive impact is the triggering of root growth, spurring tissue development, stimulating flower formation and fruit ripening, increasing resistance to disease. K nutrients act as enzyme activators that participate in plant metabolic processes, water and nutrient absorption processes in the soil. K nutrients also help distribute the results of assimilation from the leaves to all plant tissues.

Rice water waste liquid organic fertilizer also contains calcium and magnesium elements. Where both elements have the same function, namely in preventing the fall of flowers and fruit candidates so that the flowers and fruits formed are higher. In this study, as a single factor, the number of flowers and the number of fruits formed per tree in the treatment of liquid organic fertilizer of rice water waste obtained the highest 88.83 flowers and 87.75 fruits at a concentration of 15 ml/l (B3), compared to without the application of liquid organic fertilizer of rice water waste (B0), namely 65.25 flowers and 59.67 fruits. While in the treatment of magnesium sulfate fertilizer, the number of flowers and the number of fruits formed per tree was obtained the highest at 80.50 flowers and 79.67 fruits at a dose of 15 g/tree compared to without magnesium sulfate fertilizer, namely 72.42 flowers and 64.75 fruits (Table 1). In this study it can be said that in plants given magnesium sulfate fertilizer at higher doses, plant metabolic processes, especially photosynthesis, are better so that the photosynthate produced is also higher which in turn can reduce competition between fruits for assimilate and translocation of assimilate to storage organs (fruit) is higher. This can be evidenced in the percentage of fallen fruit per tree is lower in M3 at 5.70% compared to M0 which reached 15.19% (Table 1). With the increase in photosynthate produced in the application of magnesium sulfate fertilizer can also support the increase in sugar content

in the fruit, this can be proven that the increasing dose of magnesium sulfate fertilizer given, the total soluble solids increased, namely obtained 9.21 ^{0}Brix in M3 compared to M0 which is 8.25 ^{0}Brix. Supported by the opinion of [30] which states that magnesium sulfate fertilizer (MgSO4) is one type of compound fertilizer consisting of magnesium oxide (MgO) and sulfur (SO4), with the composition of magnesium oxide (MgO) = 26%, sulfur (S) = 21%. [35] states that magnesium functions in the formation of chlorophyll so that the photosynthesis process increases, increases plant resistance/immunity to pests and diseases, increases carbohydrate, fat, protein and sugar formation so that the sugar content in the fruit increases which makes the fruit taste sweeter, increases plant productivity because Mg fertilizers can prevent the fall of flowers and fruit.

Table 1 Effect of concentration treatment of rice water waste liquid organic fertilizer (B) and MKP fertilizer (M) on the number of flowers and the number of fruits formed per tree, the percentage of fallen fruits per tree and the weight per fruit

Treatment	Number of flowers formed per tree (kuntum)	Number of fruits formed per tree (2-4 cm) (buah)	Percentage of fallen fruits per tree (%)	Weight per fruits (g)	Total dissolved solids(^{o}brix)
Liquid organic fertilizer (B)					
B_0 (0 ml/l)	65.25 c	59.67 d	15.19 a	110.01 c	8.19 a
B_1 (5 ml/l)	76.33 b	66.92 c	10.08 b	132.64 b	8.25 a
B_2 (10 ml/l)	82.75 a	76.17 b	8.00 bc	140.24 ab	8.75 a
B_3 (15 ml/l)	88.83 a	87.75 a	5.70 c	145.45 a	8.78 a
BNT 0,05	**5.65**	**5.15**	**3.03**	**8.45**	**0.60**
Magnesium Sulfate (M)					
M_0 (0 g/tree)	72.42 b	64.75 c	13.63 a	120.55 b	8.25 b
M_1 (5 g/tree)	79.50 a	71.25 b	10.65 ab	131.36 a	8.50 b
M_2 (10 g/tree)	81.75 a	74.83 ab	9.57 b	136.92 a	8.75 ab
M_3 (15 g/tree)	80.50 a	79.67 a	8.11 b	138.51 a	9.21 a
BNT 0,05	**5.65**	**5.15**	**3.03**	**8.45**	**0.60**

Note: Mean values followed by the same letter in the same treatment and column, mean not significantly different at the 5% BNT test level.

Tabel 2 Average number of harvested fruits per tree due to the interaction effect of Rice Water Liquid Organic Fertilizer and Magnesium Sulfate fertilizer

Treatment		Magnesium Sulfate fertilizer (M)						
		M0		**M1**		**M2**		**M3**
Rice Water Liquid Organic Fertilizer (B)								
B0	46.67	B	50,22	AB	51.00	AB	56.33	A
	d		c		c		c	
B1	55.00	B	63.33	A	64.33	A	66.00	A
	c		b		b		b	
B2	64.00	B	66.67	B	68.33	B	84.33	A
	b		b		b		a	
B3	73.33	B	79.00	B	85.00	A	86.00	A
	a		a		a		a	
BNT 0,05	6.65							

Notes: The numbers followed by the same lowercase letters in the same column (B in the same M), are not significantly different at the 5% BNT test level; The numbers followed by the same uppercase letters in the same row (B in the same M), are not significantly different at the 5% BNT test level.

Table 3 Average fruit diameter (cm) due to the interaction effect of the treatment of Rice Water Liquid Organic Fertilizer and Magnesium Sulfate fertilizer

Treatment	**Magnesium Sulfate Fertilizer (M)**							
	M0		**M1**		**M2**		**M3**	
Rice Water Liquid Organic Fertilizer (B)								
B0	3.90	B	3.93	B	4.50	A	4.53	A
	d		c		c		c	
B1	4.53	C	5.43	B	5.47	B	6.07	A
	c		b		b		b	
B2	5.63	B	6.63	A	6.83	A	6.93	A
	b		a		a		a	
B3	6.73	A	6.77	A	6.80	A	6.97	A
	a		a		a		a	
BNT 0,05	0.48							

Notes: The numbers followed by the same lowercase letters in the same column (B in the same M), are not significantly different at the 5% BNT test level; The numbers followed by the same uppercase letters in the same row (B in the same M), are not significantly different at the 5% BNT test level.

Table 4 Average harvest fruit weight per tree (g) due to the effect of the treatment of Rice Water Liquid Organic Fertilizer and MKP fertilizer

Treatment	**Magnesium Sulfate Fertilizer (M)**							
	M0		**M1**		**M2**		**M3**	
Rice Water Liquid Organic Fertilizer (B)								
B0	6.36	AB	6.45	AB	6.66	AB	7.86	A
	c		c		c		b	
B1	8.14	A	8.52	A	8.63	A	8.71	A
	b		b		b		b	
B2	9.06	B	10.16	AB	10.66	AB	10.08	A
	b		a		a		a	
B3	11.18	A	11.51	A	11.96	A	12.03	A
	a		a		a		a	
BNT 0,05	1.43							

Notes: The numbers followed by the same lowercase letters in the same column (B in the same M), are not significantly different at the 5% BNT test level; The numbers followed by the same uppercase letters in the same row (B in the same M), are not significantly different at the 5% BNT test level.

4. Conclusion

Based on the results of this study, it can be concluded that the interaction between the concentration of liquid organic fertilizer of rice water waste and the dose of magnesium sulfate fertilizer has a significant effect on the variable number of harvested fruits per tree and the weight of harvested fruits per tree, very significant effect on fruit diameter and no significant effect on the variable number of flowers and the number of fruits formed per tree, percentage of fallen fruits

per tree, weight per fruit and total soluble solids. The highest number of harvested fruits per tree and fruit diameter were obtained at the interaction between rice water waste POC at a concentration of 15 ml/l with magnesium sulfate fertilizer at a dose of 15 g/tree, namely 86 fruits and 6.97 cm or an increase of 84.27% and 78.72% when compared to no rice water waste liquid organic fertilizer with no magnesium sulfate fertilizer, namely 46.67 fruits and 3.90 cm. The highest harvest fruit weight per tree was obtained in the interaction between rice water waste POC at a concentration of 15 ml/l with magnesium sulfate fertilizer at a dose of 15 g/tree, namely 12.03 kg, an increase of 89.15% when compared to the lowest results in the treatment without rice water waste POC with no magnesium sulfate fertilizer, which was only 6.36 kg.

Based on the results of this study can be suggested as follows: To get the maximum citrus fruit yield, it can be suggested by giving liquid organic fertilizer of rice water waste 15 ml / l and or combined with magnesium sulfate fertilizer at a dose of 15 g / tree, and further research needs to be done, to get the optimum concentration of liquid organic fertilizer of rice water waste and the optimum dose of magnesium sulfate fertilizer.

Compliance with ethical standards

Acknowledgments

The authors would like to thank the Research Institute of Warmadewa University for funding this research through the Institutional Grant Year 2024.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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