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The Effects of Shading and Organic Domestic Waste on Brazilian Spinach Growth

Pengaruh Pupuk Organik Limbah Rumah Tangga dan Naungan terhadap Pertumbuhan Bayam Brazil

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ABSTRAK

Pemanfaatan limbah rumah tangga berupa air cucian beras, limbah kulit nanas, dan nasi sisa sebagai pupuk organik cair (POC) berpotensi menciptakan media tumbuh yang baik sehingga meningkatkan pertumbuhan tanaman. Bayam Brazil (*Alternanthera sissoo*) merupakan sayuran daun yang berpotensi sebagai diversifikasi konsumsi sayuran di perkotaan yang diharapkan dapat tumbuh dengan baik pada ruang sempit khususnya di bawah naungan. Penelitian ini bertujuan untuk mengetahui pengaruh pemberian pupuk organik cair limbah rumah tangga dan naungan terhadap pertumbuhan tanaman bayam Brazil. Penelitian ini menggunakan rancangan split plot dengan main plot naungan dan sub plot POC limbah rumah tangga, yang terdiri dari 3 ulangan. Hasil penelitian menunjukkan nilai SPAD bayam Brazil dengan perlakuan naungan dan perlakuan POC air cucian beras secara linier terus meningkat hingga 8 minggu setelah tanam. Berkaitan dengan pertumbuhan vegetative bayam Brazil perlakuan naungan 0% merupakan perlakuan yang terbaik dalam hal peningkatan berat segar daun tidak layak konsumsi dan berat kering akar. Sementara itu, POC berpengaruh tidak nyata terhadap semua perlakuan. Kesimpulannya bahwa bayam Brazil dapat tumbuh dengan lebih optimal pada kondisi tanpa naungan.

Kata kunci: perbaikan media tanam, pupuk organik cair, toleransi naungan, nilai SPAD, diversifikasi sayuran

ABSTRACT

The use of household waste in the form of rice washing water, pineapple skin waste, and leftover rice as liquid organic fertilizer (LOF) has the potential to create a good growing medium so as to increase plant growth. Brazilian Spinach (*Alternanthera sissoo*) is a leafy vegetable that has the potential to diversify vegetable consumption in urban areas where it is expected to grow well in tight spaces, particularly under shading. This study aimed to find out the effects of applying liquid organic fertilizer made of household waste and the shading on the growth of the Brazilian spinach plant. The study used a split plot design with a main plot consisted of 0%, 50% and 70% shading, while subplot consisted of LOF washing water (20 ml/l), pineapple peel waste (30 ml/l) and leftover rice (50ml/l).

Each treatment was repeated 3 (three) times. The results of the study showed that the SPAD value of Brazilian spinach under shading treatment and LOF treatment of rice washing water linearly continued to increase until 8 (eight) weeks after planting. Regarding the vegetative growth of Brazilian spinach, the 0% shading treatment was the best treatment in terms of increasing the non-edible leaf fresh weight and root dry weight. Meanwhile, the LOF had an insignificant effect on all treatments. In conclusion, Brazilian spinach can grow more optimally in no-shade conditions.

Keywords: improvement of growing media, liquid organic fertilizer, shade tolerance, SPAD value, vegetable diversification

INTRODUCTION

Food needs continue to increase and must be met along with the increase of population. One of these food needs was vegetables which were a source of vitamins, minerals and fiber. Vegetable cultivation activities in the yard were a way to meet vegetable needs by optimizing the existing yard land (Arofi & Wahyudi, 2017). Brazilian spinach was a leafy vegetable that could be cultivated on narrow land (Ellya et al., 2021). Brazilian spinach could be grown under certain growing conditions. Muda et al., (2022) report that Brazilian spinach could grow normally by giving NPK (16:16:16) at a dose of 5 g per pot. Meanwhile, Brazilian spinach was recommended for optimum growth in semi-shading areas (SPN, 2022). Meanwhile, the high content of antioxidants and flavonoids in Brazilian spinach could meet the daily nutritional needs of the body (Sommai et al., 2021).

The availability of nutrients in growing media was one of the challenges in the cultivation process. Efforts that could be made to meet the needs of nutrients for plants were through fertilization. However, the selection of the type of fertilizer determines the health of consumers and the environment (Roidah, 2013). One of the fertilizers that could meet the nutrient needs of plants was Liquid Organic Fertilizer (LOF). It was a solution made of the decay of organic material and it could increase fertility and plants (Tanti et al., 2020). The basic ingredients for making liquid organic fertilizer could be derived from the materials around us, such as rice washing water, pineapple peel waste and leftover rice. The LOF made of rice washing water with a dose of 20 ml/L influences plant height and number of leaves (Hairuddin & Mawardi, 2015). A dose 30 ml/L of LOF made of pineapple peel waste was the best treatment of fruit weight per plant, fruit length and fruit volume (Satriawi et al., 2019). Meanwhile the composition of organic fertilizer from pineapple peel could improve vegetative growth of leaf vegetables such as Chinese kale (Chooklin et al., 2021). The LOF made of leftover rice affects the plant height and a greater number of leaves at a dose of 50 ml/L (Ria et al., 2021). Cultivation on narrow area such on household area has any barriers including related to the light received by the plants. Baharuddin et al. (2014) report that the amount of light affects the rate of photosynthesis so that it has an impact on plant growth. On the other hand, there were plants that adapt for being under shading. This was in accordance with Wulandari et al. (2016) stating that the shading using shading from plastic polyethylene with 47% shading tends to increase the wet weight of plants, plant height and root length in land kale plants. Providing shading with a light intensity of 50% in mustard plants showed the best results on the variables of the plant height, number of leaves, leaf area, root fresh weight, and plant dry weight (Wibowo et al., 2018). Research related to the shading and provision of LOF made of rice washing water, pineapple peel waste, and leftover rice has not been widely carried out on Brazilian spinach. Understood of Brazilian spinach to adapt ability on shaded with readily available

LOF will ensure the availability of leafy vegtable on narrow area. The study aimed to find out the best shading intensity and LOF for the growth of Brazilian spinach.

MATERIALS AND METHODS

Research Location

The research was conducted on the Universitas Sriwijaya Research Land, Indralaya, Ogan Ilir District, South Sumatra Province (3°13'2 3"S) (104°38'49"E). The study was conducted from June to August 2022. The research location has decreasing rain rate than previous months (Figure 1).

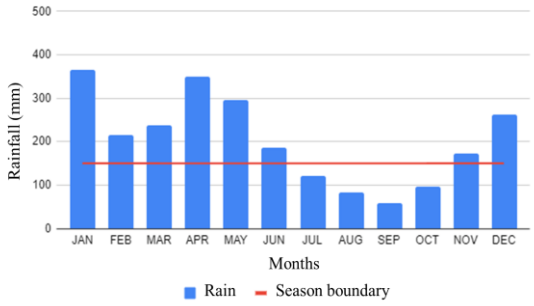

Figure 1. Average of rainfall on research location (Source: Indonesian Meteorological, Climatological, and Geophysical Agency, 2022)

Planting Material, Growing Medium, Shading and LOF

The planting material used Brazilian spinach stem cuttings measuring ± 5cm. The panting materials derived from healthy mother plant aged 2 month after planting. Each planting material was planted in polybags measuring a volume of 5 kg filled with top soil. The shading was used a type of paranet measuring 3m x 2m x 1.5m (pxlxt) with shade percentage 50% and 70%, respectively.

The process of making LOF was carried out by several procedures according to the types of material: 15 liter of rice washing water was put into 20-liter jerry could, 1 kg of brown sugar was melted and 300 ml of EM4 was added, then this mixture was put into the jerry could already give a small hose. The jerry could was tightly closed and the content was fermented for 21 days. The fertilizer was finished when it smelled distinctive and had a brownish-yellow color (Satriawi et al., 2019). Furthermore, for the pineapple peel, 10 kg of pineapple peel was chopped and then put into a 30 l jerry could and 1 kg of melted brown sugar was added and then added with 15 liter of water, then stirred until smooth, then added EM4 as much as 300 ml. Then the jerry could was tightly closed, and the content was fermented for 21 days. The fertilizer was finished when it smelled distinctive and had a brownish-yellow color (Satriawi et al., 2019). Meanwhile, for the LOF of leftover rice, 1 kg of leftover rice was allowed to stand in a jar with a small hose for 5 days until after a yellowish orange color arose. Then granulated sugar was added, in the ratio of 1 liter of water: 5 tablespoons of sugar. After that it was stirred until evenly and allowed to stand for 2 days. After 2 days, it was stirred again to mix well (Ria et al., 2021).

Experimental Design and Treatment

The plants were arranged according to the design of a split plot where the shade as the main plot and the type of LOF as a sub plot, each of which was repeated 3 times. The shading treatment consisted of 0%, 50% and 70%. Meanwhile, the LOF types comprised rice washing water (20 ml/l) (Hairuddin & Mawardi, 2015), pineapple peel waste (30 ml/l) (Satriawi et al., 2019) and leftover rice (50ml/l) (Ria et al., 2021). The LOF treatment was given 14 day after planting (DAP), 21 DAP, 28 DAP, 35 DAP, 42 DAP, and 49 DAP.

Data Collection

Data collection was carried out destructively and non-destructively. The non-destructive data collection consisted of the degree of greenness of the leaves and the canopy area beginning at 2 weeks after planting (WAP). Meanwhile, the destructive data consisted of edible leaf fresh weight, non-edible leaf fresh weight, edible leaf dry weight, non-edible leaf dry weight, stem dry weight, branch dry weight and root dry weight starting at 8 WAP. The edible and non-edible leaf determined by

visually such has light green and minimum damaged by pests and diseases. Measurement of the leaf greenness values used SPAD (Konica Minolta Chlorophyll Meter SPAD-502Plus). The nutrient analysis of each LOF was carried out in research and development of Sampoerna Agro. The nutrients were analyzed using different methods namely: N used Kjeldahl-Titrimetry, P used spectrophotometry, K used flamephotometry, and organic matter used spectrophotometry.

Data Analysis

Analysis of Variance (ANOVA) was carried out to find out the influence among the treatments, then the Least Significance Different (LSD) test was carried out (α= 5%) to find out the best treatment. The analysis used DSAASTAT for Windows 10, (developed by the University of Perugia, Agriculture and Environment) (Onofri & Pannacci, 2014).

RESULTS

LOF Nutrient Content

The results of the laboratory analysis showed that each LOF contained different N, P, K and C-organics. The rice washing water LOF contained the highest nitrogen compared to any other LOFs. Meanwhile, the pineapple peel waste had the highest phosphorus, potassium and C-organic compared to the rice washing water LOF and leftover rice LOF (Table 1).

Table 1. Analysis Results of N, P, K and C-organic contents in different LOFs

LOF	Nutrient			
	N %	P %	K %	C-org %
Rice washing water	0.04	0.002	0.005	1.72
Pineapple peel waste	0.02	0.013	0.120	2.74
Leftover rice	0.01	0.008	0.029	2.23

The Greenish Grade of Brazilian Spinach

The SPAD value was an indicator value of the leaf greenness. This could also be used as an approach to the chlorophyll content of leaves in each treatment. On the other hand, this could be used as a plant response to the provision of LOF. The SPAD values across the treatment increased starting at 3 WAP (Figure 2). The SPAD value of Brazilian spinach on all shade treatments continued to increase to 8 WAP. Nonetheless, the no-shade treatment had a significantly higher SPAD value compared to any other shade treatments on a weekly basis.

The LOF treatments of pineapple peel waste and leftover rice showed a peak SPAD value at 5-6 WAP. Furthermore, there was a downward trend in 8 WAP. Meanwhile, the trend of SPAD values in rice washing water LOF continued to increase to 8 WAP. This condition illustrated that Brazilian spinach had a decreased response to the administration of pineapple peel and leftover rice LOFs up to 8 WAP.

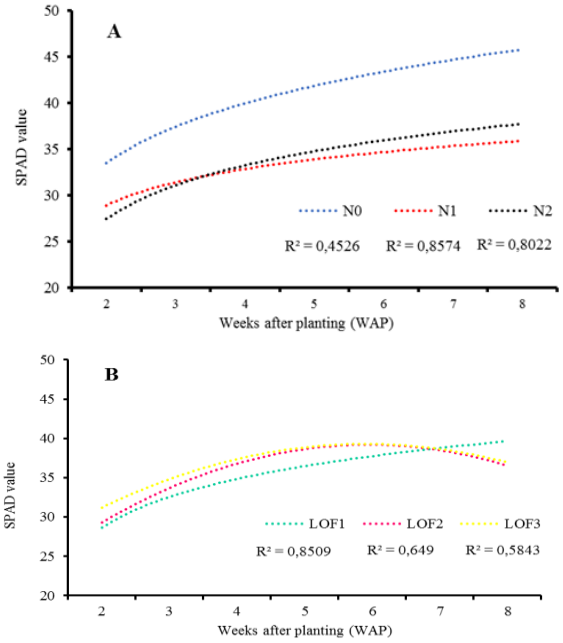

Figure 2. SPAD value on shade treatment difference (N0: shade 0%; N1: shading 50%; N2: shading 70%) (A) and liquid organic fertilizer (LOF1: rice washing water LOF; LOF2: pineapple peel waste LOF; LOF3: leftover rice LOF) (B)

Growth of Brazilian Spinach

The growth of the Brazilian spinach canopy continued to increase weekly up to 8 WAP (Figure 3). Nonetheless, each treatment showed an insignificant influence on each week. On the other hand, there was a decrease in the canopy area at 7 WAP occurring due to the condition of aging leaves. The ability of Brazilian spinach in terms of the restoration of plant organs, especially leaves, was quite good. It was characterized by a significant increase in the canopy area at 8 WAP after undergoing a decrease in 7 WAP.

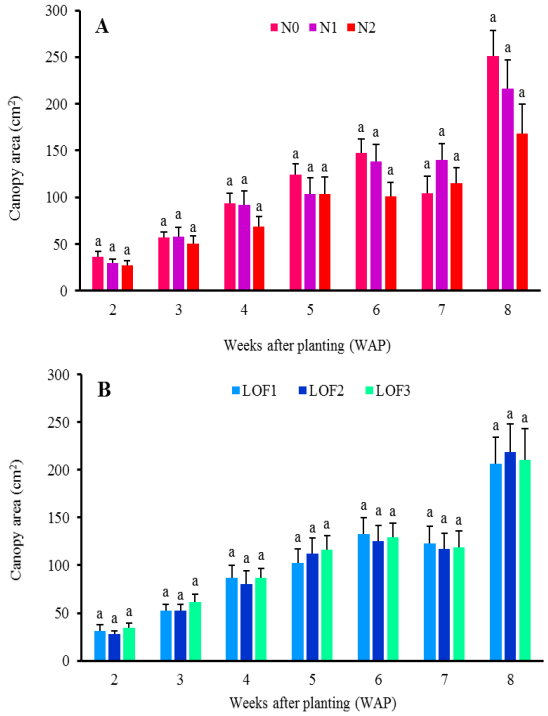

Figure 3. The area of the Brazilian spinach canopy on the different shade treatment (N0: shade 0%; N1: shading 50%; N2: shading 70%) (A) and liquid organic fertilizer (LOF1: rice washing water LOF; LOF2: pineapple peel waste LOF; LOF3: leftover rice LOF) (B)

Visually the Brazilian spinach canopy, the 0% shade treatment and LOF of rice washing water were better compared to any other treatments (Figure 4). A greener color and a wider size than other treatments were the visualization indicators that distinguished it from any other treatments. This condition showed that the treatment has no stress, especially the lack of light and the availability of nutrients so that the plant growth including the canopy growth got better than any other treatments. The portion of the distribution of photosynthates in each plant organ did not differ among the treatments, except for the roots with a 0% shade treatment (Tabel 2).

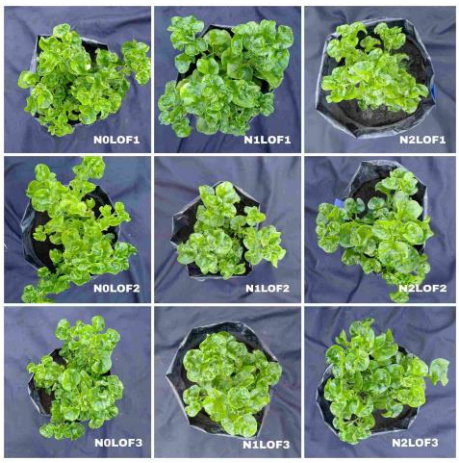

Figure 4. Visualization of Brazilian spinch canopy on shade treatment differences (N0: 0% shading; N1: shading 50%; N2: shadng 70%) (A) and liquid organic fertilzer (LOF1: rice washing water LOF; LOF2: pineapple peel waste LOF; LOF3: leftover rice LOF) (B)

Table 2. Results of photosynthate distribution portion in each plant organ among the treatments

Treatment	Parameter			
	Leaf Dry Weight	Stem Dry Weight	Branch Dry Weight	Root Dry Weight
Shading				
N0	3.09 ± 0.34 $_a$	0.83 ± 0.10 $_a$	1.56 ± 0.20 $_a$	2.64 ± 0.41 $_b$
N1	1.42 ± 0.19 $_a$	0.74 ± 0.06 $_a$	0.73 ± 0.20 $_a$	0.79 ± 0.10 $_a$
N2	1.29 ± 0.24 $_a$	0.51 ± 0.05 $_a$	0.48 ± 0.10 $_a$	0.70± 0.07 $_a$
LOF				
LOF1	2.03 ± 0.41 $_a$	0.70 ± 0.07$_a$	0.99 ± 0.22 $_a$	1.43 ± 0.38 $_a$
LOF2	1.96 ± 0.38 $_a$	0.69 ± 0.11$_a$	0.93 ± 0.24 $_a$	1.16 ± 0.29 $_a$
LOF3	1.81 ± 0.38 $_a$	0.70± 0.08 $_a$	0.84 ± 0.24 $_a$	1.54 ± 0.50 $_a$

Note: Different notations showed significant differences among the treatments with a level of 0.05% according to the LSD test

Although not yet different, the treatment N0 tended to have the highest photosynthates compared to any other shading treatments. Meanwhile, the

tendency of LOF1 photosynthate was the highest compared to any other LOF treatments, especially in terms of the dry leaf and branch weights.

The photosynthate distribution portion of at the root on N0 was higher and different compared to any other treatments. This condition was in line with the visualization of roots in N0 which had more branches than any other treatments (Figure 5). This illustrates the growth and architecture of the roots better compared to any other treatments.

Figure 5. Visualization of Brazilian spinach on the different shade treatments (N0: shade 0%; N1: shading 50%; N2: shading 70%) (A) and liquid organic fertilizer (LOF1: rice washing water LOF; LOF2: pineapple peel waste LOF; LOF3: leftover rice LOF) (B)

Yields

The yield of Brazilian spinach, in the edible leaf, did not differ significantly among the treatments. Nonetheless, the tendency of edible leaf fresh weight was at the 0% shade treatment higher than those compared to any other shade treatments. Meanwhile, LOF1 provided better yields than any other treatments although it was not different significantly among the treatments (Figure 6).

The 0% shade treatment, although it had a greater number of edible leaves, it had leaves that non-edible leaf was higher than any other shade treatments. The conditions occurred until they were significantly different compared to any other treatments. This phenomenon described the N0 treatment as allowing plants, especially Brazilian spinach leaves, to age faster so it was recommended to be harvested faster to minimize the increase in leaves unfit for consumption.

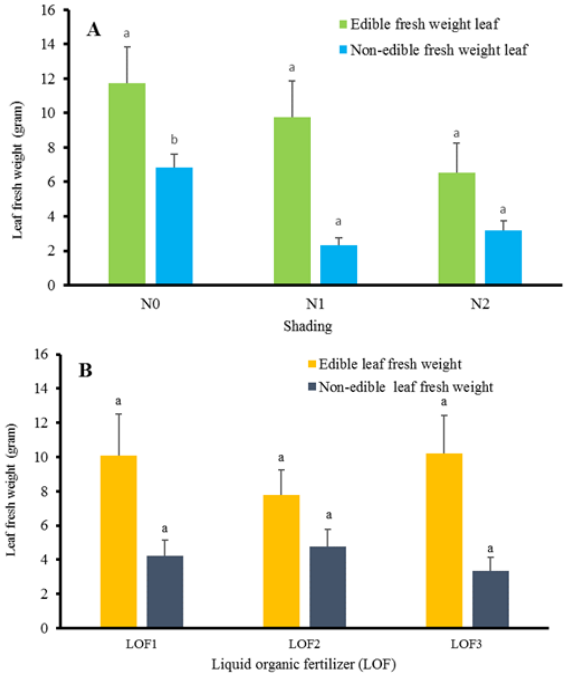

Figure 6. The fresh weight of edible leaf, non-edible fresh weight at the different shade treatments (N0: shade 0%; N1: shading 50%; N2: shading 70%) (A) and liquid organic fertilizer (LOF1: rice washing water LOF; LOF2: pineapple peel waste LOF; LOF3: leftover rice LOF) (B)

DISCUSSION

The SPAD values of Brazilian spinach plants showed an increase starting at week 2 to 8 WAP (Figure 2). This illustrates that there was an increase in the chlorophyll content of Brazilian spinach leaves. Shibaeva et al. (2020) state that the SPAD values are positively related to leaf chlorophyll. Likewise, Muchechetiet et al. (2016) also state that the SPAD values are linearly related to leaf chlorophyll. Limantara et al. (2015) state that the SPAD values are strongly related to nitrogen content. Munir (2016) reports that the element nitrogen plays a role in the formation of chlorophyll, amino acids, fatty enzymes and other compounds. According to Zhu et al. (2012), the shading affects the

chlorophyll content characterized by the SPAD values. Xiong et al. (2015) also state that sunlight greatly affects the nitrogen content in the formation of chlorophyll during plant growth. Shah et al. (2017) state that fertilizer application can increase the chlorophyll content of leaves at higher doses. According to Purwanto et al. (2017), liquid organic fertilizer is able to increase the SPAD value in plants.

Horticultural crops, especially leaf vegetables, have a degree of adaptation to shading. The results of Ekawati and Saputri's research (2020) also show that the shading affects the number of plant leaves because the vegetative growth and photosynthesis results are more likely to lead to plant growth. This condition was described by Brazilian spinach canopy growth (Figure 3; Figure 4). Suhardjito (2016) stated that sunlight is important for plants. The intensity of light influences the growth and development of plants, which is related to the process of photosynthesis. The greater the amount of energy available, the greater the number of photosynthesis results to the maximum (Faizin & Susila, 2016). The study conducted by Khusni et al. (2018) also show that the highest dry weight of red spinach plants is found in the shade of 0%. The study results of Tanari and Vita's research (2017) show that the 0% shade has a significant influence on the number of leaves, wet weight of plants, wet weight of roots, dry weight of plants and dry weight of roots of lettuce plants. Differences in photosynthesis allocation in Brazilian spinach were described by shoot dry weight (Table 2).

Habib (2018) also states that the highest yield of spinach is found in the provision of 0% shade. This is because plants in the shade of 0% carry out optimal photosynthetic metabolism so that the resulting assimilate is higher and implications for higher fresh weight yield of Brazilian spinach (Figure 6). Khodriyah et al. (2017) state that the shading is an effort to protect plants from sunlight, maintain humidity and temperature, and prevent damage to plants caused by disease pests. Meanwhile, the results of Andini and Yuliani's research (2020) show that the provision of shade provides a greener leaf. Navaneetha-Gowda et al. (2022) also states that shading the spinach plant shows the highest chlorophyll content. According to Zhu et al. (2012), the 70% shading causes stunted growth due to less sunlight, while the shade with a lower density can meet the light requirements of plants, which produces higher biomass.

The LOF treatment of had no real effect on all variables. It is suspected that the applied LOF could not provide the availability of nutrients, especially NPK beneficial for the growth of the Brazilian spinach plant. Knaofmone (2016) states that the higher the dose of LOF, the better the plants grow. Munir (2016) states that phosphorus plays a role in stimulating root growth and development. Meanwhile, the potassium plays a role in expanding root growth and leaf area. Citra et al. (2012) state that white rice washing water give the best effect on root growth. Suryadi and Supriyo (2021) state that the application of liquid organic fertilizer made of household waste is good for use in leaf vegetable crops, it can affect plant height and the number of leaves on spinach plants.

The selection of the types of LOF making material with adequate nutrient content can trigger the growth of vegetable plants. The results of the study conducted by Sari et al. (2015) show that the provision of *kepok* banana peel LOF gave significant results on plant height, number of leaves and leaf area of spinach plants. Similarly, the results of the study carried out by Syamsi et al. (2022) also show that the provision of *kepok* banana peel LOF has a significant effect on the height of the spinach plant (*Amaranthus tricolor* L.). Shah et al. (2017) state that nutrient stress can inhibit the process of photosynthesis. According to Mursalim et al. (2018), the liquid organic fertilizer made of rice, banana stems, cob fish, rice washing water and coconut water has a significant

influence on wet weight, number of leaves and height of mustard plants. Sawoy et al. (2021) state that an organic fertilizer made of rice and banana weevils has an influence on plant height and the number of leaves of spinach plants. According to Dahlianah and Novianti (2020), the LOF made of papaya fruit produces the highest average value, number of leaves and wet weight of mustard plants. According to Sari (2019), the provision of pineapple peel LOF affects the growth and yield of the Chinese broccoli plant (*Brassica oleracea* L.).

CONCLUSSION

Based on the results of the study, Brazilian spinach on no-shade (0%) has improve growth than shading on 50% and 70%. Meanwhile, LOF made from rice washing water, pineapple peel waste and leftover rice did not show any significant difference to the Brazilian spinach growth.

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