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The effectiveness of organic fertilizer from natural dyes waste on the growth of *Indigofera tinctoria* L.

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Abstract. *Indigofera tinctoria* natural dye extraction waste has not been utilized become environmental pollution can encourage climate change. Climate change causes land degradation and decreased crop productivity. Management of the waste into organic fertilizer and used in plant cultivation need to mitigate climate change. This study aimed to examine the role of organic fertilizer from natural dye waste in obtaining the optimum dose in supporting the growth of *Indigofera tinctoria*. The study used a Randomized Completely Block Design (RCBD) with one factor, namely the dose of organic fertilizer from the extraction of *Indigofera tinctoria* L. with 11 levels (0 g/plant, 50 g/plant, 100 g/plant, 150 g/plant, 200 g/plant, 250 g/plant, 300 g/plant, 350 g/plant, 400 g/plant, 450 g/plant, and 500 g/plant). The results showed that the natural dye extraction waste could be used as organic fertilizer to support the growth of *Indigofera tinctoria*. Application of organic fertilizer at a dose of 50 g/plant showed an increase in the plant height of 14% and number of leaves by 124%. The dose of organic fertilizer of 350 g/plant is the optimum dose in producing the high number of leaves, leaf area index, and plant biomass.

Keywords: biodegradable, plant extracts, remediation

1. Introduction

The natural dye extraction process of *Indigofera tinctoria* produces 90% organic waste and only 10% natural dye [1]. The waste has not been managed properly by the farmers. Waste management is done by burning. The process of burning waste produces carbon emissions that cause air pollution and have a negative impact on climate change [2]. Climate change causes land degradation and decreased crop productivity [3].

The problem of managing waste from the extraction of natural dyes encourages the use of waste as an organic fertilizer because of the high chemical content of the extracted waste. Waste from extraction of natural dyes is organic waste consisting of the structure of the *Indigofera tinctoria* plant, namely stems, leaves and pods [4]. Composting plant waste is an environmentally friendly effort by providing product values that have a positive impact on soil and plants. Several studies have reported the management of waste into organic fertilizer as a source of nutrition in agriculture such as industrial waste with a mixture of chicken manure, sawdust and green waste [5,6]. The extracted waste contains N, CH₄, NH₃, CO₂, O₂ [7]. Waste management into organic fertilizer can have a positive impact on soil and plants.

Organic fertilizers from the composting process can overcome the degradation of agricultural land resources [8] and help the growth of horticultural crops [9] Organic fertilizers can increase soil density



on dry land and increase N₂ fixation and the number of nodules in legumes [10] The application of a combination of organic fertilizer and biofertilizer can increase indican content, the yield of *Indigofera tinctoria* herbs and N and K content in the soil [11] This study aims to determine the effectiveness of natural dye extraction waste organic fertilizer on the growth of *Indigofera tinctoria* plants.

2. Materials and method

2.1. Materials

The research was conducted from May to September 2020, in Puron Village, Bulu District, Sukoharjo, Central Java, Indonesia. The research location is at di 110° 51' 49.44'' E and 7° 48' 54.3'' S. The research soil had an acid pH of 5.95, 0.33% nitrogen (N), 3.94 ppm phosphorous (P), 12.16 mg/100g of soil potassium (K), C-organic was low at 2.45%, and organic matter was low at 4.23%. Materials used in this research included *Indigofera tinctoria* L. seeds and organic fertilizer from natural dyes waste. The instruments were measures to measure plant height, scale to measure leaf weight and plant biomass, and oven to dry the plant.

2.2. Methods

The research used a Randomized Completely Block Design (RCBD) with one factor, namely the dose of organic fertilizer from the extraction of *Indigofera tinctoria* L. with 11 levels (0 g/plant, 50 g/plant, 100 g/plant, 150 gplant, 200 g/plant, 250 g/plant, 300 g/plant, 350 g/plant, 400 g/plant, 450 g/plant, and 500 g/plant). Every experimental unit was repeated 3 times until 33 experimental units were got. Every experimental unit was consist of 4 plants. Observation variables included the plant height, number of leaves, leaf area index, and plant biomass. Research data were analysed using analysis of variance with α 5% test level 95% confidence level. If it had a significant effect, further analysis was done using Duncan's Multiple Range Test (DMRT).

3. Results and discussion

3.1. The plant height

The results showed that the dose of organic fertilizer from the extraction of natural dyes had a significant effect on plant height. Plant height increased with an increasing dose of organic fertilizer (Table 1). This is because well-decomposed organic fertilizers can provide nutrients needed by plants, especially N and K elements so that the photosynthesis process will be optimum [12].

Table 1. The effect of organic fertilizer from natural dyes waste on plant height

Treatment (gram/plant)	Plant Height
0	82.67 a
50	96.83 b
100	105.33 bc
150	106.33 bcd
200	112.67 cde
250	105.67 bc
300	113.67 cde
350	114.67 cde
400	115.33 cde
450	120.33 de
500	126.33 e

Note: Number followed by the same columns showed no significant difference based on the DMRT level of 5%.

Fertilization is an effort to provide nutrients needed by plants in the soil. Plant height that was given organic fertilizer from the extraction of natural dyes at a dose of 500 grams/plant was able to reach a height of 120 cm. This is because organic fertilizers increase the regulation of soil microbial communities thereby increasing the content of C organic and soil nitrogen [13] which can further promote plant growth [14].

The application of organic fertilizer at a dose of 50 grams/plant has shown an increase in plant height and is significantly different from that without the application of organic fertilizer. This is supported by the chemical content of the organic fertilizer. The content of organic fertilizers can support the structure and function of microbial communities that provide available nutrients by mineralizing organic matter [15].

3.2. The number of leaves

The treatment of organic fertilizer from natural dye extraction waste at various doses had a significant effect on the number of leaves (Table 2). *Indigofera tinctoria* plants treated with a dose of organic fertilizer from the extraction of natural dyes of 350 grams/plant and 500 grams/plant had an average number of leaves that were not significantly different, namely 969 leaves. This indicates that the administration of a dose of 350 grams/plant of organic fertilizer from the extraction of natural dyes has been able to affect the number of leaves of the *Indigofera tinctoria* plant. This is because the content of nutrients, C-organic and organic matter in the organic fertilizer is high so that it can support the growth of plant leaves. Leaf growth was correlated with the uptake of nitrogen and phosphate of plants which was influenced by the addition of nitrogen and phosphate to the soil [16]. The addition of N can significantly affect the concentration of N and P in green and old leaves and the pattern of nutrient resorption. Based on the results of this study, shows that organic fertilizers have complete nutrition and contain growth regulators such as hormones for plant growth [17].

Table 2. The effect of organic fertilizer from natural dyes waste on number of leaves

Treatment (gram/plant)	Number of Leaves
0	197.33 a
50	634.33 b
100	668.67 b
150	700.33 b
200	690.33 b
250	768.67 bc
300	861 bc
350	968.67 c
400	879.33 bc
450	879.33 bc
500	968.67 c

Note: Number followed by the same columns showed no significant difference based on the DMRT level of 5%.

3.3. The leaves area index

The results showed that the dose of organic fertilizer from the extraction of natural dyes had a significant effect on the leaf area index (Table 3). The leaf area index of *Indigofera tinctoria* with treatment with doses of organic fertilizer from the extraction of natural dyes of 350 grams/plant and 500 grams were not significantly different. This shows that the treatment dose of organic fertilizer extraction waste of 350 grams/plant has been able to increase the leaf area index. A high leaf area index value results in a higher yield weight [18]. Organic fertilizer increases the photosynthetic efficiency of leaves so that the leaf area index increases [19]. Leaf Area Index (LAI) increased along with plant growth and reached its maximum when the canopy growth was tight. External factors also affect the optimal LAI value such as

spacing (plant density) and cropping system. Leaf area index and light energy determine the rate of photosynthesis of plants [20]

Table 3. The effect of organic fertilizer from natural dyes waste on leaves area index

Treatment (gram/plant)	Leaves Area Index
0	0.2952 a
50	1.0729 abc
100	0.7864 ab
150	1.069 abc
200	1.9798 cd
250	1.7343 bcd
300	2.1958 d
350	2.4398 d
400	1.7504 bcd
450	2.2291 d
500	2.7310 d

Note: Number followed by the same columns showed no significant difference based on the DMRT level of 5%.

3.4. The plant biomass

The results showed that the dose of organic fertilizer from the extraction of natural dyes with various doses had a significant effect on plant biomass (Table 4). The average plant biomass with treatment with doses of organic fertilizer from the extraction of natural dyes of 350 grams/plant and 500 grams/plant was not significantly different, namely 186.483 grams and 182.683 grams. This shows that the treatment dose of organic fertilizer waste extraction of natural dyes 350 grams/plant has been able to increase plant biomass. The provision of organic fertilizer can increase root activity in absorbing water and nutrients needed by plants in the metabolic process [21].

Plant biomass is a measure of plant growth and development. Calculation of plant biomass was used to determine the accumulation of organic compounds that were successfully synthesized by plants to other organs [22]. The difference in plant biomass is caused by differences in the ability of leaves to produce reduced carbon for producing plant biomass [23].

Table 4. The effect of organic fertilizer from natural dyes waste on plant biomass

Treatment (gram/plant)	Plant Biomass
0	30.52 a
50	108.25 b
100	83.25 ab
150	106.57 b
200	142.90 bc
250	140.47 bc
300	152.97 bc
350	186.48 c
400	128.043 bc
450	152.800 bc
500	182.68 c

Note: Number followed by the same columns showed no significant difference based on the DMRT level of 5%.

4. Conclusion

The natural dye extraction waste could be used as organic fertilizer to support the growth of *Indigofera tinctoria*. Application of organic fertilizer at a dose of 50 g/plant showed an increase in plant height of 14% and number of leaves by 124%. The dose of organic fertilizer of 350 g/plant is the optimum dose in producing the high number of leaves, leaf area index, and plant biomass. Utilization of waste as organic fertilizer as a step to reduce the impact of climate change and support plant growth.

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