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Effectiveness of Use of *Tithonia diversifolia* Biomass and Local Microorganisms of Banana Weevil to Increase Growth and Yield in Spinach (*Amaranthus* spp.)

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ABSTRACT

Local microorganisms of banana weevil are one of the local microorganisms that contain many phosphate solubilizing bacteria that accelerate the decomposition of organic matter. This study aimed at determining the effectiveness of using *Tithonia diversifolia* biomass and local microorganisms of the banana weevil to increase the growth and yield of spinach plants. The design used in the study was a factorial randomized block design (RBD). The first factor was the dose of plant (T), which consisted of four levels: T_0 = Zero, T_1 = 10, T_2 = 15 and T_3 = 20 t/ha *T. diversifolia* biomass. The second factor was the concentration of local microorganisms of banana weevils consisting of three levels, namely, M_1 = 100, M_2 = 200 and M_3 = 300 ml/l. The results showed that the interaction of treatment of *T. diversifolia* biomass and local microorganisms of banana weevils had no noticeable effect on all observed variables. A dose of 20 t/ha (T_3) of *T. diversifolia* biomass gave the best results on the plant height growth and the number of leaves of spinach plants. The administration of local microorganisms of banana weevils on spinach plants had no effect on all observed variables.

Key words: *Amaranthus* spp., growth, *Tithonia diversifolia,* local microorganisms, yield

INTRODUCTION

A spinach plant is highly adaptable to different ecosystems, both in optimal and marginal conditions. This can be explained by the fact that this plant produces carbon compound 4 in its photosynthesis process, which is effective in the fixation of CO_2 gas at high-temperature conditions or even under very low soil moisture (Ferreira *et al*.., 2020). This plant can provide a faster income for farmers because it has a short harvest life. Spinach plants are leafy vegetables that provide nutrients to the community because they have a very high content of vitamins and minerals (Fevria *et al*.., 2020).

The cultivation of amaranth plants is widely carried out by small farmers, so it has yet to meet the market's needs. The large market needs occur only due to an increase in the population, an increase in people's income and an increase in public awareness of meeting the nutritional needs of families. In addition, in big cities, there is also an increase in consumer demand for good-quality plant products (Zuryanti *et al*., 2016). Based on the data from Directorate General of Horticulture, the area of spinach plants was 45.914 ha with production of 171.706 t, and average productivity of 3.73 t/ha (BPS, 2021). However, the productivity of spinach plants in Indonesia can reach 20-50 t/ha. Efforts to increase spinach yields include fertilizing by utilizing organic fertilizers. The benefit of using organic fertilizer is that it can improve the physical, chemical and biological fertility of the soil. Organic matter given to soil plays a role in binding soil-free particles, plant nutrient sources and energy sources to soil microorganisms (Miah *et al.*, 2021). In addition, organic fertilizers can also increase the solubility of macronutrients (N, P, K, Ca and Mg), increase soil organic carbon, cation exchange capacity, ability to hold groundwater, reduce exchangeable aluminum saturation and soil density ratio (Sondang *et al.*, 2019).

Intensive cultivation of vegetable crops at this time uses high amounts of synthetic chemical inputs, in the form of inorganic fertilizers and pesticides, resulting in land productivity continuing to comply with and polluting the plant growing environment. One of the efforts to reduce the decline in land productivity and environmental pollution is the organic farming system. Organic farming is a form of agriculture that utilizes local resources with a combination of synergistic agroecosystem components and the use of external inputs as a complement to reduce environmental damage (Gupta, 2020).

The use of weed plant biomass such as *Tithonia diversifolia* as a source of soil organic matter at this time has not been optimally utilized. These plants tend to be categorized as nuisance plants for mother plants, discarded and burned or used as animal feed (Nuraini and Sukmawatie, 2014). Biomass produced from *T. diversifolia* can be used as a source of organic fertilizer material through direct use or composting. The results of previous studies showed that *T. diversifolia* contained 3.3-5.5% N, 0.2-0.5% P and 2.3-5.5% K. The nutrient content can be used as a source of nutrition for plants. The advantage of *T. diversifolia* as an organic matter is its high nutrient content, resulting in simple organic acids (oxalic, citric, butyric, lactic, acetic), fulvic and humic acids higher, with its ability to neutralize ferrous and aluminum metals is very high so that it will further increase the availability of phosphorus in the soil (Utami *et al.*., 2017).

The decomposition rate of organic matter in the soil is influenced by the type and the size of the organic matter. The organic matter with a low ratio of C and N will quickly undergo a degradation process. Microorganism which is currently being developed as a biological fertilizer is a local microorganism (MOL). Use of MOL as a microorganism based organic fertilizer accelerates the decomposition process and improves plant growth. These natural materials are habitats for the growth of microorganisms to accelerate the process of decomposition of organic matter or as additional nutrients for plants (Tulak *et al.*, 2022). One of the materials that can be used as a source of raw materials for making MOL is banana weevil. MOL made from banana weevil contains microorganisms (bacteria) that are useful for plants and soil fertility such as *Azospirillum* sp, *Rhizobium* sp., *Bacillus* sp, *Azotobacter* sp., *Pseudomonas* sp. and phosphate degrading bacteria. In addition to containing bacteria, MOL also contains hormones that can increase plant growth such as *gibberellin*, *cytokinins* and *auxins* and contains macronutrients and micronutrients needed by plants (Sodiq *et al.*, 2019).

This study evaluated the use of nutrient-rich biomass *T. diversifolia* and MOL from banana weevils containing microorganisms, growth hormones and macro and micronutrients that were thought to increase the growth of spinach yield and production.

MATERIALS AND METHODS

This experiment was carried out at the greenhouse of the Faculty of Agriculture, Panca Bhakti University, Pontianak. This experiment was carried out from December 2019 to February 2020. The materials used in this experiment were *Tithonia diversifolia* biomass, Local Micro Organisms (MOL) banana weevil, spinach seeds, agricultural lime, polybags and organic pesticides. The equipment used in the experiment consisted of biomass enumerators, sickles, hoes, machetes, thermometers, hygrometers, meters, scales, measuring cups, plastic buckets, plastic tubs and office stationery.

This experiment used a randomized block design (RBD) with a factorial pattern, which consisted of two factors. The first factor was the dose of plant biomass *T. diversifolia* as soil organic matter (T), which consisted of four levels: T_0 = without biomass administration, T_1 = 10 t/ha, T_2 = 15 t/ha and T_3= 20 t/ha. The second factor was the concentration of Local Micro Organism (MOL) of banana weevil (M) consisting of three levels M_1 = 100 ml/l, M_2 = 200 ml/l, and M_3 = 300 ml/l. Each combination of treatments was repeated three times so that there were 36 experimental units.

F test at a rate of 5% was used to see the effect of all treatments. The Tukey test was carried out at the level of 5% to see a real difference in each level of treatment.

Before use, the alluvial soil was cleaned, air-dried and sifted so that the soil medium was more homogeneous. This homogeneous soil was then filled into 40 x 30 cm polybags with a medium weight of 8 kg. The liming process was carried out to reduce the level of acidification (increase the pH) of the soil. The lime used to reduce soil acidification was dolomite [$CaMg(C0_3)_2$] at a 40 g/polybag dose. Liming was carried out two weeks before planting.

The administration of biomass *T. diversifolia* was carried out at the time of planting, with the dosage according to treatment. Spinach seeds before planting in polybags were first sown for one week after which they were transferred into polybags. Each pot was filled with one seedling.

The treatment of giving Local Micro Organisms (MOL) was provided at the time of planting by watering into the soil with a concentration according to the treatment and a watered solution of 250 ml per plant. Plant maintenance was carried out in three stages: embroidery on dead seedlings, watering, preventing plants from pests and diseases, and reducing weed growth. Thirty days after planting, the spinach plant was pulled out. The growth parameters included plant height, number of leaf blades, plant weight, root volume (cm^3) and chlorophyll index value.

RESULTS AND DISCUSSION

Analysis of variance for plant height, number of leaves, plant weight and root volume parameters had a noticeable effect with the application of plant biomass *Tithonia diversifolia*. At the same time, administration of *T. diversifolia,* MOL concentrations and the interaction of the two treatments showed an unreal effect on the chlorophyll index parameter. Spinach with the application of *T. diversifolia* biomass of 20 t/ha (T_3) had the best growth with an average plant height of 19.44 cm (Table 1). In contrast, spinach that was not given *Tithonia* biomass (T_0) had the slowest growth with an average plant height of 11.07 cm. Further the number of leaf blades was obtained in 20 t/ha (T_3) with an average of 10.91 strands, while spinach without treatment had the least number of leaf blades (6.18 strands). Similarly, the highest plant weight was obtained in T_3 with an average of 32.38 g, while spinach without treatment had the least plant weight (7.51 g). The highest root volume was also obtained in T_3 with an average of 8.13 cm^3, while spinach without treatment had the least root volume (1.35 cm^3).

The highest average chlorophyll index was in T_3. CCI reached 12.70 concentrations of 200 ml banana weevil. The lowest average chlorophyll index was produced at the level without the administration of *T. diversifolia* (T_0) and the level of banana weevil concentration of 200 ml, which was 10.52 CCI. A comparison of the chlorophyll index on the administration of *T. diversifolia* and the MOL concentration of banana weevil is shown in Fig. 1.

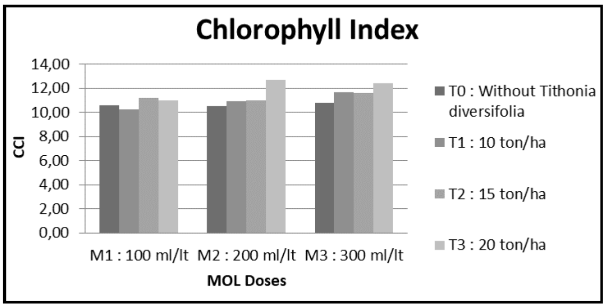

Fig. 1. Average chlorophyll index in *T. diversifolia* administration treatment and MOL concentration of banana weevil.

The average height of spinach plants, as shown in Table 1, indicated that the best height of spinach plants was produced by administration of *T. diversifolia* biomass at a level of 20 t/ha (T_3), with an average plant height of 19.44 cm. On the other hand, the treatment without administration *T. diversifolia* produced the lowest spinach plant height of 11.07 cm. This was due to the fulfilment of the availability of macronutrients (N, P, K, Ca, Mg) and microelements provided by the *T. diversifolia* biomass. The application of *T. diversifolia* in the media replaced the need for N and K from fertilizers, increased soil acidification, reduced aluminum solubility, and maintained the stock of essential minerals such as phosphorus, calcium, and magnesium in the soil (Rusaati *et al.*, 2020). Nitrogen played a role in vegetative growth, while element P

Table 1. Effect pf plant (*T. diversifolia*) biomass on plant height, number of leaves, plant weight and root volume

Administration of *T. diversifolia*	Plant height (cm)	No. of leaves (strands)	Plant weight (g)	Root volume (cm^3)
T_0	11.07±0.54a	6.18±0.81a	7.51±0.46a	1.35±0.18a
T_1	16.07±1.39b	9.02±1.79b	22.04±2.24b	5.70±0.71b
T_2	16.37±1.99b	9.20±2.02b	22.86±3.47b	6.04±1.04b
T_3	19.44±1.73c	10.91±2.15c	32.38±5.65c	8.13±1.70c
Tukey 5%	1.44	1.66	3.16	1.00

Numbers followed by the same letter are not significant.

played a role in enzymatic reactions, which were important in cell division and directly related to plant height. Element K played a role in maintaining turgor pressure, which was crucial for improving photosynthesis and metabolic processes (Chen *et al.*, 2022).

Meanwhile, the treatment without the application of *T. diversifolia* biomass into the soil showed the lowest average height of spinach plants. This treatment resulted in spinach plants lacking nutrients, hampering their growth. A plant's growth is strongly influenced by the supply and availability of nutrients in the environment in the form of both macro and micronutrients. If there is a shortage of nutrient supply, it can cause plant growth to be hampered (Khalil *et al.*, 2015). The administration of *T. diversifolia* biomass at higher doses resulted in better average growth of spinach plants due to the sufficient supply of nutrients in the soil, especially nitrogen. During the vegetative growth period, the results of assimilation were transferred to the root, leaf and stem organs of the plant, with the greatest result of assimilation distributed to the top of the shoots. Moreover, the application of *T. diversifolia* biomass had important physical aspects as a green fertilizer that maintained the availability of water in the soil, thus, maintained soil moisture to provide water for plants (Hafifah *et al.*, 2016).

The results of observations on the number of spinach leaves, plant weight and root volume showed that the best result was in the treatment of *T. diversifolia* at the level of 20 t/ha (T_3), while the treatment without the administration of *T. diversifolia* gave the lowest number. The application of *T. diversifolia* into the soil provided the fulfilment of the availability of nutrients (micro and macro) provided by the biomass of *T. diversifolia*. The application of biomass *T. diversifolia* acted as a green fertilizer which was classified as organic fertilizer so that it contributed organic matter to the soil (Hafifah *et al.*, 2016).

The application of organic fertilizers played a role in improving the physical, chemical and biological properties of the soil so that it could increase the fertility of the soil (Riyanto *et al.*, 2021). The chemical components of biomass were able to provide macro- and micronutrients in the soil even in relatively small amounts. In addition, organic fertilizers could increase the value of cation exchange capacity soil and were able to bind adverse Fe, Al and Mn cations. This was an advantage of using organic fertilizers in addition to improving the physical, chemical and biological properties of the soil. Organic fertilizers could also help streamline the use of inorganic fertilizers excessively and increase production productivity.

The application of plant biomass *T. diversifolia*, MOL concentrations, and both treatments showed an unreal effect on the chlorophyll index. The chlorophyll index determined the chlorophyll content in the leaves of spinach plants related to the colour of the leaves in spinach plants. Minerals such as N, P, K, Ca, S and Mg were very decisive on the amount of chlorophyll contained in spinach leaves. According to Aryani *et al.* (2019), *T. diversifolia* contained 0.60% Mg, which was relatively low. Magnesium was the dominant element in the leaves, regulating the circulation of phosphorus and carbohydrates so that magnesium was classified as an important component for chlorophyll. The low magnesium content in the biomass of *T. diversifolia* plants caused no noticeable effect in the administration of plant biomass *T. diversifolia* on the variable chlorophyll index.

The application of banana weevil MOL had an unreal effect on every observed growth parameter and yield of spinach plants. This was due to the low concentration of MOL used, so the plant's nutritional needs had not been optimally met. MOL generally contained macro and micronutrients and microorganisms. The presence of microorganisms in the soil could improve soil properties, including soil structure, and help the availability of nutrients both directly through binding activities of nutrients and indirectly by decomposing organic matter and recycling nutrients (Adomako *et al.*, 2022).

The identification was carried out on the MOL of banana weevils to determine the content of microorganisms present. The genera of microorganisms found and their characteristics can be seen in Table 2 below. Based on the results of the MOL identification, four types of bacterial genera were obtained, namely, *Acetobacter*, *Bacillus*, *Azosprillium*, and *Pseudomonas*. The results of this identification aligned with the research conducted by Budiyani *et al.* (2016) which also discovered four genera of these bacteria. Genus *Bacillus*

Table 2. Genus, population and biochemical properties of bacteria in mol banana weevil

Genus of bacteria	Bacterial population (cfu/ml)	Biochemical properties of bacteria				
		Energy sources	O_2 needs	OF	Urea	H_2S
Acetobacter	190.000	Insaccharides	Optional	Fermentative	+	-
Bacillus	227.500	Insaccharides	Optional	Fermentative	+	-
Azosprillium	215.000	Insaccharides	Optional	Fermentative	+	-
Pseudomonas	205.000	Insaccharides	Optional	Fermentative	+	-

was the largest population of microorganisms found in the MOL of banana weevils. The bacteria that were identified were fermentative bacteria that can degrade organic matter such as carbohydrates and proteins into urea but cannot produce H_2S. Genus *Bacillus* had ascending physiological properties because each type had different abilities including being able to degrade organic compounds such as protein, starch, cellulose and hydrocarbons. Further, able to produce antibiotics, playing a role in nutrification and denitrification, nitrogen binder, cellanium oxidizer and manganese oxidizer reduction were chemolitotrophic, aerobic or facultative anaerobic, alkaliphilic, psychopriphilic or thermophilic (Sondang *et al.*, 2020).

CONCLUSION

Treatment with 20 t/ha using *Tithonia diversifolia* biomass gave the best results on the observed variables such as plant height, number of leaves, plant weight and root volume. The application of MOL banana weevil and interaction of the two treatments had an unreal effect on all of the observed variables.

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