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GROWTH and YIELD RESPONSE of TOMATO (Lycopersicum esculentum Mill.) on VERMICOMPOST FERTILIZATION and WATER SHOOTS PRUNING

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ABSTRACT

Inorganic fertilizers used continuously in tomato cultivation cause soil degradation which will affect the growth and yield of tomato plants. Efforts to maintain soil fertility include applying organic fertilizers and reducing inorganic fertilizers, one of which is vermicompost. The aim of the study was to obtain the best treatment combination from the administration of various doses of vermicompost and the time of pruning water shoots. The research was conducted from July to October 2022 in Kalasan, Yogyakarta. The research method was a field experiment using a factorial Complete Randomized Block Design. Factor I was the dosage of vermicompost: 5 tons/ha, 10 tons/ha, 15 tons/ha, and 20 tons/ha. Factor II was the time of pruning water shoots: 20 days after planting (DAP), 35 DAP and 50 DAP. The results showed that vermicompost 20 tons/ha by pruning water shoots at 20 DAP gave the best results on the number and weight of fruit per plant. The treatment of vermicompost at 20 tons/ha gave the best results on plant height and stem diameter, as well as pruning water shoots at 20 DAP.

Keywords : *tomato, vermicompost, water shoots pruning*

INTRODUCTION

Tomato (Lycopersicum esculentum Mill.) is a fruit vegetable belonging to the annual plant and belongs to the Solanaceae family. Tomatoes are a source of vitamin C, vitamin A (carotene), and minerals which play an important role in meeting nutritional needs so that tomatoes are popular with the public (Laginda et al., 2017).

According to Manurung (2020) the supply of tomatoes in Indonesia comes from domestic production plus import activities. From 2019 to 2021, the supply of tomatoes in Indonesia was dominated by domestic production, which continue to increase. Based on data from the Central Bureau of Statistics (2022) tomato production in Indonesia in 2019 reached 1,020.33 thousand tons, then increased to 1,084.99 thousand tons in 2020, and 1,114.40 thousand tons in 2021. The Food Security Agency of the Ministry of Agriculture (2020) states that domestic use of tomatoes is not only for household consumption but also for other uses, such as the need for seeds, the food and non-food industries, and export activities. The Central Bureau of Statistics (2022) states that consumption of tomatoes by households in Indonesia in 2019 reached 629.02 thousand tons, then increased to 634.01 thousand tons in 2020, and 677.97 thousand tons in 2021.

Tomato plants really need the availability of water and sufficient nutrients for the process of plant growth so that fertilization needs to be done to complement the needs of plant nutrients. According to Pranoto et al., (2020) farmers tend to use inorganic fertilizers in larger doses because inorganic fertilizers contain relatively higher levels of nutrients, decompose more quickly so that they are more quickly absorbed by plants, and are practical and easy to apply. The use of inorganic fertilizers continuously in the long term will damage soil fertility, causing soil degradation. Soil that is always given excessive doses of inorganic fertilizers without considering the application of organic matter causes the soil to become hard so that it is difficult for plant roots to penetrate the soil, this also results in a decrease in the population and activity of soil microorganisms because they are not supplied with food (organic matter) (Fateha *et al*, 2020). Provision of organic fertilizers can supplement the availability of nutrients for plants and improve soil conditions by providing organic matter needed by soil microorganisms. One of the organic fertilizers that can be used is vermicompost.

Vermicompost, also known as worm waste, is compost obtained from the decomposition process of organic materials assisted by earthworms. Vermicompost is beneficial for soil and plants because it contains macro and micro nutrients and organic compounds so it is useful in providing the nutrients needed by plants and improving soil structure. According to Sari *et al*., (2022) the nutrient content in vermicompost is Nitrogen (N) 1.80-2.05%, Phosphorus (P) 1.32-1.93%, Potassium (K) 1.28-1 .50%, Sulfur (S) 0.04%, Calcium (Ca) 3.0-4.5%, Magnesium (Mg) 0.4-0.7%, Iron (Fe) 0.3-0.7 ppm, Zinc (Zn) 0.028-0.036 ppm, and Aluminum (Al) 0.0034-0.0075 ppm.

Improvements in plant cultivation techniques also play an important role in supporting increased yields of tomato plants, one of which is pruning water shoots. Pruning water shoots is done by cutting the shoots that appear in the axils of the leaves, with the aim that photosynthetic translocation will be focused on the area of generative organ formation, besides that, making tomato plants not too dense so that sunlight can enter each plant canopy and air circulation runs well. Pruning time is one of the things that need to be considered in pruning. Pruning carried out in the vegetative phase of plants will reduce the growth of vegetative organs so that it will stimulate generative growth, while pruning in the generative phase of plants will cause photosynthetic results not only for fruit formation but also divided to grow new leaves.

RESEARCH METHODS

The research was carried out from July to October 2022 in Kalibening, Tirtomartani, Kalasan, Sleman, Yogyakarta Special Region. The materials used included tomato seeds of the Servo F1 variety, soil, vermicompost with Lumbricus rubellus worm, rice husk, goat manure, NPK 15-15-15 fertilizer, Gandasil D and Gandasil B foliar fertilizer, fungicide with active ingredient Mankozeb 80%, and insecticides with active ingredients of Carbofuran, Cypermethrin, and Profenofos.

The study was a field experiment using a factorial Completely Randomized Block Design (4x3) with 3 replications to obtain 36 experimental units. Each

experimental unit consisted of 8 plants, so the total was 288 plants. Observational data were analyzed with ANOVA at 5% level and further tested with DMRT at 5% level.

Seeding was carried out in seedling trays with seedling media in the form of soil and goat manure (1:1). Maintenance during the nursery was carried out by watering once a day and fertilizing when the plants were 10 days after seedling using Gandasil D fertilizer with a concentration of 2 gram/L which was applied with a volume of 100 ml/tray by spraying. Preparation of the planting medium was carried out 14 days before transplanting by filling the planting medium in the form of soil and rice husk (2:1) and vermicompost according to the treatment into polybags then arranged according to the layout of the experiment with a distance between polybags of 10 cm × 10 cm. Seedlings were transferred to polybags when they were 20 days after sowing by planting 1 seed per polybag. The planting hole is given an insecticide with active carbofuran ingredients first. Pruning of water shoots according to treatment is carried out in the morning. Maintenance includes watering twice a day, weeding, replanting, installing stakes, follow-up fertilization using NPK fertilizer when the plants are 30 HST, by dissolving 5 grams of NPK fertilizer in 1 liter of water applied with a volume of 400 ml/plant (2 grams/plant) by pouring it out. Gandasil B foliar fertilizer is given at a concentration of 2 grams/L which is applied with a volume of 100 ml when the plants are 21 DAP, 150 ml when the plants are 35 DAP, 200 ml when the plants are 49 DAP. Pest control in the vegetative phase was carried out by spraying the active ingredient Sipermethrin with a concentration of 1.5 ml/L, pest control in the generative phase was carried out by spraying the active ingredient Profenofos with a concentration of 1.5 ml/L, and spraying the fungicide with the active ingredient Mankozeb 80% with a concentration of 6 grams/L was carried out to anticipate the plants being attacked by fungal diseases. The first harvest was carried out when the tomato plants were 62 DAP at intervals of 5 days until 8 harvests were obtained.

RESULTS AND DISCUSSION

Treatment of vermicompost and pruning of water shoots had an effect on plant height, stem diameter and number of leaves (Table 1). There was no interaction between the two treatments. From Table 1 it can be seen that the vermicompost treatment of 20 tons/ha resulted in a significantly higher average plant height, stem diameter and number of leaves compared to the vermicompost treatments of 5 tons/ha, 10 tons/ha, and 15 tons/ha. Provision of vermicompost at the right dose can meet the needs of plant nutrients, especially nitrogen nutrients which play an important role in the process of forming plant vegetative organs. Vermicompost can increase the availability of nutrients in the soil, especially nitrogen, phosphorus and potassium. Nitrogen is the main constituent of chlorophyll formation (Badar *et al*., 2021). The element phosphorus plays a role in the formation of a number of enzymes and proteins, while potassium acts as an enzyme activator (Anjani *et al*., 2022).

Table 1. Average Plant Height (cm), Stem Diameter (cm) and Number of Leaves (strands) of Tomato Plants with Vermicompost and Water Shoots Pruning

Treatment	Observation time at 28 DAP		
	Plant height	Stem Diameter	Number of Leaves
Vermicompost			
5 tons/ha	84,33 d	9,14 c	97,86 c
10 tons/ha	87,50 c	9,48 bc	114,44 b
15 tons/ha	92,78 b	9,84 b	118,31 b
20 tons/ha	97,99 a	10,49 a	125,25 a
Rerata	90,65	9,74	113,96
Pruning Water Shoots			
20 DAP	97,50 p	10,04 p	105,35 q
35 DAP	87,61 q	9,63 pq	119,71 p
50 DAP	86,83 q	9,55 q	116,83 p
Average	90,65	9,74	113,97
Interaction	(-)	(-)	(-)

Note : Numbers followed by the same letter in column (a, b, c) or (p, q, r) show no significant difference at the DMRT level of 5%. The (-) sign indicates no interaction.

Giving vermicompost at a dose of 20 tons/ha means it provides more nutrients to plants, compared to other dose levels. The more doses of fertilizer given, the more nutrients that can be available so that the nutrient needs of plants can be met. The high dose of fertilizer given can increase the photosynthetic process of plants so that the photosynthates produced will then be used for the formation of plant organs, especially for increasing plant height (Jatsiyah *et al*., 2020). According to Badar *et al*. (2021) nitrogen is the element most needed by plants in the vegetative phase because nitrogen is the main constituent of chlorophyll formation. Chlorophyll functions to capture sunlight which is useful for helping plants in the process of photosynthesis, and the energy from the resulting photosynthesis is useful in cell division and elongation so as to increase plant height. The energy used in cell division is formed with the help of the phosphorus nutrient available in vermicompost. According to Arista et al., (2015) the nutrient phosphorus plays a role in the formation of ATP which is used by plants as energy in the process of cell division so that when the nutrient phosphorus is fulfilled it affects the enlargement of the stem diameter. Adequate phosphorus nutrients can encourage root formation so that plants can absorb water and nutrients properly. Pia *et al*., (2020) stated that groundwater plays a role in dissolving nutrients so that plant roots can absorb nutrients easily, besides that water also dissolves 36 carbohydrates produced from the photosynthesis process and transports them to all parts of the plant for the plant growth process so that the formation of plant organs including the formation of leaves. The formation of leaves is also related to the height of the plant because the higher the stem of the plant, the more places the leaves grow.

Application of vermicompost also contributes growth-stimulating hormones which can trigger an increase in plant height and enlargement of stem diameter. Fitri *et al*., (2017) stated that the content of growth-stimulating hormones in

vermicompost also plays a role in plant growth, such as auxin which can stimulate shoot cell elongation and division, cytokinins play a role in stimulating cell division, and gibberellins play a role in shoot stem cell division and increase the rate of photosynthesis that stimulates the increase in height in plants. Gibberellins in vermicompost also play a role in increasing stem diameter by stimulating the growth of vascular tissue and encouraging cell division in the cambium, so that by administering vermicompost fertilizer at the right dose, the need for plant nutrients and growth-stimulating hormones will be fulfilled so that the plant growth process will run well.

By pruning water shoots at 20 DAP, tomato plants produced a significantly higher average plant height compared to water shoot pruning treatments at 35 DAP and 50 DAP. Pruning servo tomatoes at 20 DAP means pruning at the end of the vegetative phase of the plant and water shoots will not grow back because the growth of the vegetative organs will stop when entering the generative phase (flowers appear). Pruning water shoots at 20 DAP gives the best results for tomato plant height, because water shoots can reduce the number of branches that are formed while leaving productive branches. This causes the shape of the plant to become more open because there are not too many branches so that sunlight can be absorbed evenly in each plant canopy. Even absorption of sunlight can increase the photosynthetic process of plants so that the resulting photosynthate will also increase which will then be used to increase stem height. This is in accordance with the results of Ramadhan's research (2021) that tomato plants that are pruned at 25 DAP produce the highest plants compared to tomato plants that are not pruned and pruned at 50 DAP, because pruning at 25 DAP causes branches that are unproductive is lost so that the plants are not lush and can receive sunlight evenly.

Pruning water shoots at 20 DAP produced fewer leaves than pruning water shoots at 35 DAP and 50 DAP. Servo tomato plants are plants with a determinate growth type, where in the vegetative phase there is rapid growth of branches and leaves, so that many water shoots are formed, but stop when the plant enters the generative phase. Pruning treatment at the age of 20 DAP is a pruning carried out in the vegetative phase of the plant, so that by pruning at that age it can reduce the number of leaves that grow on water shoots which will not grow anymore. This is also done to form a plant framework so that many branches are not formed so that the plants are not dense and minimize overlapping leaves.

Vermicompost treatment and pruning of water shoots have an effect on flowering time. There was no interaction between the two treatments. The average age of flowering is presented in table 2, which shows that the vermicompost treatment of 20 tons/ha resulted in a significantly faster average flowering age compared to the vermicompost treatments of 5 tons/ha, 10 tons/ha, and 15 tons/ha. The pruning treatment of water shoots at 20 DAP resulted in a significantly faster average flowering age compared to the pruning treatments of water shoots at 35 DAP and 50 DAP.

Table 2. Average Age of Flowering (DAP) with Vermicompost Treatment and Water Shoots Pruning

Pruning Water Shoots	Vermicompost				Average
	5 tons/ha	10 tons/ha	15 tons/ha	20 tons/ha	
20 DAP	31,33	30,00	30,00	30,00	30,33 q
35 DAP	32,00	31,67	31,00	30,00	31,17 p
50 DAP	32,33	31,67	31,33	30,67	31,50 p
Average	31,89 a	31,11 b	30,78 b	30,22 c	31,00
Interaction					(-)

Note : Numbers followed by the same letter in column (a, b, c) or (p, q, r) show no significant difference at the DMRT level of 5%. The (-) sign indicates no interaction.

Giving more vermicompost means providing a greater supply of nutrients, especially phosphorus and potassium for plants so that it affects the flowering process to be faster. According to Marhaeni et al. (2018) phosphorus in vermicompost plays a role in assisting assimilation and respiration, accelerating flowering, and helping the ripening of seeds and fruit. Yuanita *et al*. (2016) stated that potassium plays a role in the formation of proteins and carbohydrates, and strengthens plant tissues so that flowers do not fall easily. Pruning water shoots at 20 DAP can stimulate plant generative growth, it is suspected that at that age the plants begin to focus on translocation of carbohydrates for flower formation. According to Gustia (2016) pruning that done when the plant enters the generative phase causing reduced vegetative organs, carbohydrates that were originally to be translocated for the formation of new shoots are focused on forming flowers so that more carbohydrates are used for flowering.

Table 3. Average Number of Fruits per Plant with Vermicompost Treatment and Water Shoot Pruning

Pruning Water Shoots	Vermicompost				Average
	5 tons/ha	10 tons/ha	15 tons/ha	20 tons/ha	
20 DAP	38,75 de	45,83 b	46,67 b	51,50 a	45,69
35 DAP	33,08 g	40,42 d	43,50 c	44,58 bc	40,40
50 DAP	32,00 g	35,75 f	35,92 f	37,67 ef	35,33
Average	34,61	40,67	42,03	44,58	40,47
Interaction					(+)

Note : Numbers followed by the same letter show no significant difference at the 5% DMRT level. The (+) sign indicates there is an interaction.

Vermicompost treatment and pruning of water shoots affected the number of fruits per plant. Between the two treatments there was an interaction. The average number of fruits per plant is presented in table 3 which shows that the combination of vermicompost treatment at 20 tons/ha and pruning of water shoots at 20 DAP resulted in a significantly higher average number of fruits per plant compared to other treatment combinations.

Pruning water shoots at 20 DAP was carried out at the end of the vegetative phase of the plant, at which time the tomato plants began to focus on translocation of carbohydrates for the formation and strengthening of the generative organs, so that the flowers did not fall easily until fruit formation occurred. Pruning also aims to absorb sunlight evenly throughout all parts of the plant and increase air circulation and CO_2 availability in the plant canopy. Adequate food reserves obtained from pruning treatments are supported by the supply of nutrients from vermicompost fertilization. Applying vermicompost at 20 tonnes/ha causes the plants to obtain more phosphorus and potassium for fruit formation. Phosphorus plays a role in the formation of a number of proteins and plays an important role in the formation of flowers, fruit and seeds, besides that potassium plays a role in strengthening plant tissue so that the fruit does not fall easily.

Table 4. Average Fruit Weight per Plant (grams) with Vermicompost Treatment and Water Shoot Pruning

Pruning Water Shoots	Vermicompost				Average
	5 tons/ha	10 tons/ha	15 tons/ha	20 tons/ha	
20 DAP	1.856,39 e	2.266,71 c	2.319,27 bc	2.634,11 a	2.269,12
35 DAP	1.630,38 f	2.023,61 d	2.257,86 c	2.425,66 b	2.084,38
50 DAP	1.522,57 g	1.727,18 ef	1.763,08 ef	1.851,56 e	1.716,10
Average	1.669,78	2.005,83	2.113,40	2.303,78	2.023,20
Interaction					(+)

Note : Numbers followed by the same letter show no significant difference at the 5% DMRT level. The (+) sign indicates there is an interaction.

Vermicompost treatment and pruning of water shoots had an effect on fruit weight per plant. Between the two treatments there was an interaction. The average fruit weight per plant is presented in table 4 which shows that the fruit weight per plant with the combination of vermicompost treatment at 20 tons/ha and water shoot pruning at 20 DAP resulted in a significantly heavier average compared to the other treatment combinations.

Pruning the water shoots of tomato plants at 20 DAP is the right time because this age is a transition from the vegetative phase to the generative phase so as to minimize the branches formed and the photosynthate produced by the plants will be translocated to fruit formation. The photosynthate used for fruit formation was obtained from the pruning treatment of water shoots supported by the application of vermicompost fertilizer on tomato plant growing media. Vermicompost fertilizer 20 tons/ha contains nutrients potassium and phosphorus which is greater than the doses of other treatments. According to Kurniawan *et al*., (2017) the element potassium plays a role in the formation of proteins, strengthens plant tissues so that flowers and fruit do not fall easily, while phosphorus plays a role in the formation of flowers, fruits and seeds and plays a role in the transfer of ATP in plant cells which cannot be replaced by other elements. The more elements of potassium and phosphorus obtained by plants, the fruit formation process can run well and can further affect fruit weight per plant.

Fruit weight per plant of 2,634.11 grams (2.6 kg) is a yield that fits the description, namely 2.11 – 3.49 kg. The recommended dose of NPK fertilizer for tomato cultivation from the Ministry of Agriculture, Director General of Horticulture (2021) is 500 kg/ha. With a population of 25,000 tomato plants per hectare (a description of the Servo F1 tomato plant), the NPK fertilizer requirement is 20 g/plant. In this study, the NPK fertilizer used was 2 g/plant, which means it can reduce the need for NPK fertilizer by 18 g/plant (450 kg/ha). It can be said that the use of this vermicompost can reduce the use of NPK inorganic fertilizers by as much as 90% with yields of fruit weight per plant according to the description.

CONCLUSION

Based on the results of the study, it can be concluded that the interaction of vermicompost treatment at 20 tons/ha with pruning of water shoots at 20 HST gave the best results on the number and weight of fruit per plant. The treatment of vermicompost at 20 tons/ha gave the best results on plant height and stem diameter, likewise the pruning treatment of water shoots at 20 DAP gave the best results on plant height and stem diameter.

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