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The response of oil palm seedlings' growth to vermicompost and water stress under the main nursery stage

Respon pertumbuhan bibit kelapa sawit terhadap kascing dan cekaman air di bawah tahap pembibitan utama

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ABSTRACT

The availability of nutrients and water are two things that are essential for the development of plants. Future oil palm agriculture will require a strategy for the management of water because of the erratic nature of the weather. The addition of organic matter, such as vermicompost, is one strategy for addressing the issue of insufficient water supplies. The primary objective of this study is to investigate the relationship between oil palm seedlings' exposure to vermicompost and various levels of water stress in the main nursery. During the three-month study, 100, 200, and 300 g of vermicompost per polybag was combined with 1.0, 1.5, and 2.0 L/polybag/day. There was no relationship between the dose of vermicompost and the water stress that had observed. The addition of 300 g/polybag of vermicompost increased root fresh weight by 37.8% compared to 100 g/polybag. Moreover, water stress leads to a reduction in plant height and dry weight of the shoots. Compared to 2 L/polybag/day, plant height was lowered by 23.3% and 19.8% at watering volumes of 1.0 and 1.5 L/polybag/day, respectively. In addition, when compared to the appropriate water level of 2 L/polybag/day, high water stress (1.0 L/polybag/day) declined shoot dry weight by 12%.

Keywords: main nursery, water stress, organic matter, oil palm seedling,

ABSTRAK

Ketersediaan unsur hara dan air merupakan dua hal yang esensial bagi perkembangan tanaman. Pertanian kelapa sawit ke depan akan memerlukan strategi pengelolaan air karena sifat cuaca yang tidak menentu. Penambahan bahan organik seperti vermikompos atau kascing merupakan salah satu strategi untuk mengatasi masalah ketersediaan air yang tidak mencukupi. Tujuan utama dari penelitian ini adalah untuk mengetahui pengaruh vermikompos dan berbagai tingkat cekaman air terhadap bibit kelapa sawit terhadap di pembibitan utama. Selama tiga bulan penelitian, sebanyak 100, 200, dan 300 g vermikompos per polibag dikombinasikan dengan volume penyiraman sebesar 1,0, 1,5, dan 2,0 L/polibag/hari. Tidak ada interaksi antara dosis vermikompos dengan cekaman air yang diamati. Penambahan vermikompos sebesar 300 g/polybag secara nyata meningkatkan bobot segar akar sebesar 37,8% dibandingkan dosis 100 g/polybag. Cekaman air menyebabkan penurunan tinggi tanaman dan berat kering pucuk. Tinggi tanaman turun sebesar 23,3% dan 19,8% pada volume penyiraman masing-masing 1,0 dan 1,5 L/polybag/hari dibandingkan dengan 2 L/polybag/hari, Selain itu, jika dibandingkan dengan kadar air yang sesuai rekomendasi yaitu 2 L/polybag/hari, cekaman air yang tinggi (1,0 L/polybag/hari) menurunkan berat kering tajuk sebesar 12%.

Kata kunci: pembibitan utama, cekaman air, bahan organik, bibit kelapa sawit

INTRODUCTION

The oil palm (*Elaeis guineensis* jacq), is a plantatcion crop that plays a major part in Indonesia (Nugraha Ramadhani & Priyo Santoso, 2019; Purba, 2019). Palm oil is used in the food and fuel industries because it can be refined into vegetable oil and biodiesel (Mahlia et al., 2019; Meijaard et al., 2020; Zahan & Kano, 2018). Annually, an oil palm plantation can produce 18–30 tons of fresh fruit bunches per hectare which is comparable to 4.3–7.2 tons of crude palm oil (CPO) per hectare. When compared to other plants, oil palm has the ability to produce the most amount of vegetable oil per unit area than any other plant (Darmawan et al., 2021).

The growth and production of plants, such as the oil palm, are extremely reliant on elements that are not just genetic but also environmental and climatic in nature. If there is always enough groundwater available, oil palm plants have a good chance of growing to their full potential. The oil palm tree needs between 1,750 and 3,000 mm of precipitation per year and less than two dry months (Darmawan et al., 2021; Domonhédo et al., 2018; Liliane & Charles, 2020; Masani et al., 2018; Safitri, Hermantoro, et al., 2018; Yue et al., 2021). The amount of water that is readily available is one of the most significant variables that inhibit the development and production of this plant (Liliane & Charles, 2020; Safitri, Hermantoro, et al., 2018; Safitri, Kautsar, et al., 2018; Wang et al., 2020). In addition, oil palm seedlings require support from good planting media and fertilizers, including the addition of soil amendment and fertilizer (eg compost). This is especially important for soils that have marginal conditions (Abdi et al., 2018)

Anomalies in temperature and weather patterns that have become increasingly common in the past years are tangible manifestations of very serious climate change in every region of the world. It is difficult to forecast the weather in the months when there should be high-intensity rain, but instead there is a drought as a result of the influence of the climate anomaly (Bulgin et al., 2020; Johnson et al., 2022; Zhang et al., 2022). This is because of the influence of global warming. The primary contributors to this problem include illegal logging, inappropriate use of fertilizer and chemical pesticides, and use of non-environmentally friendly energy. These behaviors do contribute to an increase in the average temperature of the earth's surface. The effects of climate change are being felt in every aspect of human existence, however, the agricultural and plantation industries are bearing the brunt of the consequences. As a result of water stress, soil quality and fertility have begun to deteriorate, which in turn has a negative impact on crop yields (Dubovitski et al., 2021; Lamb et al., 2021; Liliane & Charles, 2020; Zhang et al., 2022).

The application of organic matter is one method that may be utilized to improve the capacity of the soil to retain water (Abdi et al., 2018; Minasny & McBratney, 2018). Vermicompost is one of the organic resources that can be utilized in the soil improvement process. Organic matter, in general, has the potential to enhance soil aeration, soil chemical properties, increase the capacity of soil to bind nutrients, water holding capacity, buffering capacity, and serve as a source of energy for soil microbes (Kautsar et al., 2022; Minasny & McBratney, 2018; Mishra & Dash, 2022; Olle, 2019; Singh et al., 2020). There are several techniques for making vermicompost, either using earthworms as commonly used or using a combination of black soldier fly larvae and earthworms (Sebayang et al., 2022). The addition of vermicompost showed an increase in the growth of plants such as Brassica oleracea at a dose of 250 kg/ha (Dewanti et al., 2019). Therefore, it is important to understand the application of vermicompost in main nursery to improve the growth of oil palm seedlings under water stress conditions.

MATERIALS AND METHODS

This investigation was carried out between the months of February and May 2022 using triplicate under completely randomized design that had a total of two factors. The first independent variable was the amount of vermicompost, which were 100, 200, and 300 g polybag^{-1}. The water volume was the second factor, which were 1.0, 1.5, and 2.0 L polybag^{-1} day^{-1}.

Sifted topsoil classified as Inceptisol from Sewon, Bantul, Yogyakarta, Indonesia has been combined with the amount of vermicompost and then placed in polybags at 40 x 40 cm size. Before planting, the polybags that have been loaded with media are watered until they reach the field capacity. Polybags are positioned inside of 6 x 6 m greenhouse that is enclosed with UV plastic and has a front height of 2 meters and back height of 1.5 meters. After being sown in the pre-nursery with smaller polybags, the oil palm seedlings at 5 months' age of the Simalungun variety at uniform agronomic conditions were used in this study. The seedlings of oil palm were given water twice daily, in the morning and in the afternoon. The process of weeding involves the routine removal of weeds that have grown in and around polybags. The control of pests was accomplished manually by hand picking.

Analysis

The seedling height increase, number of fronds, stem diameter, shoot fresh weight, shoot dry weight, roots fresh weight, roots dry weight, root volume, and root length were measured. After the seedlings had been growing for one week, measurements of their height and the number of leaves had been taken once per week until harvest at 13 weeks after transplanting. While observations of other parameters were made at harvest. Determining the height of the seedling by measuring from the bottom of the stem to the top. A total number of leaves be determined from the leaves that have fully opened. At harvest time, stem diameter was measured using a caliper. The fresh weight of the shoots and roots were determined by utilizing an analytical balance to weigh each component separately. After drying the plant sample in an oven at 70°C for 48 hours, the dry weight of the sample was determined.

Statistical Analysis

A one-way ANOVA was performed to determine the differences between treatments. As a post hoc test, Duncan's Multiple Range test (DMRT) was used, with the statistical difference level set at 5%. All statistical analyses were conducted using SPSS version 26 (IBM Corp., Armonk, New York, USA).

RESULTS AND DISCUSSION

Agronomic Parameters

There was no significant interaction between the dose of vermicompost and the amount of water on the growth of seedlings in the pre-nursery. Vermicompost at doses of 100 and 200 grams had the same effect as a dose of 300 g polybag^{-1} on the parameters of plant height increase, frond number, stem diameter, root volume, and root length (Table 1). Research carried out by Agung (2019) demonstrated that providing oil palm plants with vermicompost in amounts as high as 750 g polybag^{-1} was responsible for an increase of 12.5% in a height greater than without any vermicompost for a period of 5 months in the main nursery. According to the findings of Khasanah's (2018) research, administering a dose of vermicompost equal to 1000 grams in a polybag led to a stem diameter growth of 4.93% as compared to a dose of 750 g. Both the amount of vermicompost used and the lengthened amount of time that it was observed contributed to the distinctive outcomes of this study in comparison to those of earlier investigations.

Vermicompost dose had no effect on the trend of increase in plant height or the number of fronds produced by oil palm seedlings (Figures 1A and 1C). Meanwhile, different result was shown in the rise in seedling height due to the water volume treatment (Figure 1B). The treatment demonstrated that the provision of water in accordance with the recommendation (without water stress) resulted in a higher growth rate than the application of water stress. Since the fourth week of observation, the growth rate has a tendency to slow down when there is 50% water stress or 1 L polybag^{-1} day^{-1}. This

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is due to the short time research, thus the effect of organic fertilizer or the volume of watering on the main nursery could not well observed. Similar findings on main nursery were reported by Silalahi et al. (2021).

Meanwhile, the water volume demonstrated that volumes of 1.0, 1.5, and 2.0, L polybag^{-1} day^{-1} had the same effect on the growth of oil palm seedlings, with the exception of plant height (Table 2).

Table 1. Effect of vermicompost on agronomic parameters of oil palm seedling in the main nursery.

Parameters	Vermicompost (g polybag^{-1})		
	100	200	300
Plant height increase (cm)	23.23 ± 3.18	24.3 ± 3.78	24.87 ± 4.19
Frond number	13.56 ± 1.33	14.11 ± 0.60	14.56 ± 1.01
Stem diameter (cm)	35.54 ± 3.61	36.13 ± 2.38	36.91 ± 3.42
Root volume (cm^3)	38.11 ± 9.73	43.33 ± 10.9	46.11 ± 16.35
Root length (cm)	49.11 ± 9.45	50.89 ± 7.79	49.44 ± 3.68

Note: Values are given as mean ± standard deviation. The lowercase letters in the same row indicate significant differences according to DMRT (P< 0.05) test.

When compared to levels of 2 L polybag^{-1} day^{-1}, the watering volume of 1.0 and 1.5 L polybag^{-1} day^{-1} demonstrated a significant decrease in plant height by 23.3% and 19.8%, respectively. The low plant height of oil palm seedlings will have an impact on oil palm productivity at an older age. Therefore, avoiding water stress from an earlier age is one of the most important strategies that can be employed to achieve maximum productivity (Chen et al., 2022; Kaur et al., 2020; Liliane & Charles, 2020).

Table 2. Effect of water volume on agronomic parameters of oil palm seedling in the main nursery.

Parameters	Water volume (L polybag^{-1} day^{-1})		
	1.0	1.5	2.0
Plant height increase (cm)	21.62 ± 2.86 b	22.60 ± 2.20 b	28.18 ± 1.56 a
Frond number	13.78 ± 1.30	14.22 ± 0.67	14.22 ± 1.20
Stem diameter (cm)	34.58 ± 3.10	37.22 ± 3.04	36.79 ± 2.84
Root volume (cm^3)	42.56 ± 4.75	42.78 ± 8.70	42.22 ± 20.48
Root length (cm)	48.11 ± 6.90	49.00 ± 6.16	52.33 ± 8.29

Remarks: Values are given as mean ± standard deviation. The lowercase letters in the same row indicate significant differences according to DMRT (P< 0.05) test.

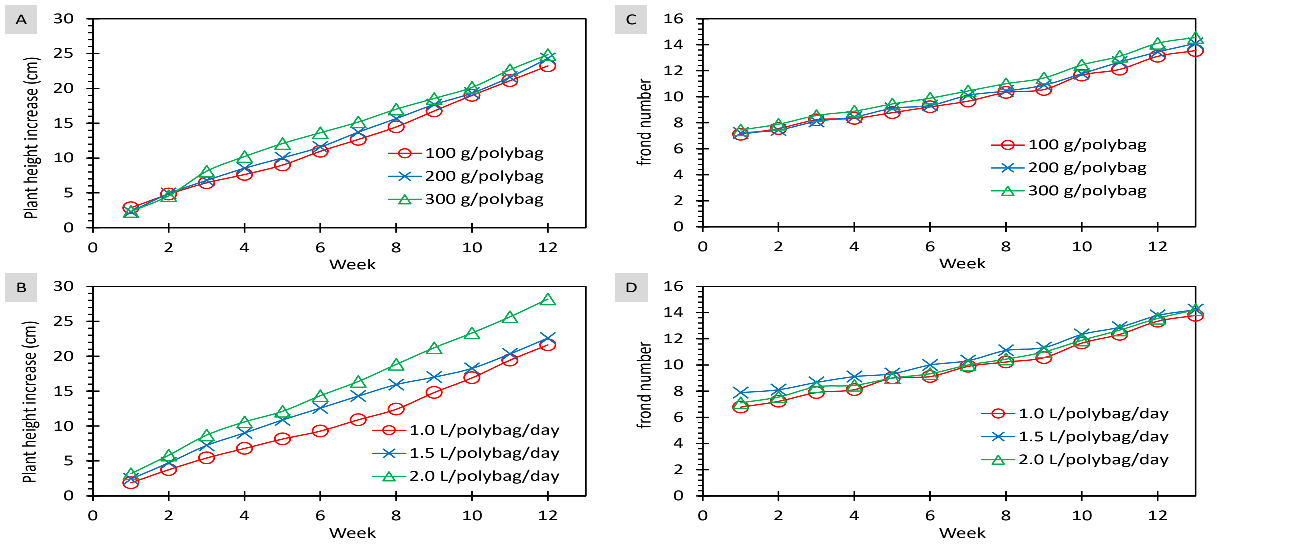

Figure 1. Effect on vermicompost (A, C) and water volume (B, D) in plant height (A, B) and frond number (C, D) of oil palm seedling in the main nursery. Bars indicate standard deviation.

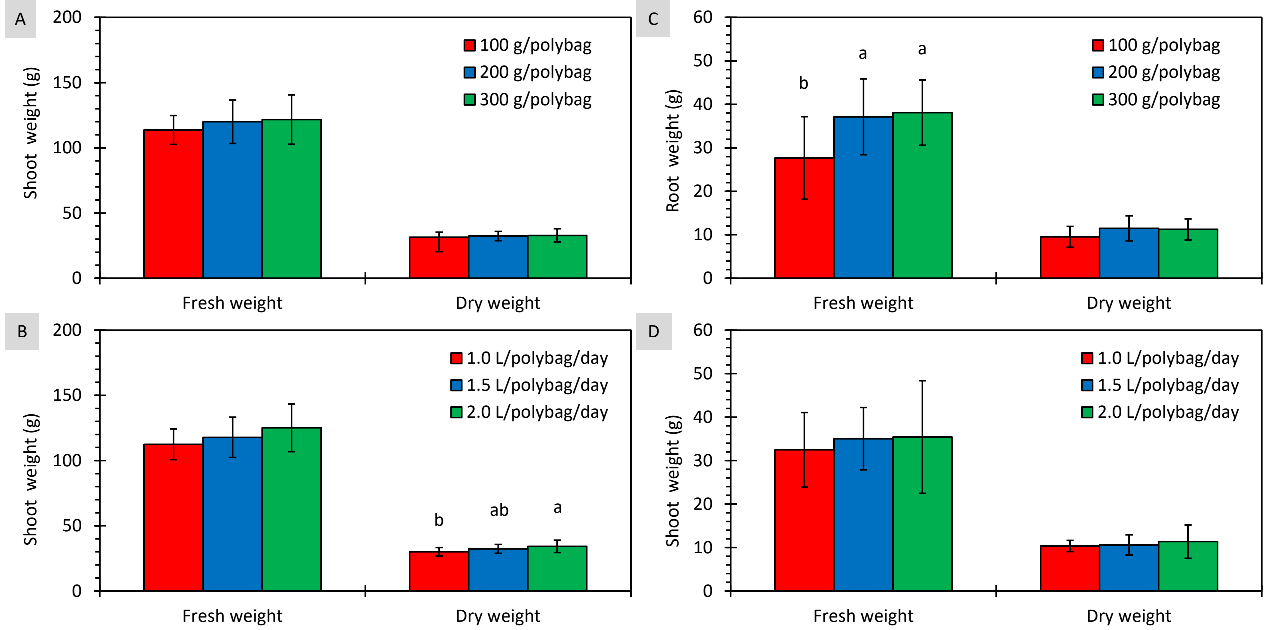

Figure 2. Effect on vermicompost (A, C) and water volume (B, D) in shoot weight (A, B) and root weight (C, D) of oil palm seedling in the main nursery. Bars indicate standard deviation. The lowercase letters indicate significant differences according to DMRT ($P< 0.05$) test.

Fresh and Dry Weight

The addition of vermicompost in several doses did not result in any differences in the fresh or dry weight of the shoots (Figure 2A), nor in the weight of the roots (Figure 2C). When compared to 100 g polybag^{-1}, the root fresh weight demonstrated that applying 200 and 300 g polybag^{-1} of vermicompost was able to produce a significant increase. However, water stress was found to have a significant impact on the dry weight of the shoots (Figure 2B).

The shoot dry weight was lowered by 12% when subjected to high water stress (1.0 L polybag^{-1} day^{-1}), in comparison to the acceptable water level of 2 L polybag^{-1} day^{-1}. The disruption of protein and chlorophyll biosynthesis was caused by water stress, which negatively impacts plant growth (Farooq et al., 2020; Naz et al., 2016; Yetik & Candoğan, 2022). As a result, there is a

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requirement for management, which consists of watering according to volume. It is also not advisable to increase the amount that is being irrigated. The addition of soil water content that is in excess of the field capacity causes plants to grow more slowly than normal. This is because the shortage of oxygen in the soil inhibits the development of the plant's roots (Chen et al., 2022; Kaur et al., 2020; Liliane & Charles, 2020).

CONCLUSION

The addition of vermicompost at 300 g polybag^{-1} significantly increased the fresh weight of roots by 37.8% compared to 100 g polybag^{-1}. Meanwhile, water stress indicates a decrease in plant height and shoot dry weight. Plant height was found to be reduced by 23.3% and 19.8%, respectively, at watering volumes of 1.0 and 1.5 L polybag^{-1} day^{-1}, compared to that at 2 L polybag^{-1} day^{-1}. In addition, high water stress (1.0 L polybag^{-1} day^{-1}) resulted in a 12% decrease in shoot dry weight compared to the optimal water level of 2 L polybag^{-1} day^{-1}.

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