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EFFECTS OF VERMICOMPOSTS PRODUCED FROM VEGETABLE WASTE ON THE GROWTH PEPPERS

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Abstract: Vermicomposts, produced commercially from vegetable wastes, were substituted at a range of different concentrations into a soil-less commercial bedding plant container medium, Petroganik, to evaluate their effects on the growth and yields of peppers in the greenhouse. Six-week-old peppers (Capsicum annum L. var. California) were transplanted into 100%, 80%, 60%, 40%, 20% or 10% Petroganik substituted with 0%, 10%, 20%, 40%, 60%, 80% and 100% vermicompost. All plants were watered three times weekly with 200 ppm Peter's Nutrient Solution from the time of transplanting up to 107 days. Peppers grown in potting mixtures containing 40% vegetable waste vermicomposts and 60% Petroganik yielded 45% more fruit weights and had 17% greater mean number of fruits than those grown in Petroganik only. The mean heights, numbers of buds and numbers of flowers of peppers grown in potting mixtures containing 10–80% vermicompost although greater did not differ significantly from those of peppers grown in Petroganik There were no positive correlations between the increases in pepper yields, and the amounts of nitrate and microbial biomass-N in the potting mixtures, or the concentrations of nitrogen in the shoot tissues of peppers. Factors such as: an improvement of the physical structure of the potting medium, increases in populations of beneficial microorganisms and the potential availability of plant growth-influencing-substances produced by microorganisms in vermicomposts, could have contributed to the increased pepper yields obtained.
Keywords: Vermicompost, peppers, petroganik.

1. Introduction

Vermitechnology is a technology that has recently been widely used to process organic waste into vermicompost with the help of earthworms. Earthworms together with microorganisms will destroy, increase surface area, reduce C/N ratio, modify the chemical, physical and biological properties of organic waste to facilitate microbial activity. to produce vermicompost. This technology is simple, efficient, and inexpensive (Kavita and Carg, 2017). Compared to compost, vermicompost is more stable, contains more nutrients with a simpler structure so that it is easily absorbed by plants, does not contain toxic compounds and is odorless (Suthar, 2009).

Converting organic waste into compost in the traditional way requires: (i) a long time, (ii) costs for probiotics, (iii) costs for aeration. In addition, compost will contain little nutrients, due to nitrogen evaporation (Ruixue et al, 2019). A simple, efficient, inexpensive and environmentally friendly technology is needed to convert organic waste into compost. Various

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organic wastes are used as raw materials for vermicompost such as cow dung, paper waste and rice straw (Kavita and Garg (2017)), blood powder and sawdust (Fereshteh and Somayeh, 2018), horse manure, lions, elephants (Edmundo et al, 2017), tea dregs and industrial solid waste (Moorthi et al, 2017).

The use of vermicompost as a plant fertilizer resulted in higher plant quality compared to plants treated with chemical fertilizers. Linee et al (2017) reported that vermicompost-treated soil was able to produce 4.51 tons/ha of cabbage while soils with NPK fertilizer produced 4.22 tons/ha of cabbage. Likewise, tomatoes that were given vermicompost reached a height of 37 cm, while those given NPK fertilizer were 48 cm high, Xiaoqiang et al (2018) reported that the growth of calendula and geranium was faster in vermicompost-treated soils compared to compost-treated soils. The results of research by Alvarez et al (2018) showed that growing media containing vermicompost and biochar in a ratio of 86:10, could increase the number of geranium flowers to 37 pieces. In the same way, Wu et al (2019) reported that fertilizers containing biochar and vermicompost at 3% each, could increase rice production by 26.5-35.3%.

In their study of the effect of fertilizer content for remediation of soil contaminated with cadmium, Ying et al (2019) reported that fertilizers containing vermicompost and biochar as much as 2.5% each can increase the pH of acid rainwater to 7, reducing the cadmium content in the soil.According to Ren et al (2018), biochar functions to improve soil physical properties, and vermicompost adds soil nutrients (Linee et al, 2017). This means that fertilizers containing biochar and vermicompost will increase crop production. In their research.Alvarez et al (2018) reported that the morphology and physiology of geraniums and petunas were better in soils treated with 12% biochar and 30% vermicompost, compared to soils treated with vermicompost only.

Capsicum annum L.), which belong to the family Solanaceae, are known for their versatility as a vegetable crop and are consumed both as fresh vegetables or dehydrated for spices. As with other vegetable crops, peppers are still usually grown using conventional applications of inorganic fertilizers and pesticides(Bosland and Vostava, 2000). However a growing awareness of some of the adverse economic and environmental impacts of agrochemicals in crop production, has stimulated greater interest in the utilization of organic amendments such as composts or vermicomposts for crop production (Linee et al (2017)). Given that it is not only plant morphology that needs to be measured, but also plant physiology needs to be analyzed to determine the mineral content of plants, so in this study the effect of vermicompost on the growth and yields of peppers.

2. Methods

The experiment was conducted in a Horticulture Department greenhouse at the Dept of Biology, Universitas Negeri Jakarta. Peppers were grown in a standard soilless commercial greenhouse container medium (Petroganik) (PT Gersik, Indonesia), with a range of concentrations of a commercially produced vegetable waste vermicompost substituted into corresponding concentrations of Petroganik The commercial vegetable waste vermicompost, from local market Rawamangun, Jakarta, consisted of supermarket vegetable wastes, processed by earthworms (Eisenia fetida), in indoor automated continuous flow vermicomposting reactors (Edwards and Burrows, 2003).

The basic chemical properties of Petroganik and the food waste vermicompost are summarized in Table 1. Six-week old pepper seedlings var. California' were germinated in Petroganik, and transplanted into 30 l polybag, containing 100%, 80%, 60%, 40%, 20%, 10%, or 0% Petroganik substituted with 0% (control/100% MM360), 20%, 40%, 60%, 80%, or 100% (by volume) of vegetable waste vermicompost, respectively. There were four replicate polybag, each containing one pepper plant, for each Petroganik/ vermicompost mixture(Fig 1).

Fig 1 seeding pepper in polybag

Polybag were moved into a greenhouse, watered regularly with tap water three times a week and plant nutrient BETA POC solution. This is a watersoluble fertilizer, recommended for continuous liquid feed programs of bedding plants, and contains 7.65% NH_4-N, 11.80% NO_3-

N, 11% P_2O_5, 22% K_2O, 0.13% Mg, 0.02% B, 0.01% Cu, 0.1% Fe, 0.064% Mn, 0.01% Mo, and 0.015% Zn.

Heights of pepper plants were measured, and the numbers of buds and flowers counted, 21, 32, and 41 days after transplanting. Pepper fruits were harvested at the green mature stage and weighed. Fresh whole plants were harvested 96 days after transplanting, all leaves were removed from the stems, oven-dried at 60^0C for 3 days; dry shoots were weighed, ground with hammer mill and analyzed for nitrate-nitrogen analysis,

Data were analyzed statistically by one-way ANOVA in a general linear model using SAS (SAS Institute, 2001). For each sampling date and for each measured parameter, the means were separated statistically using least significant difference (LSD). Statistical significance was defined as P 6 0:05.

3. Results

3.1Chemical propertis feritilizer

The basic chemical properties of Petroganik and the vegetable waste vermicompost are summarized in Table 1.

Table 1: Chemical properties of the commercial potting medium (Petroganik and the vermicompost)

Fertilizer	pH	EC	N (%)	C-oranic (%)	P (%)	K (%)
Petroganik	5,90	1.35	0.43	3,70	0.15	1,59
Vermicompost	7,4	16,90	1,30	1	2,7	9,2

3.2.Effect vermicompost on morphology pepper plants

Six-week old pepper seedlings va Heights of pepper plants did not differ significantly between treatments and sampling dates (Table 2). Pepper plants grown in Petroganik produced most buds but the numbers of buds did not differ significantly from those in pots substituted with up to 80% of vegetable waste vermicomposts, 21, 32 and 41 days after transplanting (Table 2).

Table 2: Mean heights, numbers of buds, numbers of flowers and dry shoot weights of peppers grown in (Petroganik) substituted with different concentrations food waste vermicomposts

Vermicompost (%)	Height(cm)			Number of buds			Number of flowers			Dry shoot weight		
	Days after transplanting			Days after transplanting			Days after transplanting			Days after transplanting		
	21	32	41	21	32	41	21	32	41	21	32	41
control	69	143	308	16	45	76	0.4	0.6	7	0.2	0.4	7.3

10	76	144	309	14	41	67	0.2	0.5	6	0.1	0.3	6.7
20	84	168	366	13	44	70	0.4	0.6	8	0.2	0.4	8.6
40	74	144	304	14	35	66	0.3	0.5	8	0.1	0.3	8.3
60	71	132	299	14	44	63	0.7	1.0	8	0.4	0.7	7.9
80	74	155	302	12	38	67	1.0	1.7	6	0.8	1.3	6.1
100	78	141	286	11	38	55	1.1	1.4	7	0.6	1.1	7.1

The numbers of flowers did not differ significantly between treatments, 41 days after transplanting, although the pepper plants grown in the 80% vermicompost/20% Petroganik had most flowers, 32 days after transplanting. Pepper plants in 0%, 10%, 20%, 40%, and 60% vermicomposts substituted with 100%, 90%, 80%, 60%, and 40% Petroganik mixtures had significantly larger dry shoot weights (P 6 0:05) than those grown in 80% and 100% vermicompost 20% and 0% Pettroganik mixtures. The concentrations of mineral-N increased significantly, with increasing concentrations of vermicomposts in the mixtures, but leveled out after 107 days (Table 3).

Table 3: The concentrations of N, petroganik substituted with different concentration of food waste vermicompost at transplanting and 107 days after transplanting and organic nitrogen in shoot tissues 107 days after transplanting

Vermicompost (%)	Mineral N(mg/g)		Microbial biomass N(mg/g)		Tissue N (mg/g)	
	Days after transplanting		Days after transplanting		Days after transplanting	
	0	107	0	107	0	107
control	154	216	67	83	83	54
10	389	173	85	94	94	51
20	458	149	69	168	168	51
40	706	155	116	66	66	49
60	720	216	112	62	62	48
80	930	225	121	96	96	48
100	1006	181	132	75	75	48

The concentrations of microbial biomass N did not differ significantly between treatments at transplanting, but growth media with a 20% vermicompost substitution had significantly more microbial biomass (P 6 0:05) than those from the Petroganik 0 control, 107 days after transplanting. Concentrations of total N in pepper shoot tissues were significantly greater (P 6

0:05) in pots containing Petroganik only compared to those in plants from pots substituted with more than 60% vermicomposts

Peppers grown in pots containing 40% vermicomposts/60% Petroganik had significantly larger mean marketable fruit yields (Table 4) and larger mean fruit weights (Table 4) (P > 0:05) than those grown in pots with any other Petroganik /vermicomposts mixtures.

Table 4. Effect vermicompost concentration on biomass

Vermicompost (%)	Plant(g)	Fruit (g)
10	1400	35
20	1700	37
40	1800	37
60	2400	40
80	1800	33
100	1200	33

1

The numbers of flowers did not differ significantly between treatments, 41 day

3.3. Effect of vermicompost on remove Cd on soil ollution

The effect of increasing the dose of vermicompost on the removal of heavy metal Cd (II) in polluted soil can be seen in Figure 2.

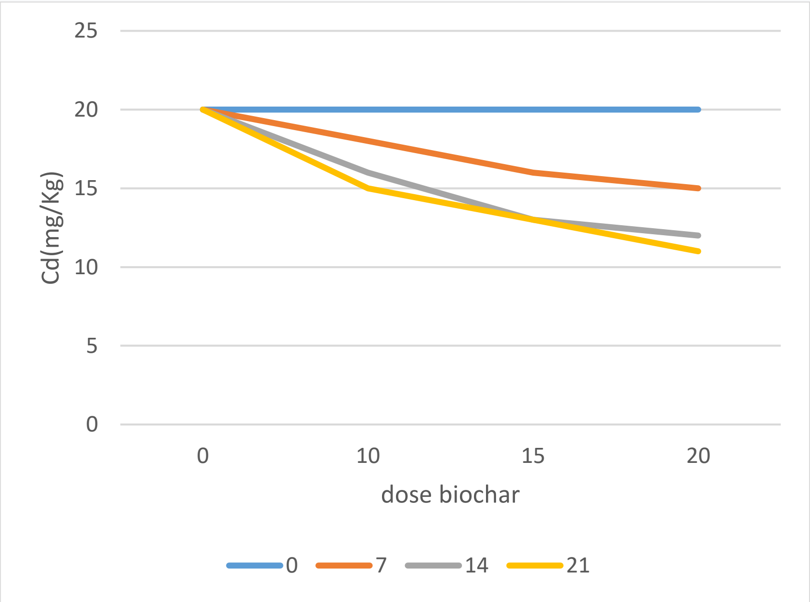

Fig 2. Effect of time and dose of vermicompost on. Removal ion Cd^{+2}

From Figure 2, it can be seen that the higher the dose of addition of vermicompost and the longer the incubation time, the more efficient the removal of heavy metals from Cd will be. The highest removal of heavy metal Cd occurred with the addition of vermicompost vermicompost as much as 20% with a Cd concentration of 10.85 mg/kg and removal efficiency of 45.45%. This result is in accordance with the research of Alaboudi et al. (2019) that the more doses of biochar added to the soil, the efficiency of heavy metal removal will increase. The most possible removal mechanism for heavy metal Cd is through complexation, ion exchange, and if possible precipitation reactions will occur at soil pH > 7 (Alloway et al, 2012). According to He et al (2019) stated that the FTIR spectrum shows a shift in the intensity of the absorption band when biochar is added to soil contaminated with heavy metals, this indicates the occurrence of complexation between heavy metals and vermicompost According to Li et al (2010) hydrogen atoms in –COOH (hydroxyl group) can be released as H+ ions or undergo deprotonation, so it has the opportunity to form complexes with metal ions.

4. Discussion

A number of workers have shown that substitutions of vermicomposts into commercial growth media for bedding plants, increased plant growth and yields.. Atiyeh et al. (2000a) reported that the substitution of Petroganik with 10% or 50% pig manure vermicompost increased the dry weights of tomato seedlings significantly, compared to those grown in the 100% Petroganik alone. However, in our current experiments the dry shoot weights of peppers grown in potting mixtures that had been substituted with 10%, 20%, 40% or 60% food waste vermicompost did not differ significantly from those of plants grown in Petroganik only. Such non-significant effects of vermicompost on heights, numbers of buds, and numbers of flowers of peppers might have been because the pepper seedlings used in this experiment were germinated and grown in Petroganik, during their first six weeks of seedling growth, before transplanting them into the vermicompost Petroganik mixtures.

The largest increase of 45% in fruit yield was from peppers grown pots with 40% vermicomposts/60% Petroganik with 17% greater mean number of fruits. These results are similar to those obtained by Atiyeh et al. (2000a) who reported that lower concentrations of Table 2 Mean heights, numbers of buds, numbers of flowers and dry shoot weights of peppers grown in (Petroganik) substituted with different concentrations o vermicomposts (produced greater tomato plant growth and yield effects than the higher concentrations. They reported that the largest marketable tomato fruit yields resulted from the substitution of 20% vermicompost into 80% Petroganik. Atiyeh et al. (2000) also reported that tomatoes grown in vermicompost with concentrations below 50% usually produced more fruits which were classified large' in size. Wilson and Carlile (1989) reported increases in the growth rates, of tomatoes, lettuces, and peppers, in response to much lower substitutions of 8-10%, 8%, and 6%, respectively, of a duck waste vermicompost into 90-92%, 92%, and 94% peat mixtures. Increases in yields of plants grown in vermicompostsubstituted media, has consistently been correlated positively with increases in proportions of marketable fruits and decreased proportion of non-marketable fruits (Atiyeh et al., 2000a). In our experiment, yields of peppers were also greater due mainly to the larger fruit sizes. The proportions of marketable fruits also tended to be larger on peppers grown in potting mixtures with 40% food waste vermicomposts and 60% Petroganik Table 4 compared to those of peppers grown Petroganik only. However, although there was an obvious trend, the proportions of marketable and non-marketable fruits (data not shown) did not differ significantly in response to vermicompost substituted, as did the data on tomato yields reported by Atiyeh et al. (2000a).

The increased yields of peppers that we observed could be influenced by the greater availability of plant nutrients in the growth media. However, this is unlikely because in our experiment all treatments were watered regularly with complete nutrient solutions regularly, which virtually eliminated nutrients as major contributing factor in increasing yields of tomatoes or peppers. The total amounts of mineral-N and microbial biomassN, in the growth mixtures increased significantly ($P < 0:05$) in response to increasing substitution rates of food waste vermicompost into the potting mixtures on all sampling dates (Table 3). However, increases in mineral-N, in the mixtures, were not correlated with increases in pepper yields. The concentrations of microbial biomass-N did not differ significantly between any treatment, either at transplanting or after transplanting. However, there was a significant increase in microbial biomass-N in the potting mixture substituted with 20% vermicomposts, 107 days after transplanting, but this increase was not correlated with any increase in pepper yields. Similarly, the assimilation of nitrogen into the shoot tissues of peppers was not correlated with increases in yields of peppers. High rates of vermicompost substitution may cause adverse effects on plant growth and yield. This was obvious in Atiyeh et al. (2000a) experiments showing tomato plants with decreased growth and yields at substitution rates of pig manure vermicomposts greater than 60% into Petroganik 60. In our current experiment, yields from plants grown in pots with 60% and 80% vermicomposts decreased significantly (P 6 0:05) which could have been due to either high soluble salt concentrations, poor aeration, heavy metal toxicity, and/or plant phytotoxicity in the undiluted vermicompost.

It is possible that other growth-enhancing factors, resulting from mixing smaller concentrations of food waste vermicompost into Petroganik may have been responsible for the growth changes of peppers and other crops. Such factors could include improvements of the physical structure of the container medium, increases in enzymatic activities, increased numbers of beneficial microorganisms or biologically active plant growth influencing substances, (Christina et al, 2020) such as plant growth regulators and humic acids. For instance, applications of humic acids that had been extracted from vermicomposts increased the overall growth of tomatoes and cucumbers significantly (Atiyeh et al., 2002). It has been reported that humic fractions obtained from earthworm casts can mimic the modes of action of plant growth regulators or hormones. Applications of humic acids to soils increased the dry matter yields of corn and oat seedlings (Albuzio et al., 1994), numbers and lengths of pepper roots (Samia and Heba, 2018), vegetative growth of *Pisum sativum*(Deepamala et al., 2017)and induced shoot and root formation in tropical plants. The stimulatory effects of humic acids that have been hypothesized as ‘‘direct’’ action, are probably more hormonal in nature, together with an ‘‘indirect action’’ on increased activity and metabolism of soil microorganisms, the dynamics of the uptake of soil nutrients, and soil physical conditions (Muscolo et al1999). Atiyeh et al. (2002) postulated, that although plant hormones are quite transient in soil, they may become adsorbed onto the complex structure of humic acids and have acted in conjunction with them to influence plant growth. In support of this hypothesis Canellas et al. (2000) identified exchangeable auxin groups from humic acids extracted from cattle manure, following a structural analysis, which enhanced root elongation, lateral root emergence and plasma membrane Hþ-ATPase activity of maize roots.

The overall effects of the applications of food waste vermicompost in this experiment, in terms of vegetative growth was not very pronounced but were significant in terms of yield increases of peppers, particularly in potting mixtures substituted with 40% food waste vermicompost. Since the contributions of nutrients from the mixtures on the growth and yield of peppers could be eliminated as a possibility, it seems likely that other plant growth-influencing materials such as humic acids and/or plant growth regulators, improvement of physical structure of potting medium and the presence of beneficial microorganisms increase the yields of peppers as recorded.

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