Effects of *Chromolaena odorata* Compost on Soil and Nutrient Uptake of Lettuce (*Lactuca sativa*)

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ABSTRACT

The use of synthetic inorganic fertilizers containing chemical compounds cause soil quality to decrease. Chromolaena odorata are potential weeds used as a source of organic matter, which can be used as compost. This research aimed to determine the effect of Chromolaena odorata compost on the soil and nutrient uptake of lettuce. The research was conducted using a single factor experimental method arranged in a Randomized Complete Block Design. The treatments tested were the applications of C. odorata weed compost at various doses (222 grams/pot, 444 grams/pot, and 666 grams/pot) with control treatments of 200 ml/pot NPK Phonska (15:15:15), 320 grams/pot cow manure, and without fertilization. The experiment consisted of three blocks with three samples and three units of sample plants within each treatment. The results showed that the application of C. odorata weed compost significantly improved nutrition and nutrient uptake of lettuce. The dose of 444 grams/pot C. odorata weed compost was the best dose to increase soil quality and nutrient uptake of lettuce.

Keywords: C. odorata, Inorganic fertilizer, Lettuce

ABSTRAK

Penggunaan pupuk anorganik mengandung senyawa kimia menyebabkan kesuburan tanah menjadi berkurang. Gulma kirinyu merupakan gulma yang cukup potensial untuk dimanfaatkan sebagai sumber bahan organik, salah satunya dapat dijadikan sebagai kompos. Penelitian ini bertujuan untuk mengetahui pengaruh dan mendapatkan takaran kompos gulma kirinyu yang terbaik dalam meningkatkan kualitas tanah dan serapan hara tanaman selada. Penelitian dilakukan menggunakan metode percobaan faktor tunggal disusun dalam Rancangan Acak Kelompok Lengkap dengan perlakuan yang diujikan adalah kompos gulma kirinyu dengan takaran 222 gram/pot, 444 gram/pot dan 666 gram/pot, serta perlakuan pembanding yaitu perlakuan takaran NPK Phonska (15:15:15) 200 ml/pot, takaran pupuk kandang sapi 320 gram/pot dan tanpa pemupukan. Setiap perlakuan terdapat tiga blok sebagai ulangan dengan masing – masing perlakuan terdiri dari tiga sampel dan setiap perlakuan terdiri atas tiga unit tanaman korban. Hasil penelitian menunjukkan bahwa kompos gulma kirinyu meningkatkan nutrisi dan serapan hara pada tanaman selada. Takaran kompos gulma kirinyu 444 gram/pot merupakan takaran terbaik dalam meningkatkan kualitas tanah dan serapan hara pada tanaman selada.

Kata Kunci: Gulma kirinyu; Pupuk anorganik; Selada

INTRODUCTION

Lettuce is one of the popular vegetables due to its color, texture, and taste liked by most people (Lutfi, 2017). Besides, lettuce contains nutrients that are beneficial to human body, including vitamins, protein, carbohydrates, calcium, phosphorus, and iron. Lettuce also provides a high economic value as the number of international hotels and restaurants serving dishes such as salads and hamburgers. This is indicated by the increase in demand for lettuce in the world market, amounting to 2,792 tons in 2012 and the large quantity of imported lettuce in 2012, which was 145 tons (Akhlaq, 2018). Therefore, lettuce production needs to be improved. BPS-Statistics Indonesia (2014) showed that the production of lettuce in Indonesia from 2010 to 2013 was 283,770 tons, 280,969 tons, 294,934 tons, and 300,961 tons.

The continuous use of inorganic fertilizers leads to soil degradation, in which the soil becomes rapidly hardened and less able to store water, thereby reducing crop productivity. Besides, the excessive use of inorganic fertilizers will have an impact on the environment, causing N_2 emissions and water pollution (eutrophication), damaging biota and organisms in soil, and decreasing soil biology.

Soil fertility in modern agriculture can change, which can be caused naturally or as a result of human activity (Price, 2006). Decrease in soil fertility can occur chemically due to nutrient impoverishment such as high transported nutrients that are

not accompanied by nutrient addition to the soil, soil acidification (the decrease in soil pH), loss of organic matter, and increase levels of toxic elements such as Aluminum (Al) and Manganese (Mn) (Hartermink, 2003).

The natural decline in soil fertility is caused by water erosion due to rain, which results in the loss of fertile topsoil and leaves a new or less fertile surface layer. In addition, a decrease in soil fertility can be caused by human actions such as the exploitation of soil nutrients through harvesting all parts of the plant without adequate nutrient supply. Unused crop yields that are not returned to the soil and excessive tillage will also cause accelerated loss of soil organic matter so that the soil is unable to bind nutrients (Hartermink, 2003). Therefore, to increase soil fertility and reduce the use of inorganic fertilizers, an alternative is needed by using organic fertilizers.

Organic fertilizers are fertilizers derived from living things such as plants, animals, or plant residues obtained through decomposition or weathering. Organic fertilizer can be in the form of solid or liquid, which functions as a supply of organic matter to improve soil physical properties including soil structure, soil aggregate, water absorption, soil chemical properties (adding and activating nutrients), and soil biology. The source of organic matter can be compost, green manure, manure, crop residues, and municipal waste (Simanungkalit et al., 2006). One of the organic fertilizers is *C. odorata* compost.

C. odorata is originally from Caribia and America, which is potential enough to be used as a source of organic matter due to its high biomass production. Wardhani (2006) showed that *C. odorata* produced 18.7 tons/ha in fresh form and produced 3.7 kg/ha in dry form. *C. odorata* biomass has so high nutrient content of 2.65% Nitrogen, 0.53% Phosphate, and 1.9% Potassium that it can be used as alternative organic fertilizer (Suntoro et al, 2001). *C. odorata* is an perennial weed that can grow in area of various perennial crops such as cashews, oranges and oil palm. *C. odorata* can grow on infertile areas and have very light seeds enabling it to grow and spread widely.

The success factor in increasing nutrition and nutrient uptake is the provision of *C. odorata* compost. These factors will affect cultivated crops, one of which is lettuce. Compost, in its application, is required in relatively large amounts. However, a high dose of compost will affect the provision of nutrients and nutrient uptake of plants, while the low dose causes the provision of nutrients and nutrient uptake to be meaningless. Therefore, it is necessary to know the right dose of *C. odorata* weed compost. Based on these problems, it is necessary to do research to get the right dose of *C. odorata* weed organic fertilizer to improve nutrition and nutrient uptake in lettuce plants. This research aimed to determine the effect of *C. odorata* weed compost doses on soil and nutrient uptake of lettuce as well as to obtain the best dose of *C. odorata* compost in improving nutrient and their uptake of lettuce plants.

MATERIALS AND METHOD

This research was conducted at the Sustainable Prosperous Rural Farming (P4S) Training Center, Kepuhan, Argorejo, Sedayu, Bantul and Production Management Laboratory, Plant Science Laboratory, Horticulture Laboratory, Ecology Laboratory, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, which was held for three months. The materials used in the study were *C. odorata* leaves, EM-4, rice bran, rice husk, water, sugar cane drops and NPK Phonska (15:15:15).

The research was conducted using a single factor experimental method arranged in a Randomized Complete Block Design (RCBD). The treatments tested were the doses of *C. odorata* weed compost, consisting of 222 grams/pot, 444 grams/pot, and

666 grams/pot, with comparative treatments of 200 ml/pot NPK Phonska (15:15:15), 320 grams cow manure, and without fertilization. The experiment consisted of three blocks with three samples and three units of sample plants within each treatment.

The stages of this research included the making of C. *odorata* weed compost, preparation of planting media, seed preparation and seeding, planting, maintaining, observing, and analyzing data.

Making *Chromolaena odorata* Compost

C. odorata compost was made two weeks before planting with the required material of 85 kg of C. odorata leaves. The making of C. *odorata* compost was done by enumeration so that it is easier to compost, faster to decompose, and easy to flip and breed the bacteria so that the bacteria are active during composting. The bacterial starter was soaked into the media, and the bran was administered and accumulated so that the bacteria were active and hot, accelerating the decay. Next, the reversing aeration was made so that the maturity of the compost was evenly distributed, and the processed air was circulated so that it was not hot and dry. Mature compost was characterized by a decrease in temperature (<40°C), crumb texture, black color resembling soil, and odorless.

Medium Preparation and Planting

Planting media used was silty-clay soil (dominant in Sedayu area) combined with the treatments as previously described as much as 8 kg/pot. The lettuce used was cultivar Green rapids. Planting was done after the seeds were sown for two weeks with two plants per planting hole. Maintenance consisted of watering, subsequent fertilization for NPK Phonska, and weed control. Watering was done intensively every two days unless the soil was in humid conditions. Follow-up fertilization of 200 ml NPK per/pot was done twice, namely in the first week and the second week after planting. The weed control was done manually.

Observations were made in the fourth week after planting. The data were analyzed by using Analysis of Variance at $\alpha = 5\%$ and further tested using Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$.

RESULTS AND DISCUSSION

Soils are mixture of mineral materials, organic matter, liquids, and gases. Based on the relative proportion of mineral material, organic matter, and pore space, the soil has texture, structure, and chemical properties affecting its potential. Besides, the relatively low investment cost and simple technology in composting also allow the better soil potential (Lim et al., 2019). The results of the soil analysis are presented in Table 1.

The results of soil analysis indicated that the soil used as planting media in this study was silty-clay textured soil with a fraction of clay and silt dominating the soil (Table 1). Soil pH value indicates that the soil was alkaline soil with a pH H2O value that was higher than 6 so that it contained high alkaline saturation, resulting in high available P.

Table 1. Results of analysis of the soil used as planting media

Variables	Value
Clay Texture (%)	40.21
Silt Texsture (%)	31.92
Sand Texture (%)	27.87
Rate of soil (%)	10.81
Permeability (cm/hour)	1.16
pH H_2O	8.10
Organic C (%)	0.80
Cation Exchange Capacity (%)	30.56
Bases saturation (%)	60.21
Volume (gram/cm3)	1.34
Porosity (%)	33.62
Total N (%)	0.18
Available P (ppm)	6.00
Available K (me/100 g)	0.20

Remarks: Data of soil analysis carried out in soil laboratory of Agricultural Technology Assessment Center Yogyakarta

Soil texture is the smoothness or roughness of the soil determined by the type and amount of soil particles (sand, silt, and clay). The results showed that the doses of *C. odorata* compost had a significant effect on the soil texture (Table 2). The application of *C. odorata* compost at a dose of 666 grams/pot resulted in significantly lower clay texture compared to other treatments. The application of *C. odorata* compost at doses of 666 grams/pot and 444 grams/pot produced significantly higher silt fraction compared to the treatment of NPK Phonska, cow manure, *C. odorata* compost at 222 grams/pot, and without fertilization. The application of *C. odorata* compost at a dose of 666 grams/pot and cow manure produced significantly higher sand fraction compared to the treatment of NPK Phonska, *C. odorata* compost at 222 grams/pot and 444 grams/pot, and without fertilization. The application of *C. odorata* at 222 grams/pot and 444 grams/pot showed the same effect on the sand fraction. The NPK treatment resulted in snad fraction that was not significantly different from that of without fertilization.

Table 2. Percentage of soil fractions after treatment

Treatments	Clay (%)	Silt (%)	Sand (%)
C. odorata 222 grams/pot	38.18 b	33.69 b	28.14 bc
C. odorata 444 grams/pot	36.61 c	35.03 a	28.36 b
C. odorata 666 grams/pot	35.69 d	34.92 a	29.39 a
NPK Phonska (15:15:15) 200 ml/pot	39.83 a	32.36 c	27.82 cd
Cow manure 320 grams/pot	38.15 b	32.37 c	29.48 a
Without fertilization	40.00 a	32.43 c	27.70 d
CV (%)	0.86		

Remarks: Means followed by the same letters in the same column are not significantly different based on DMRT at α 5%

Soil permeability is the ability of the soil to pass through the water flow through the pore space. The results indicated that the doses of *C. odorata* compost had a noticeable effect on soil permeability (Table 3.). The application of *C. odorata* compost at a dose of 666 grams/pot and 444 gram/pot produced higher permeability compared to the treatment of NPK Phonska, *C. odorata* compost at 222 grams/pot, and without fertilization.

H_2O is degree of soil acidity related with the sum of weak acid within liquid. The results showed that the weed had a significant effect on the pH of H_2O (Table 3). *C. odorata* compost resulted significantly lower pH H_2O compared to the treatment of NPK Phonska, cow manure, and without fertilization (Table 3). The application of *C. odorata* compost at a dose of 666 grams/pot resulted a lower H_2O pH compared to *C. odorata* compost at a dose of 222 grams/pot and 444 grams/pot because organic matter can decrease pH by 0.21 – 4.57% (Gusain et al, 2018).

Table 3. Permeability, pH H_2O, and organic C after treatment

Treatments	Permeability (cm / hour)	pH H_2O	C-Organic (%)
C. odorata 222 grams/pot	38.18 b	33.69 b	28.14 bc
C. odorata 444 grams/pot	36.61 c	35.03 a	28.36 b
C. odorata 666 grams/pot	35.69 d	34.92 a	29.39 a
NPK Phonska (15:15:15) 200 ml/pot	39.83 a	32.36 c	27.82 cd
Cow manure 320 grams/pot	38.15 b	32.37 c	29.48 a
Without fertilization	40.00 a	32.43 c	27.70 d
CV (%)	0.86		

Remarks: Means followed by the same letters in the same column are not significantly different based on DMRT at α 5%

Organic C content in the soil describes the state of organic matter in the soil. The results indicated that the doses of *C. odorata* compost had a signofocant effect on the organic C in the soils (Table 3.). The application of C. odorata compost at a dose of 666 grams/pot produced significantly higher organic C compared to other treatments (Table 3) because compost can recycle carbon, nitrogen, phosphate, and potassium (Oldfield et al., 2018).

The compost of *C. odorata* can improve soil permeability. The application of *C. odorata* compost at 666 grams/pot and 444 grams/pot produced significantly higher permeability compared to the treatment of NPK Phonska, *C. odorata* compost at a dose of 222 grams/pot and without fertilization. This result is due to the high dose of organic mat-

ter that has the ability to save larger water, thereby moisturizing the soil.

C. odorata compost produced significantly lower pH of H_2O compared to the treatment of NPK Phonska, cow manure, and without fertilization. This result is because organic matters can decrease the pH of soil that is originally alkaline to neutral pH.

C. odorata compost can increase the organic C in the soil. The application of *C. odorata* compost at 666 grams/pot produced significantly higher organic C compared to other treatments. It is because the higher the dose given will result in the higher organic C.

C. odorata compost weed can decrease the texture of the soil clay. Sufficient content of organic matter in the soil can improve soil condition so as not to be too heavy and not too light in soil processing. In wet condition, clay-textured soil becomes sticky, making it difficult to process. The addition of organic matter can simplify the preparation of the soil. The clay-textured soil often experiences crack that is harmful to the development of roots. Thus, the addition of organic matter will reduce cracking.

C. odorata weeds have high nutrient elements content, such as nitrogen, phosphate, and potassium. These elements are essential nutrients for growth that can improve quality of soil chemical properties. The results showed that the dose of *C. odorata* weed compost had a significant effect on soil total nitrogen and nitrogen nutrient uptake of the plants (Table 4).

The application of weed compost can increase the nitrogen content in the soil and nitrogen uptake because composting of garden waste with livestock manure can reduce nitrogen loss and facilitate organic matter humification (Chen et al., 2019). Besides, Wong et al. (2017) added that composting could control the nitrogen loss. *C. odorata* weed compost at a dose of 666 grams/pot produced the highest nutrien content and nutrient uptake. This result is due to the higher doses given that leads to the greater results. Nitrogen uptake in plants was positively correlated with total nitrogen in soil (0.95 **) that supports plant growth. Organic matter increases total nitrogen by 15.61–22.14% (Gusain et al, 2018). The use of compost in agriculture is constrained because of its long-time action and reduced supply of nutrients to the crops. To enhance the content of nutrients available for the plants in the compost, its supplementation with nutrients and inoculation with microorganisms have been proposed (Sanchez et al, 2018).

Table 4. Total N in the soil and nitrogen uptake of lettuce plants

Treatments	Total N in the soil (%)	Nitrogen uptake (%)
C. odorata 222 grams/pot	2.29 d	2.55 e
C. odorata 444 grams/pot	2.83 b	3.04 b
C. odorata 666 grams/pot	3.05 a	3.42 a
NPK Phonska (15:15:15) 200 ml/pot	2.44 c	2.85 c
Cow manure 320 grams/pot	2.32 cd	2.71 d
Without fertilization	0.11 e	2.14 f
CV (%)	3.61	2.63

Remarks: Means followed by the same letters in the same column are not significantly different based on DMRT at α 5%

Table 5. Available P in the soil and P uptake of lettuce plants

Treatments	Available P in the soil (ppm)	P uptake (%)
C. odorata 222 grams/pot	11.67 e	0.18 d
C. odorata 444 grams/pot	20.33 b	0.32 b
C. odorata 666 grams/pot	23.00 a	0.36 a
NPK Phonska (15:15:15) 200 ml/pot	16.33 c	0.26 c
Cow manure 320 grams/pot	14.33 d	0.23 c
Without fertilization	5.33 f	0.16 d
CV (%)	5.52	7.98

Remarks: Means followed by the same letters in the same column are not significantly different based on DMRT at α 5%

The results showed that *C. odorata* weed compost doses gave significant effect on available P in the soil and phosphate uptake of the plant (Table 5). Phosphate uptake in plants was positively correlated with available phosphate in the soil (0.95 **), which supported leaf growth and increased

root growth. Organic matter increases total P by 29.75–50.67% (Gusain et al, 2018).

The results showed that doses of C. *odorata* weed compost significantly affected available soil potassium and potassium uptake of the plant (Table 6). Potassium uptake in plants were positively correlated with the available potassium in the soil (0.95 **), which supported plant growth characterized by plant height, number of leaves, leaf area, shoot fresh weight, shoot dry weight, net assimilation rate, and relative growth rate. Therefore, the absence of potassium affects the assimilate transport (Wijaya, 2008). Organic matter increases total K by 30.3–81.59% (Gusain et al, 2018).

Table 6. Available K in the soil and K nutrient uptake of lettuce plants

Treatments	Available K (me/100 gram)	K uptake (%)
C. odorata 222 grams/pot	0.23 c	1.42 d
C. odorata 444 grams/pot	0.34 a	1.70 b
C. odorata 666 grams/pot	0.36 a	1.93 a
NPK Phonska (15:15:15) 200 ml/pot	0.30 b	1.59 c
Cow manure 320 grams/pot	0.24 c	1.52 c
Without fertilization	0.16 d	1.21 e
CV (%)	4.09	2.43

Remarks: Means followed by the same letters in the same column are not significantly different based on DMRT at α 5%

The application of C. *odorata* weed compost at various deses resulted in higher total nitrogen available P, and available K when compared to NPK Phonska treatment and without fertilization. In addition, C. *odorata* weed compost at a dose of 666 grams/pot produced higher nitrogen uptake, phosphate leaf, and leaf potassium compared to other treatments.

CONCLUSION

The application of C. *odorata* compost significantly increased soil quality and uptake of nitrogen, phosphate, and potassium. C. *odorata* at a dose of 444 grams/pot gave the highest content of nitrogen, phosphate, and potassium in lettuce plants compared to inorganic fertilizer, cow manure, and without fertilizer treatments.

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