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The effect of cow manure application and watering interval on patchouli growth in regosol soil

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Abstract. Soil has an important role for plants, aside for a growing medium and rooting, it also provides water, air, and nutrients. The types of soil affect plant growth and development. Regosol is one type of soil, which has a coarse grain texture and low capacity of water and mineral holding, and widely used for plants with relatively low water requirement. The purpose of the study was to examine the effect of cow manure and watering on patchouli (*Pogostemon cablin* Benth) growth on regosol soil. This study used factorial Complete Randomized Block Design (CRBD), with cow manure fertilizer dose as first factor (0, 500, and 1000 g/plant) and watering interval (every day, 2, 4, 6, and 8 days) as second factor; each treatment combination have three replications. The results showed that the application of cow manure combined watering intervals did not affect patchouli growth, but each manure treatment or watering interval independently affected plant height, number of branches, number of leaves, fresh weight of roots, fresh weight of leaves and branches, total fresh weight, root dry weight, leaf and branch dry weight, and patchouli total dry weight within 22 weeks after planting.

1. Introduction

Patchouli plant (*Pogostemon cablin* Benth) is one of the plants which derived from *Labiata* family, known to produce some essential oils, and at least 90% of the world's patchouli essential oils come from Indonesia. Indonesian patchouli oil is famous for its best quality in the world market [1]. Patchouli oil is considered as the key ingredient for aromatic products, antiseptics, aromatherapy, cosmetics, pesticides and fixatives to bind other essential oils. In traditional Asian and Arabic medicine, patchouli oil is used as a stimulant. The world patchouli oil production is dominated by Indonesia and China, with a total production of 563 tons/year or worth of 6.8 million US dollars with a price of US \$ 12,100/ton [2]. The Indonesian Ministry of Trade states that Indonesia is able to dominate the market share of world patchouli oil up to 90% competing with Malaysia, the Philippines, India and China.

Patchouli plants can be developed in the yard, fields, gardens, and moor. But to get high productivity, a deep, fertile, humus-rich, loose structure, and well drained soil is needed. Some suitable soil types for this reasons is regosol, latosol, and alluvial. The texture of the soil is sandy clay or dusty clay, has good absorption, and not vulnerable to flood in rainy season. Regosol soil has rough texture or high sand content and has good porosity because it is dominated by macro pores, but has a low fertility rate where essential nutrients are easily washed away [3].

Patchouli cultivation in regosol soil can be done, but poor water holding capability of regosol soil become the main issue. Giving organic matter to the soil will affect the physical, chemical and biological



properties of the soil simultaneously, as it is improve soil aerase, increase the ability of soil to retain nutrients, increase the capacity to hold water, increase soil holding capacity, provide nutrients and energy sources for soil microorganisms [4].

Manure is an organic fertilizer derived from animals [5]. Some of the beneficial effects of manure are: a source of plant-available NH_4^+ , increases mobility and availability of P and micronutrients due to organic matter (OM) complexation, increases soil OM, increases soil moisture retention, improved soil structure, decreased soil bulk density, and increased infiltration rate, increased buffer capacity, reduce Al^{+3} toxicity in acid soil by complexation with OM and increased CO_2 in the plant canopy, particularly plant stands with restricted air circulation. Continuous use over a long term will improve soil fertility [6]. In other words, manure has the ability to change soil capability, which becomes the factor that determine soil fertility [7]. In contrast to the use of inorganic fertilizers, continuous practice has an impact on damage to soil fertility. Research on organic fertilizer has been carried out, including research on the effects of organic fertilization on soil properties [8–10] and the effect of waste compost on land [11]. In addition to fertilizing factors, other factors that can affect plant productivity are the availability of water. The purpose of this study was to examine the effect of cow manure and watering interval on patchouli on regosol soil.

2. Methods

The study was conducted in Sardonoharjo Village, Ngaglik Subdistrict, Sleman Regency, Yogyakarta from January to June 2018. The materials used were patchouli cuttings of Patchoulina 2 variety, cow manure, and regosol soil. This study used factorial Complete Randomized Block Design (CRBD), which consist of 2 factors, namely cow manure dose (S) and watering interval (P) with 3 replications each. The first factor was cow manure dosage consisted of 3 levels: 0 (S0), 500 (S1), and 1000 g/plant (S2). The second factor was watering interval, consisted of 4 levels: every day (P0), every 2 days (P1), every 4 days (P2), every 6 days (P3), and every 8 days (P4).

The watering interval treatment was carried out after 1-month plant age. Watering was carried out in the morning before 08.00h until it reaches the condition of field capacity. The variables observed in this experiment included: plant height, number of branches, canopy dry weight, and root dry weight.

Observation data were analyzed using variance analysis with a 5% significance parameter and followed by Duncan's Multiple Distance Test (DMRT) at the level of 5% upon significant result.

3. Results and discussions

The observation of patchouli growth parameters on regosol soil by the treatment of cow manure and watering intervals is presented in Table 1.

Table 1. Summary of variance analysis with 95% confidence in all observational parameters.

Parameters	Treatments		
	Cow Manure Fertilizer Dose (S)	Watering Interval (P)	Interaction (S×P)
Plant height	**	**	ns
Number of branches	**	**	ns
Number of leaves	**	**	ns
Root fresh weight	**	**	ns
Canopy fresh weight	**	**	ns
Total fresh weight	**	**	ns
Root dry weight	**	**	ns
Canopy dry weight	**	**	ns
Total dry weight	**	**	ns

ns = non significant, ** = significant

Table 1 shows that there was no interaction between the treatment of cow manure and watering intervals on all parameters of observation but each treatment independently had a significant effect on plant height, branch number, leaf number, root fresh weight, canopy fresh weight, total fresh weight, root dry weight, canopy dry weight, and patchouli total dry weight at the age of 22 weeks after planting.

Table 2. Effect of cow manure and watering interval on plant height, number of branches, number of leaves, total fresh weight and total dry weight at 22 weeks after planting

Treatment	Parameter				
	Plant Height (cm)	Number of Branch (pieces)	Number of Leaves (strands)	Total Fresh Weight (gram)	Total Dry Weight (gram)
Cow Manure					
0 g/plant	52.00 ^a	21 ^a	573 ^a	607.21 ^a	120.01 ^a
500 g/plant	60.58 ^b	26 ^b	697 ^b	659.10 ^{ab}	141.23 ^b
1000 g/plant	63.33 ^c	27 ^b	712 ^b	700.84 ^b	142.60 ^b
Watering Interval					
Daily	64.38 ^c	29 ^c	794 ^d	708.09 ^a	155.99 ^c
Every 2 days	61.73 ^c	27 ^c	702 ^c	649.12 ^a	140.43 ^{bc}
Every 4 days	57.92 ^b	24 ^b	640 ^{bc}	649.64 ^a	132.44 ^{ab}
Every 6 days	55.82 ^{ab}	22 ^{ab}	606 ^{ab}	640.33 ^a	126.39 ^{ab}
Every 8 days	52.00 ^a	21 ^a	573 ^a	631.40 ^a	117.83 ^a

The numbers followed by different letters in a column shows significant results in the DMRT test with a level of 5%

Environmental factors that affect plant growth are sunlight, temperature, water and soil. Water is one of the vital components needed in relatively large quantities for plant growth and development. The important role of water in plants are the main substance for forming protoplasm, as a nutrient solvent, as a medium for metabolic reactions, as a hydrogen source in photosynthesis, maintaining cell turgidity, regulating plant movement mechanisms, cell extension, as metabolic and respiratory material. Reducing the amount of water affects the metabolic process, which triggers a decrease in plant quality. Reduction of the watering interval means reduced water availability which results in a decrease in plant height, number of branches, number of leaves, fresh weight and dry weight of patchouli plants (Table 2). Plants that are watered everyday are higher with more branches and leaves and significantly different from plants that are watered 6 days or once every 8 days. Plants that are watered with optimum watering intervals are able to carry out photosynthesis properly, with the fulfillment of water requirements, the maximum photosynthetic output so that better growth was produced. Drought stress on plants cause stomata closure, decreasing the rate of photosynthesis and the rate of transpiration, decreasing the rate of absorption and nutrient translocation (nutrients), decreasing cell elongation, and inhibiting growth [12]. If the rate of photosynthesis decreases, the plant growth will also be affected due to reduced energy sources needed for cell division and enlargement. Cell division activities are inhibited, causing no addition of mass or cell content and cell expansion, so cells remain smaller [13,14]. Stresses cause inhibition of cell division, enlargement and elongation due to low availability of water. Drought stress causes a decrease in plant water potential due to reduced water diffusion from soil solutions into plants, thereby reducing cell turgor [15].

Based on Table 2, 1000 g of cow manure dose application has a higher plant height, number of branches, number of leaves, fresh weight and dry weight than those with 500 g cow manure dose or even one without cow manure. Addition of cow manure as organics matter can improve physical, chemical and biological properties of regosol as the availability of N, P, and K nutrients can be fulfilled. The physical properties of the soil increase with the addition of clay fractions from cow manure and the ability of regosol soil to hold water in order to help patchouli water need.

Table 3. The effect of watering intervals on patchouli roots and canopy at 22 weeks after planting

Watering Interval	Root fresh weight (gram)	Canopy fresh weight (gram)	Root dry weight (gram)	Root dry weight (gram)
Daily	59.69 ^a	737.44 ^b	11.76 ^a	144.23 ^c
Every 2 days	62.22 ^a	626.89 ^a	12.44 ^{ab}	127.99 ^{bc}
Every 4 days	66.87 ^b	598.33 ^a	13.07 ^b	119.37 ^{ab}
Every 6 days	70.44 ^c	571.11 ^a	14.19 ^c	112.20 ^{ab}
Every 8 days	74.80 ^d	522.00 ^a	15.10 ^c	102.73 ^a

The numbers followed by different letters in a column shows significant results in the DMRT test with a level of 5%

Table 3 shows that the less frequent watering causes a decrease in the weight of patchouli plants. Plants that lack water or suffer from water stress generally have a smaller size compared to plants that grow normally. Patchouli growth in regosol soil reaches optimal at watering intervals every day because the water needs of plants were fulfilled. The availability of water will increase the photosynthetic activity of plants so that the physiological process of the plant runs well. Watering done every 8 days causes a decrease in the fresh and dry weight of the canopy at the most. But the fresh and dry weight of roots tends to increase, this is due to the clammy (lack of water) conditions patchouli plants limit their activity by increasing the number of roots and modifying the structure and position of the leaves.

Table 4. The effect of cow manure on patchouli roots and canopy at 22 weeks after planting

Cow Manure Fertilizer Dose	Root Fresh Weight (Gram)	Canopy Fresh Weight (Gram)	Root Dry Weight (Gram)	Canopy Dry Weight (Gram)
0 g/plant	63.88 ^a	543.33 ^a	12.61 ^a	107.40 ^a
500 g/plant	67.1 ^b	630.07 ^b	13.35 ^{ab}	127.88 ^b
1000 g/plant	69.41 ^b	660.07 ^b	13.35 ^b	128.63 ^b

The numbers followed by different letters in a column shows significant results in the DMRT test with a level of 5%

Low drainage and porosity are the physical properties of regosol which causes high tendency toward erosion and have low levels of productivity. In order for regosol soil to be used as agricultural land it is necessary to make improvements in physics, chemistry and biology by fertilization. Based on T-able 4, the application of 1000 g / plant cow manure can increase the root weight and canopy weight of patchouli plants, it shows that organic matter in cow manure has a positive effect on soil physical properties by increasing soil porosity available for root growth [16].

4. Conclusion

Watering interval affects the growth of patchouli in regosol soil. Less frequent watering decrease plant height, number of branches, and canopy weight of patchouli plants but increase the weight of patchouli roots. Patchouli plants with watering of eight days have smaller growth compared to patchouli plants with daily watering, every two days, every four days and every six days because in conditions of being choked (lack of water), patchouli plants tend to limit their activities by increasing the number of roots and modification of the structure and position of leaves. The supply of cow manure to patchouli on regosol soil can increase patchouli growth. Low organic matter and nutrient absorption, rough or sandy soil texture and high infiltration rates cause low fertility and regosol soil productivity. Providing cow manure is an effort to restore organic matter into the soil. Organic matter is a soil-fixing material that plays a role in creating fertility, both in physically, chemically and biology. Provision of 1000 g/plant cow manure can improve patchouli plant growth better than giving 500 g/plants or without cow manure.

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