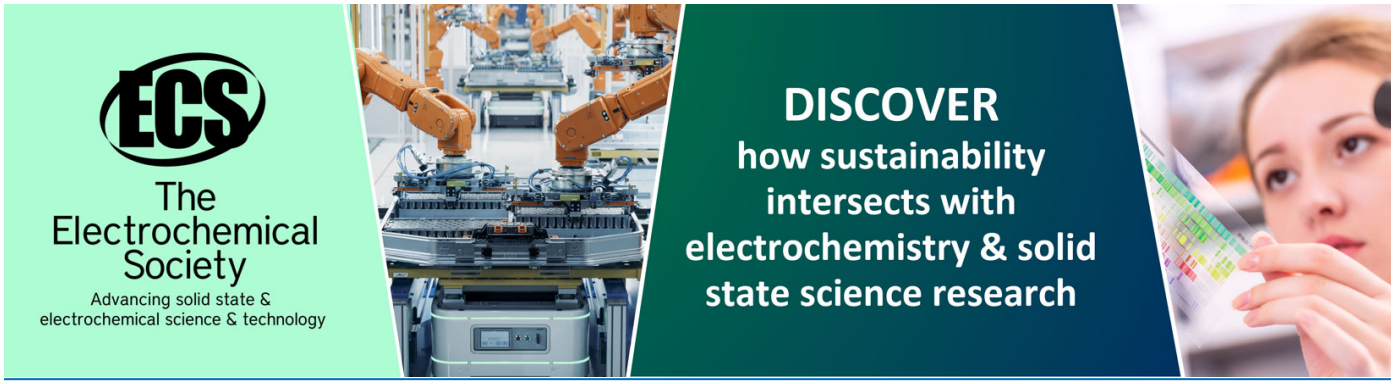
Growth and yield of patchouli (*Pogostemon cablin*, Benth) due to mulching and method of fertilizer on rain-fed land



IOP Conf. Series: Earth and Environmental Science **122** (2018) 012057 doi:10.1088/1755-1315/122/1/012057

Growth and yield of patchouli (*Pogostemon cablin*, Benth) due to mulching and method of fertilizer on rain-fed land

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Abstract. The drought stress that occurs during growth results in a drastic reduction in growth and yield. This study was aimed to study the effect of mulching and method of fertilizer application in reducing the impact of drought stress on patchouli plants. The experiment was conducted from July to December 2016 using a split plot design into three replications with two treatment factors. The first factor was mulch factor with three levels, i.e. M_0 (without mulch), M_1 (rice straw mulch) and M_2 (silver black plastic mulch). The second factor was the method of fertilizer application consisting of three stages: C_1 (once), C_2 (twice), C_3 (three times). The parameters included plant height, number of branches, number of leaves, root length, wet weight of plant, root canopy ratio, total of chlorophyll, soil temperature and soil moisture content. The results showed the use of straw mulch reduce the impact of drought stress on patchouli plants. Two times fertilizer application gave better growth and yield. The use of straw mulch produced lower temperature degrees and maintained soil moisture content.

1. Introduction

Patchouli (*Pogostemon cablin*, Benth) is one of the essential oil-producing plants of the Labiatae family. Living in the subtropics, growing well at altitudes of up to 1,200 m asl in warm and wet climates with rainfall between 1,500 mm to 3,000 mm annually evenly throughout the year, 70-90% humidity, 24-28°C temperatures. Good soil types are regosol, latosol and alluvial. Sandy clay texture or clay dusty, have a good absorption and not inundated during the rainy season with soil pH 5.5-7.0 [1].

Patchouli plants have shallow roots that are less resistant to drought. Such rooting morphological characteristics result in patchouli sensitivity to soil moisture deficits. Generally patchouli are cultivated on dry land with irrigation from rainfall only, and no fertilization with the dose and the right time in accordance with the needs of patchouli plants.

In areas with low rainfall and uneven distribution, such as in North Aceh with rainfall of 1,478 mm/year the need for soil and water conservation through mulching. The use of mulch has an important role in reducing excess water evaporation, thus helping to maintain soil moisture [2], modify the soil temperature [3].

Patchouli plants need a sufficient amount of nutrients and their giving at the right time. Fertilization is one way for patchouli plants to grow fertile, leaves and high production. Provision of fertilizer inappropriate doses of plants is expected to stimulate vegetative growth and improve the process of plant assimilation and oil production.

The use of mulch and fertilizer with the right dose and time is expected to reduce the impact of water shortage on patchouli plants. This study aims to study the effect of mulch and the appropriate way of fertilizing the patchouli plants in an effort to reduce the impact of drought stress in North Aceh.

2. Materials and methods

The research was conducted in Reuleut Timu Village Muara Batu District, North Aceh Regency at altitude of ± 8 m above sea level (asl) from July to December 2016. The materials used are Tapaktuan variety seedlings, cow manure, mulch, urea fertilizer, SP-36, KCl and Mg, Furadan 3 G, Sevin 85 SP and Dithane M 45. The instrument used is Traceable ® Digital ground thermometer (range -50^{o}C - 300^{o}C), oven, digital scales, poly bag, sprayer, plastic strap, ruler.

The experiment was conducted by using a split plot design 3 replications. The main plot of mulch (M), consisting of M_0 (without mulch), M_1 (rice straw mulch) and M_2 (silver black plastic mulch), while subplot is a method of fertilizer (C), consisting of C_1 (once, all doses at planting time), C_2 (twice, ½ dose at plant + ½ dose age 3 months) and C_3 (three times (1/3 dose at plant + 1/3 dose of plant age 2 months + 1/3 dose of plant age 4 months). The observational data were analyzed by anova, if there was a significant followed by a further 5% BNT advanced test.

Plant material derived from shoots cuttings grown in polybag that contain a mixture of soil and cow manure. Cuttings kept for three weeks, then planted with a distance of 60 cm x 40 cm. Giving mulch straw done after planting, while silver black plastic mulch given before planting.

Watering plants done until the age of 30 days after planting (dap). Furthermore, water needs of plants only from rainfall only. The amount of rainfall is measured by an observatory measuring device located at the experimental site.

Observations of growth and yield were performed on plant height, number of branches, number of leaves, root length, wet weight of plant, root canopy ratio, chlorophyll count, soil temperature and soil moisture content. Soil temperature observations carried out at 07:30, 13:30 and 17:30 every 15 days at a depth of 0 cm, 5 cm and 10 cm. Measurement of soil water content is done by the tensiometer every 7 days at 07:30 and 17:30.

3. Results and discussion

The analysis of variance indicates that single mulching does not show any significant in average plant height, average number of branches, average number of leaves, average root of length, average wet weight of plants, average root canopy ratio and total of chlorophyll, but instead a highly significant on the average soil temperature and the average soil water content. The method of single fertilizer use shows significant to the average of plant height. There was no significant interaction between mulch treatment and fertilizer method on all observed parameters (Table 1).

Although the single did not show significantly, the level of rice straw mulch treatment (M_1) showed higher growth and yield compared without mulch (M_0) and black silver plastic mulch (M_2). As indicated on the larger average plant height parameter of 2.66% of M_0 and 9. 21% of M_2. the average number of branches greater than 0.18% of M_0 and 28.80 of M_2, the average number of leaves is 34.38% greater than M_0 and 37.69% of M_2, average root length greater than 5.35% of M_0 and 8.12% of M_2, average wet weight of the larger plant 14.45% of M_0 and 11.41% of M_2, and root canopy ratio 49.62% greater than M_0 and 30.95% of M_2.

The use of rice straw mulch is able to influence better growth of plant height, number of branches, number of leaves, root length, wet weight of the plant, the ratio of plant root of patchouli compared with without mulch and black silver plastic mulch. It is suspected that rice straw mulch suppresses lower soil temperatures, maintaining higher soil water levels so that nutrient uptake, water, and metabolism processes can occur well (Table 2). Mulch reduces the negative impact of water pressures on plant growth and fruit yield and increases the availability of N [4], reducing the amount of water provided, improving crop yields and plant chlorophyll content [5].

Rice straw mulch that has weathering can increase the nutrients for plants, as expressed [2] that the use of rice straw mulch can increase the organic carbon content and soil nutrient availability, while also improving the soil structure in the long term. Rice straw mulch also has other benefits such as improving the micro climate and soil texture, moisture conservation, soil fertility, weed control, plant pest control [6].

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

No	Parameters	F critis value		
		Mulch (M)	Fertilization method (C)	Interaction (M x C)
1.	Plant height	2.57 ns	4.79 *	0.16 Ns
2.	Number of branches	0.35 ns	1.72 ns	1.44 Ns
3.	Number of leaves	3.82 ns	2.46 ns	0.49 Ns
4.	Root of length	1.36 ns	1.27 ns	0.69 Ns
5.	Wet weight of plants	0.56 ns	0.38 ns	0.49 Ns
6.	Root canopy ratio	1.81 ns	2.62 ns	0.27 Ns
7.	Chlorophyll	0.48 ns	3.48 ns	1.52 Ns
8.	Soil temperature	27.77 **	- -	- -
9.	Soil water content	26.07 **	- -	- -

ns = non significant, * = significant ** = highly significant

Level treatment without mulch according to observational data have a lower water content than rice straw mulch and mulch black plastic silver, this resulted in an effect on the vegetative growth of the plants. In soil with decreased soil water content (low moisture content) will experience the effects of drought stress so as to decrease plant growth such as plant height [7, 8], number of leaves, number of branches, wet weight of patchouli plant [9], root growth [10]. Sufficient water content is available, resulting in high and increasing number of plant leaves [11].

Unlike the case with underground growth, the roots are less inhibited than the top canopy growth due to lack of water. This is the same that [12] which reveals that some roots continue to extend to a low groundwater potential and inhibit shoot growth.

Mulch applications have not been able to improve the yield and production of patchouli oil than without mulch. The absence of significant to the yield and production of patchouli oil is believed to be the availability of adequate amount of moisture content for growth and production of patchouli oil. On average the difference in the amount of groundwater content is only ± 10% between mulch without mulch.

Treatment level C_2 showed higher growth of patchouli plants and significantly from C_1, which was indicated by the plant height parameter of 48.66 cm and larger 9.06% of C_1 and 1.77% of C_3 (Table 2).

The way fertilizer twice affects the increase of plant growth and patchouli yield. It is suspected that the fertilization effect twice gives enough nutrients at the right time. Increased cell division and synthesis of chlorophyll, protein and amino acids related to fertilization with the right dose and time [13].

Patchouli responds well to optimal fertilizer application at intervals twice that increase the production of fresh leaves [14] increase plant height, plant wet weight and production of essential oil of [15], increase the dry weight of patchouli leaf [16].

Application of fertilizers with appropriate doses and timing affects the growth and yield of patchouli plants [9]. In addition, fertilization affects vegetative growth resulting in increased crop production [13].

Although there was no significant, the amount of chlorophyll of patchouli leaf was higher at C_3 level (three times the fertilizer application). This is related to the time of chlorophyll measurements taken several days after fertilizer application where nutrients have been absorbed by plants so that the leaves of plants are greener. Absorption of nutrients from the soil in the root plays an important role in the synthesis of chlorophyll by plants [17]. Plants containing enough nutrients will show the color of dark green leaves which means high chlorophyll content in the leaves.

Table 2. Summary of the mean value test for the average parameters of plant height (PH), average soil temperature (ST) and average soil moisture content (SMC) due to mulch treatment and fertilizer application.

Parameters	Average value		
	PH	ST	SMC
	Mulch (M)		
M_0	47.54	34.73 a	85.14 c
M_1	48.84	31.70 c	96.46 a
M_2	44.34	33.54 b	92.02 b
BNT 0,05	Ns	**	**
	Fertilization method (C)		
C_1	44.25 b	-	-
C_2	48.66 a	-	-
C_3	47.80 a	-	-
BNT 0,05	*		

ns = non significant, * = significant ** = highly significant

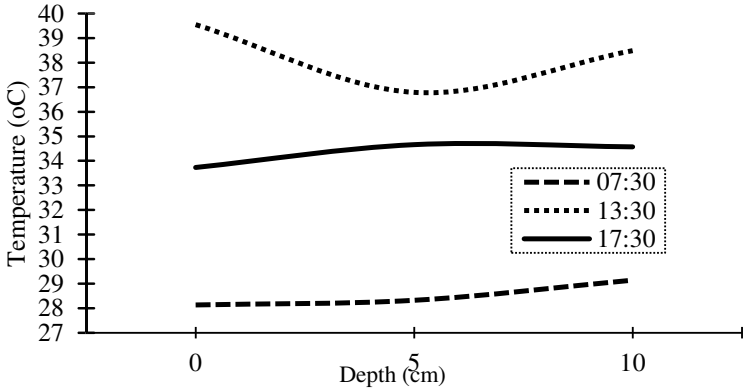

Figure 1. Soil temperature profile with depth at various times

Mulch treatment showed a highly significant against the average daily of soil temperature. The highest average soil temperature was achieved in without mulch (M_0) that was 34.73°C followed by M_2 33.54°C and M_1 31.70°C. This suggests that the use of rice straw mulch provides a lower temperature than the use of silver black plastic mulch and without the use of mulch (Table 2).

The average daily soil temperature according to depth indicates the temperature decreases by increase in depth. This decrease occurs both on M_0, M_1 and M_2. Soil temperature profile in the morning, according to the depth indicates that the lower soil temperature at a depth of 0 cm is 28.13°C, increased by 0.19°C at a depth of 5 cm and increased again by 0.82°C at a depth of 10 cm. Profile soil temperature at noon at the depth shows that higher soil temperature at a depth of 0 cm is 39.55°C, decreased by 2.76°C to a depth of 5 cm and decreased again by 1.70°C at a depth of 10 cm. Soil temperature profile in the afternoon, according to the depth shows that, soil temperature is lower at a depth of 0 cm ie 33.73°C, increased by 0.93°C at a depth of 5 cm and decreased again by 0.09°C at a depth of 10 cm (Figure 1).

Straw mulch is able to maintain a lower soil temperature compared to silver black plastic mulch and without mulching. The same is obtained in [18] studies using various types of mulch revealing that plastic mulch provides a higher maximum ground temperature compared to hay mulch. The degree of soil temperature indicated in rice straw mulch was at the patchouli environmental temperature between 24-32°C and did not experience large fluctuations.

The level of rice straw mulch treatment showed highly significant with the level of treatment without mulch and black silver plastic mulch on soil moisture content. The highest average soil moisture content was reached by a rice straw mulch level of 96.46%, followed by silver black plastic mulch of 92.02% and without mulch of 85%. The amount of soil water content in the mulch treatment is influenced by the ability of rice straw mulch in infiltrating more water when it rains and to maintain lower soil temperatures (31.70°C) compared without mulching (34.73°C) and silver black plastic mulch (33.54°C). Higher soil temperatures affect larger evapotranspiration rates in soil and plants (Table 2 and Figure 2).

Plastic and straw mulch significantly reduces evaporation from the soil surface, thus higher groundwater content is always present in the topsoil of the plot without mulch usage. Humidity found in the topsoil has an important role for plants to absorb nutrients to carry on their lives. Research shows that mulch provides many benefits to crop production through soil and water conservation. According to [19] the provision of organic mulch yields higher canopy and oil. Straw mulch and plastic mulch increase plant yield and leaf chlorophyll content. This shows that mulch reduces the negative impact of drought stress on plant growth [20].

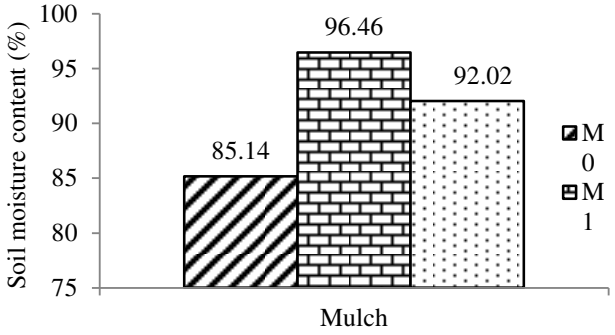

Figure 2. The water content of the soil (%) due to the mulch treatment (M)

4. Conclusions

The treatment of rice straw mulch has a better effect on the growth of patchouli plants, resulting in lower temperatures and maintaining higher soil moisture content than without mulch and black silver plastic mulch. Fertilization twice gave a significant to the height of patchouli plants, as well as affecting better growth in leaf number parameters, root length and wet weight of patchouli plants.

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Acknowledgements
The author would like to thank the Directorate of Research and Community Service (DRPM) Ministry of Research, Technology and Higher Education, For the grant of research grant for a doctoral dissertation in 2017.