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Fertilizing dosage on three patchouli varieties (*Pogostemon cablin* Benth.) to reduce the effects of drought stress

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Abstract

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The research aims to obtain fertilizer dosage and patchouli tolerant varieties in an effort to reduce the effects of drought stress. Conducted in a plastic house using a split split plot design in the randomized block designs with three factors and repeated twice, namely the factor of water supply (K) in the field capacity (fc) as the main plot, the variety factor (V) as the subplot and a fertilizer dose factor (P) as the sub-subplots. Parameters observed were plant height, root length, root wet weight, root dry weight, canopy wet weight, dry weight of the plant, root canopy ratio, chlorophyll, and proline content. The results showed that the lower field capacity reduced plant height, chlorophyll content, increase root length, root wet weight and proline content. Tapaktuan varieties have a good adaptation to drought stress. A dose of 128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha produces better plant growth and yield compared to other doses, while a dose of 311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha could reduce the impact of drought stress with lower proline levels.

Keywords: fertilizer dosage; varieties; drought stress; proline; chlorophyll; patchouli alcohol

Introduction

Patchouli (*Pogostemon cablin* Benth.) is an essential oil producing plant that is cultivated on dry land. Aceh Province is the number one producer of the highest quality and the main producer of Indonesian patchouli oil exports to the international market (Asnawi et al., 2018; Haryono, 2015)

Drought stress causes a decrease in crop production, one of them is patchouli which is very sensitive to the situation because it has shallow roots. Plants that are affected by drought stress will experience vegetative growth and yield disturbance, but will protect themselves by producing organic compounds, one of which is through the synthesis and proline accumulation (Verslues et al., 2006).

In order to overcome drought stress in patchouli cultivation, the application of drought tolerant patchouli varieties is one of the most efficient and inexpensive technology choices. The Lhokseumawe, Tapaktuan and Sidikalang varieties are superior patchouli varieties in Indonesia that passes high yields, but are still relatively vulnerable to drought stress (Nuryani, 2006).

In addition to the availability of sufficient water, plant,s growth is greatly influenced by the availability of nutrients in the soil. Patchouli in its growth requires sufficient water and is very greedy for nutrients, especially nitrogen, phosphorus and potassium (Emmyzar & Ferry, 2004). Appliation of the right dosage into patchouli is expected to stimulate vegetative growth (Wahyuni et al., 2011), stimulating root's growth so as to reduce the effects of drought stress (Karlina & Koesriharti, 2018). Patchouli cultivation with superior varieties and fertilizer effective dosage according to plant requirements is expected to increase vegetative growth, so that if there is a shortage of water, patchouli plants can reduce the impact of drought stress.

This study aims to obtain fertilizer dosage and tolerant patchouli varieties in an effort to reduce the effects of drought stress.

Materials and Methods

The study was conducted in a plastic house using a split-split plot design in the randomized block designs with two replications. The treatment that was tried was the giving water factor (K) in the field capacity (fc) as the main plot consisting of, K_1 = 100% fc, K_2 = 75% fc, K_3 = 50% fc and K_4 = 25% fc, the patchouli variety factor (V) as subplot consists of V_1 = Lhokseumawe variety, V_2 = Tapaktuan variety and V_3 = Sidikalang variety and fertilizer dosage factor (P) as sub-sub plots, consisting of P_1 = 128,8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha, P_2 = 233 kg N/ha + 196 kg P_2O_5 /ha + 120 kg K_2O/ha + 135 kg MgO/ha dan P_3 = 311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha.

The materials used are three varieties of Aceh patchouli type Pogostemon cablin Benth, manure, chemical fertilizer. The tools used are tensiometer, optics; CCM 200 plus portable. There were 504 polybags sized 60 kg of soil planted with one patchouli plant and placed in 72 (seventy two) trial plots. The observational data were analyzed by ANOVA (LSD test of 5%).

Patchouli seed material from shoots up to 20 cm long was sowed in a small polybag mixed with soil and manure. Seedsthat have sprouted and leaves are planted into a large polybag sized 60 kg of soil arranged 60 x 40 cm apart an a randomized trial plots. Drought stress application is carried out at the age of one month after planted according to treatment. Plant treatment includes watering, weeding and eradicating pests and diseases. Patchouli fertilizing is done one week before planting according to the treatment dosage. Soil's water content was measured every morning using a tensiometer (soil moisture tester) to determine when and the amount of water should be given to each trial plot. Proline content analysis was conducted using Bates et al. (1973) method on the leaf segments 2-3 number of shoots at the age of 180 days after transplanting (DAT). Chlorophyll measurements were carried out at 08.00-10.00 by attaching leaves into the CCM 200+ portable Optisciences sensor with cci (chlorophyll content index). Patchouli alcohol content was analyzed by gas chromatography-mass spectrometer (GC-MS).

The parameters observed were plant height, root length, root wet weight, root dry weight, crown wet weight, plant dry weight, root canopy ratio, chlorophyll and proline content.

Results and Discussions

Patchouli growth

Provision of water in the field capacity produces significantly different plant height growth between treatment levels. The highest plant height at 75% fc is significantly different from 50% fc. Patchouli's plant height decreased with reduced water content provided. The lower field capacity inhibits upper vegetative growth, but increases the root length and root wet weight growth at 25% fc, 26.38 cm and 3.34 g.

Table 1. Patchouli parameter data due to water treatment (K) in the field capacity, patchouli varieties (V) and fertilizer dosage (P)

T	PH, cm	RL, cm	WRW, g	RDW, g	CWW, g	PDW, g	RCR	Chlo (CCI)
K_1	39.16 ab	24.52 a	2.51 ab	0.85	10.81	3.36	4.37	28.33 a
K_2	41.52 a	23.44 ab	2.87 a	0.83	19.99	4.77	6.39	22.43 ab
K_3	37.18 b	20.22 b	1.59 b	0.59	9.66	3.08	6.85	18.67 b
K_4	40.03 a	26.38 a	3.34 a	0.85	15.56	3.51	6.49	17.60 b
V_1	36.37 b	25.77 a	2.96	0.81	11.45 ab	3.60	4.60 b	22.21
V_2	46.33 a	25.25 a	2.58	0.77	19.92 a	4.64	9.20 a	21.34
V_3	35.71 b	19.91 b	2.32	0.76	9.15 b	2.71	4.27 b	21.72
P_1	41.70 a	26.94	3.23	0.80	19.42 a	4.59	7.06	22.56
P_2	40.65 a	21.35	1.96	0.82	11.55 ab	3.33	5.18	23.24
P_3	36.06 b	22.64	2.68	0.72	9.56 b	3.13	5.83	19.49

Note: The numbers followed by the same letter in the same column are not significantly different (LSD 0.05). T= treatment, PH = plant height, RL = root length, WRW = wet root weight, RDW = root dry weight, CWW = canopy wet weight, PDW = plant dry weight, RCR =root canopy ratio, Chlo = chlorophyll

Both parameters show significant differences with 50% fc. The amount of chlorophyll produced decreases with decreasing of field capacity. The highest chlorophyll was obtained at 100% fc which was 28.33 cci and the lowest at 25% fc which was 17.60 cci. The treatment level of 100% fc shows a significant difference with 50% fc and 25% fc. Did not show significant differences in root dry weight and plant dry weight (Table 1).

Plant height and amount of chlorophyll is bigger at 75% fc, while the root length and root weight are bigger at low water levels. The decrease in plant height and the amount of patchouli's chlorophyll is affected by the low capacity of the soil so it interferes with cell division, inhibits nutrient absorption by patchouli plants. In this condition, the plant is more focused on extending its roots in order to obtain a lot of water sources in deeper soil layers (Hassanein, 2015; Wu et al., 2008), and inhibits shoot growth, thereby increasing the plant root canopy ratio (Kirnak et al., 2001). An increase in root length under drought stress conditions is also associated with an increase in the content of abic acid in the roots (Manivannan et al., 2007). Reduction of plant height is associated with disturbance in cell division, elongation and expansion under drought stress conditions (Hussain et al., 2008; Manivannan et al., 2008; Sikuku et al., 2010).

Lower water content decreases the amount of chlorophyll patchouli plants. It shows that the lower of the water content, the lower the of amount of chlorophyll. This was thought to be the caused by disruption of the formation of chlorophyll during drought stress. The lower the water content the lower the chlorophyll content (Anjum et al., 2003; Anower et al., 2017). Drastic reduction in chlorophyll begins to appear at 50% of the field capacity, thereby reducing crop yields. Decreasing the amount of chlorophyll due to drought stress will reduce crop yields (Mafakheri et al., 2010).

Tapaktuan varieties produce a higher plant height at 46.33 cm and significantly different from the Lhokseumawe and Sidikalang varieties. The high adaptation of Tapaktuan varieties also occurred in the canopy wet weight parameter that was 19.92 g and the root canopy ratio was 9.20. The Lhokseumawe variety is more superior to the root length parameter which is 25.77 cm, which is significantly different from the Sidikalang variety. There were no significant differences in the chlorophyll parameters due to the treatment of the varieties (Table 1).

Tapaktuan varieties produce higher plant height, canopy weight and root canopy ratio compared to the other two varieties. Tapaktuan varieties genetically suspected have a good response to drought stress compared to Lhokseumawe and Sidikalang varieties. The response of varieties is influenced by genetic factors and the environment in which the plant grows, thus affecting the appearance of the plant both physiologically and morphologically (Wahyuni et al., 2011). These results are the same as those obtained by Djazuli (2010) that Tapaktuan varieties have a better response to drought stress compared to Lhokseumawe and Sidikalang varieties.

Fertilizer dosage make a significant difference in plant height and plant canopy weight. The best fertilizer dosage is shown in P_1 (128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha), which is 41.70 cm for plant height and 19.42 g of canopy wet weight which is significantly different from P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) dose. The dose of fertilizer given was not significantly different from the other parameters (Table 1).

A fertilizer dose of 128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha is a recommended dosage of patchouli cultivation in Indonesia capable of producing plant height and patchouli wet weight that is higher than other fertilizer dosage. This is because the nutrient content in the dosage is suitable and optimum for patchouli plant needs. Patchouli responds well to the application of fertilizers at optimum doses (Singh & Rao, 2008), to obtain optimal growth, fertilizers must be in accordance with plant needs (Sugiarti et al., 2004).

Prolin

Interaction occurs between the level of water supply in the field capacity with patchouli varieties on the accumulation of proline. The highest interaction was shown by Tapaktuan (V_2) varieties at 50% fc (K_3) in the amount of 86.35 μ mol/g. At a field capacity of 25% (K_4), Tapaktuan varieties were able to produce a greater accumulation of proline that is 50.61 μ mol/g which was very significantly different from the Lhokseumawe variety and Sidikalang variety (Table 2). This shows that the tapaktuan varieties have a good response to low water levels. This result is different from that obtained by Setiawan et al. (2012) who obtained the Lhokseumawe and Sidikalang varieties were more tolerant with higher pro-

Table 2. Interaction between administration of water (K) to field capacities and variety (V) to the content of proline (μ mol/g)

Treatment	V_1	V_2	V_3
K_1	51.31 b (B)	47.60 d (C)	58.20 a (A)
K_2	65.76 a (A)	65.38 b (B)	53.15 b (C)
K_3	65.76 a (B)	86.35 a (A)	38.95 d (C)
K_4	50.06 c (B)	50.61 c (A)	49.15 c (C)

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row are not significantly different (LSD 0.05) line levels compared to Tapaktuan varieties. The smaller the soil moisture content, the proline levels increase (Setiawan et al., 2013).

An interaction occurs between the level of water supply in the field capacity and the dose of fertilizer to the accumulation of proline. The highest interaction was shown by the dose of P_3 fertilizer at 50% (K_3) field capacity, which was 85.96 μ mol/g. At a field capacity of 25% (K_4), fertilizer dosage P_2 (233 kg N/ha + 196 kg P_2O_5/ha + 120 kg K_2O/ha + 135 kg MgO/ha) accumulates a large amount of prolin which is 59.68 μmol/g and is very significantly different from P_1 (128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha) and P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) (Table 3).

Table 3. Interactions between water content (K) levels in field capacities and fertilizer dosage (P) to the content of proline (μ mol/g)

Treatment	P_1	P_2	P_3
K_1	54.98 c (A)	51.65 c (B)	50.48 c (C)
K_2	58.65 a (B)	72.50 a (A)	53.15 b (C)
K_3	56.93 b (B)	48.16 d (C)	85.96 a (A)
K_4	48.91 d (B)	59.68 b (A)	41.24 d (C)

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row are not significantly different (LSD 0.05)

The application of high dose P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) fertilizer could reduce the impact of drought stress on patchouli plants as evidenced by the lower accumulation of proline at 25% water content in the amount of 41.24 μ mol / g followed by a P_1 (128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha) dose of 48.91 μ mol/g and dose P_2 (233 kg N/ha + 196 kg P_2O_5/ha + 120 kg K_2O/ha + 135 kg MgO/ha) of 59.68 μ mol/g. Higher doses of fertilizer accumulate lower levels of proline. The low accumulation of proline occurs because fertilizers contribute to maintaining plant physiology so it grows optimally growth (Alwi et al., 2018; Salehi et al., 2016).

Interactions between varieties and fertilizer dosages occur on the proline content. Application of high dose P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) fertilizer results in a low proline content in Sidikalang (V_3) variety of 44.22 μ mol / g. P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) dose can reduce the impact of drought stress which is characterized by low accumulation of proline content in Sidikalang varieties (Table 4).

Table 4. Interactions between varieties (V) and fertilizer dosage (P) to the proline content (μ mol/g)

Treatment	P_1	P_2	P_3
V_1	50.77 c (C)	68.46 a (A)	55.45 b (B)
V_2	54.20 b (C)	59.78 b (B)	73.47 a (A)
V_3	59.63 a (A)	45.75 c (B)	44.22 c (C)

Note: The numbers followed by the same lowercase letters in the same column and the same uppercase letters in the same row are not significantly different (LSD 0.05)

It is suspected that the application of high-dose fertilizer P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) stimulates the growth of patchouli plant roots which is faster and longer, so that the roots get water in deeper soil. Plants that experience rapid development and growth could reduce the effects of drought stress due to an increase in the absorption of nutrients and water by roots in deeper layers. Long roots can reach deeper water so that the maximum uptake of water by plants (Blum, 2011; Djazuli, 2010).

Conclusion

Provision of water in the field capacity decreases plant height growth, canopy wet weight, amount of chlorophyll, but increases root length, acetate wet weight and proline content. Tapaktuan varieties have better adaptability to drought stresses which are characterized by higher proline accumulation. P_1 fertilizer dose (128.8 kg N/ha + 25 kg P_2O_5/ha + 84 kg K_2O/ha + 42 kg MgO/ha) results in better growth and yield of patchouli, while P_3 (311 kg N/ha + 35 kg P_2O_5/ha + 394 kg K_2O/ha + 63 kg MgO/ha) can reduce the impact of drought stress on Sidikalang varieties.

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