Effects of organic fertilizer and water stress on Valerian biomass (*Valeriana javanica* (BL.) DC.) for domestication

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Abstract. Valerian (*Valeriana javanica* (BL.) DC.) has the potential to be developed as a medicinal plant. However, this plant is still collected from nature, so this will threaten Valerian germplasm, varying quality and uncertain crop yields. Moreover, the impact of climate change, such as drought and lack of nutrients in the soil, could threaten Valerian's presence. This research aimed to investigate the tolerance level of Valerian on several water stress levels and influence of organic fertilizer on the plant biomass. This experiment utilized completely randomized design with 2 factors and three repetitions. The first factor was organic fertilizer consisting of no fertilizer (control), cow manure, and goat manure. The second factor was water stress consisting of 100% field capacity, 80% field capacity, 60% field capacity and 40% field capacity. The result depicted that 40% field capacity produced the lowest biomass compared to 60 %, 80 % and 100 % field capacity. In addition, goat manure resulted in higher biomass than cow manure.

1. Introduction

Valerian (*Valeriana javanica* (BL) DC.) is a medicinal plant from family *Valerianaceae*. Valerian root has already been utilized from ancient times by Greek and Roman physicians. It can be used for diuretic, spasmylytic agents and anodyne [1]. The most important part of this plant is the root collected after the leaves fall from the plant [2]. In Indonesia, the requirement of raw material of Valerian is limited from nature and is fulfilled by import. Collecting raw material from nature will threaten the existence of Valerian germplasm, varying quality and uncertain crop yields [3]. Moreover, the impact of climate change, such as drought and lack of nutrients in the soil, can threaten Valerian presence. Thus, research about the potential of Valerian cultivation as a medicinal plant is very crucial to prevent raw material scarcity.

Valerian plant cultivation is inseparable from the need for water [4]. Plants need water to absorb nutrients and translocate throughout the network as raw material in the photosynthesis process [5]. Water requirements for plants vary depending on the type of plant and its growth phase. In the dry season, plants often get water stress due to lack of water supply in the root area and evapotranspiration rate that exceeds the rate of water absorption by plants. The soil water content affects the growth and development of the plants that grow on it. Whenever water becomes limited, growth will decrease and productivity will decrease [6]. Drought stress reduces biomass productivity due to decreased primary metabolism, reduced leaf area and photosynthetic activity. The decrease in biomass accumulation in some medicinal plants increases secondary metabolites to increase the medicinal content. However, excessive water stress reduces the quality of the active components of medicinal plants [7].

Cultivating wild plants into medicinal plants, to meet the need for medicinal ingredients in large quantities, considering that the growing requirements and cultivation methods are intensive [8]. To increase plant biomass, organic fertilization can be carried out, especially the crops in the form of leaves and roots. Fertilizer is a material given to the soil, both organic and inorganic, to replace the loss of nutrients from the soil and aims to increase plant production in good environmental factors [9]. Plants need fertilizer for growth, especially in the vegetative phase (formation of roots, branches, leaves and stems). Fertilizer is also useful for the formation of green leaves (chlorophyll). This study aimed to study the Valerian tolerance at various levels of water stress and the effect of organic fertilizers on biomass.
2. Materials and methods
The research was conducted in greenhouse of Faculty of Agriculture, Universitas Sebelas Maret. Experimental materials were Valerian seeds, cow manure and goat manure. Valerian plants were cultivated in 2.5 kg polybags. The study used a completely randomized design with two treatment factors and three replications. The first factor was organic fertilizer, namely control (without fertilizer), cow manure and goat manure. The second factor was water availability (100% field capacity, 80% field capacity, 60% field capacity and 40% field capacity). Valerian plant seeds were obtained by germinating the seeds. After 6 weeks, the seeds (small plants) were transferred to the polybags. Fertilization was carried out based on the treatments with a dose of 40 g per polybag. The dosage of animal manure was 20 tons ha\(^{-1}\). Fertilization was given once after 1 month in the polybag by immersing around the stem. The amount of water available was given through sprinkling at each treatment every 2 days. Valerian plants were harvested 3 months after planting. The data obtained from the experiment were analyzed by analysis of variance (ANOVA) with the F-test of 5% level, followed by Duncan's multiple distance difference test (DMRT) and Correlation Regression test [10].

3. Results and discussion
The part of the Valerian plant used as medicinal raw material is the simplicia. Valerian simplicia is mainly collected from roots. Simplicia is a product of dry ingredients from plant parts as a source of medicinal raw materials containing various metabolites with varying levels [11]. The product of dry plant matter is, in principle, the result of fresh weight, which is stripped of its moisture content by oven at a temperature of 60 - 750 °C so that constant weight of the living biomass is obtained [12].

3.1. Dry weight of stems
Provision of water under conditions of low field capacity (40%) gives relatively low yields (6.43 g), when compared to conditions with higher field capacities, namely 60% (8.73 g), 80% (12.04 g) and 100% (13.80 g) (in Table 1). The decreasing level of water availability causes the dry weight of the stems to decrease [13]. This occurs due to decreased water intake, leading to water entry through the stems, which water plays a role in physiological processes, resulting in slowness in stem growth [14]. In water shortage conditions (40% water availability), yields are relatively low compared to treatment with water availability in greater quantities [15].

Stem dry weight resulted from animal manure has the same effect both control and with manure. This result can be caused by the duration of the research [16]. The effect of organic fertilizers could be seen in the longer duration than inorganic fertilizers due to the time required for further decomposition and nutrient availability. Absorption of nutrient is vary depending on type of plants and type of fertilizers. Based on nutrient analysis, cow manure contained Nitrogen 2.33 %, P\(_2\)O\(_5\) 0.61 %, K\(_2\)O 1.58 %, Ca 1.04 %, Mg 0.33 %, Mn 179 ppm and Zn 70.5 ppm. Goat manure contained Nitrogen 2.10 %, P\(_2\)O\(_5\) 0.66 %, K\(_2\)O 1.97 %, Ca 1.64 %, Mg 0.60 %, Mn 233 ppm and Zn 90.8 ppm [16].

| Treatment | Stem Dry Weight (g) |
|-----------|---------------------|
| Water     | Control  | Goat   | Cow    | Average |
| 40%       | 4.24     | 7.64   | 7.41   | 6.43    |
| 60 %      | 7.24     | 9.55   | 9.42   | 8.73    |
| 80 %      | 12.66    | 11.59  | 11.89  | 12.04   |
| 100 %     | 12.99    | 15.10  | 13.32  | 13.80   |
| Average   | 9.2825a  | 10.97a | 10.51a |         |

Note: Numbers followed by the same letter in the same row or column are not significantly different at the 5% level.
3.2. Leaf dry weight

In Table 2, it can be seen that the dry leaf weight at 40% (5.85 g) water availability was the lowest compared to the water availability of 60% (7.31 g), 80% (8.44 g), and 100% (11.50 g). This is due to lack of water available for plants, which causes photosynthetic inhibition in the leaves. Islami and Utomo [17] stated that drought stress in plants will cause a decrease photosynthetic activity. Three mechanisms decrease photosynthetic activity, namely 1) reduced leaf surface area, 2) closing stomata, 3) reduced protoplasm activity, which has been dehydrated. In conditions of water shortage (40% water availability) yields are relatively low compared to treatment with water availability in greater quantities.

The application of cow manure produces higher leaves dry weight compared to cow manure and control. However, application of cow manure and goat manure generates the same effect. The leaves dry weight resulted from cow manure significantly higher than control. This result was caused by the nutrient content in cow manure that contained higher nitrogen than other fertilizers [9].

| Treatment | Leaves Dry Weight (g) |
|-----------|-----------------------|
|           | Control | Goat | Cow | Average |
| 40%       | 3.72    | 6.95 | 6.89 | 5.85 c  |
| 60%       | 7.04    | 7.52 | 7.38 | 7.31 b  |
| 80%       | 8.45    | 8.11 | 8.76 | 8.44 b  |
| 100%      | 10.95   | 11.07| 12.49| 11.50 a |
| Average   | 7.54b   | 8.41ab| 8.88a|

Note: Numbers followed by the same letter in the same row or column are not significantly different at the 5% level.

3.3. Root dry weight

The dry weight of the roots at 40% of water was obtained relatively low. It is suspected that the low root dry weight is due to the low water content in the media. Water stress will cause the plant roots to be formed slightly and in small size with a relatively narrow spread area. Low soil water content will reduce root elongation, penetration depth and root diameter [7]. In water shortage conditions (40% water availability), yields are relatively low compared to treatment with water availability in greater quantities [18].

The application of different organic fertilizers significantly affects the root dry weight of Valerian. The higher root dry weight is obtained from goat manure. In comparison, application of cow manure produces the same performance as control. The effect of goat manure is due to the higher content of phosphate and potassium, which higher than cow manure. Goat manure contained P₂O₅ of 0.66% and K₂O 1.97%, while cow manure merely contained 0.61% P₂O₅ and K₂O 1.58% [9][19].
Table 4. Effect of different organic fertilizer treatments and water availability on Valerian plant height (cm)

| Treatment | Plant Height (cm) |
|-----------|-------------------|
|           | Water |
|           | Control | Goat | Cow | Average |
| 40%       | 8.37    | 49.77 | 38.73 | 32.29 d |
| 60%       | 10.23   | 56.83 | 46.9  | 37.98 c |
| 80%       | 20.17   | 58.8  | 78.97 | 52.64 b |
| 100%      | 19.1    | 67.43 | 63.59 | 50.04 a |

Average 19.29 c 77.61b 76.06a

Note: Numbers followed by the same letter in the same row or column are not significantly different at the 5% level.

Table 5. Effect of different organic fertilizer treatments and water availability on the number of leaves.

| Treatment | Number of Leaves |
|-----------|------------------|
|           | Water |
|           | Control | Goat | Cow | Average |
| 40%       | 503     | 505  | 536 | 514.66 b |
| 60%       | 577     | 574  | 554 | 568.33 b |
| 80%       | 722     | 653  | 652 | 675.66 a |
| 100%      | 732     | 678  | 708 | 706.00 a |

Average 633.5a 602.5a 612.5a

Note: Numbers followed by the same letter in the same row or column are not significantly different at the 5% level.

3.4. Plant height

Based on the data analysis, it was found that the results of fertilization and water treatment affected plant height (Table 4). Application of goat manure generates a higher plant compared to cow manure and control. The effect of goat manure is caused by the higher content of nitrogen and potassium in goat manure than cow manure.

In water shortage conditions (40% water availability), yields are relatively low compared to treatment with water availability in greater quantities [20]. The higher plant was produced from 80% water availability reaching 65.64 cm. While the application of 100% water available resulted in the second grade of plant height. It means that application water of 80% water availability is sufficient for the growth of Valerian. The application of water of 60% decreased Valerian plant height about 27.85% compared to plant height produced by 80% water available.

3.5. Number of leaves

Fertilizer treatment did not affect the number of leaves, while water availability affected the number of leaves (Table 5). Treatment of water availability 40% and 60% was not significantly different, but significantly different with 80% and 100%. In water shortage conditions (40% water availability), yields were relatively low compared to treatment with more water availability (Table 5). In woody plants, the response of plants to water stress from the soil such as organic limitations and water stress tends to increase the content of phenolic compounds in the leaves and vice versa, if the availability of water and excess nutrients will reduce the content of secondary metabolites [21].

Organic fertilizer generates a similar effect on the number of leaves of Valerian. Application of goat manure and cow manure produce the same number of leaves with control. A variety of organic fertilizers could significantly affect plant growth depending on the duration of application. Because this research was...
conducted in a short period, the effect could be seen in the next period. This condition is different from previous research that applying animal manure can increase the number of leaves in other plants [22].

4. Conclusions
A 40% of water availability produced the lowest biomass compared to 60%, 80% and 100% treatment. Thus, water conservation is very crucial in order to cultivate Valerian in climate change conditions. Goat manure generated a higher effect than cow manure on dry stem weight, dry root weight and plant height. Goat manure fertilizer produced higher biomass than cow manure fertilizer. Further research is needed to increase biomass, which at the same time, can increase the content of secondary metabolites.

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