The effect of water stress on growth rate in *Mentha arvensis*

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**Abstract.** *Mentha arvensis* is commonly known as pudina, corn mint or wild mint belonging to the Lamiaceae family. It is also widely cultivated in Bangladesh, Nepal, India, Srilanka, Thailand, and Japan for its use as a food seasoner, household remedy, and industrial purposes. This paper investigated the treatment of drought and flood stress on *Mentha arvensis* by controlling the irrigation intervals. The growth parameters which include plant height, number of branches, number of leaves, root length and root weight of *Mentha arvensis* were measured. *Mentha arvensis* was planted by using stem cutting and irrigation intervals was controlled in three different conditions after 5 weeks of plantation. The vegetation phase was observed after the water treatment started. Based on the result, *Mentha arvensis* at 4 days and 6 days of water treatment was more affected by the water stress. This shows that 4 days and 6 days of water treatment undergo slower growth rate in their plant height, number of branches and number of leaves compared to 2 days of water treatment. *Mentha arvensis* grow best under 2 days of water irrigation intervals. Plants showing improved growth with limited water are considered to tolerate drought, regardless of how the improvement occurs.

1. Introduction

*Mentha arvensis* commonly known as pudina, corn mint or wild mint in Bangladesh and India and it belongs to the family Lamiaceae. This plant is a small to moderate sized perennial herb and commonly use as food seasoner, household remedy, and industrial purposes in Bangladesh, Nepal, India, Srilanka, Thailand and Japan [1]. In Ayurveda, this plant is considered as appetizer and useful in gastric troubles. However, world climate is varying and usually changes whether due to natural variability or as a result from human activity. A change in climate can affect many related aspects of where and how people, plants and animals live, such as food production, availability and use of water, and health risks. For example, a change in the usual timing of rains or temperatures can affect when plants bloom, set fruit, and growth. Mostly plant is vulnerable to environmental problem because it is immobile than animal and human. Water are important to plant for development and survival. Water stress may arise through either an excess of water or a water deficit. For instance, flooding stress is the most commonly on oxygen stress due primarily to reduce oxygen supply to the roots and lack of rainfall or drought can affect the *Mentha arvensis* physiological, development and survival. The objectives of this study are to apply the treatment of drought and flood stress on *Mentha arvensis* by controlling the irrigation intervals. Then, to measure the growth rate that include height, number of branches and number of leaves, root length and root weight of *Mentha arvensis*. 
2. Methods

2.1. Plant material and germination
The Mentha arvensis was obtained from the local nursery at Batu Pahat, Johor. Then, it was planted by using stem cutting and watered normally in the beginning of plantation.

2.2. Water treatment
After 5 weeks of cultivation, the irrigation intervals were controlled in three different conditions; 2 days (flood condition), 4 days (control) and 6 days (drought condition). Both plants were watered equally with 200 ml of water.

2.3. Physiological measurement
The height of plant was measured using a ruler and thread. The number of branches and leaves attached to the stem was counted manually. The length of the root was measured after the treatment ended. The plant was plucked to measure the root length. The plant was placed on the graph paper to measure the root length. The root parts were measured and weighed using an electronic balance.

2.4. Relative water content (RWC)
The procedure for RWC was slightly modified from [4], which were plucked 3-4 leaves and weighed to give a value of fresh weight (FW). Then leaf pieces were immersed in distilled water overnight and were placed in fridge at darkness to keep away from physiological activity by physical inhibition of growth and respiration. The sample was taken out of the water and were well dried of any surface moisture quickly and lightly with filter paper and immediately weighed to obtain fully turgid weight (TW). For dry weight (DW), the leaf pieces were placed in an oven at 60°C in 24 hours. After 24 hours, the leaf pieces were taken out from oven and weighed. The relative water content was calculated by using equation below:

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\text{RWC (\%) = \left( \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \right) \times 100}\]

3. Results and discussion
Mentha arvensis were treated with water stress by controlling the water irrigation at 2 days, 4 days and 6 days. It has been shown that water stress can affect the growth rate parameters.

**Figure 1.** Plant height of Mentha arvensis. M. arvensis was watered every 2 days, 4 days and 6 days that indicates water stress condition. Measurement was taken according to irrigation intervals.

Water stress in plants causes the decrease of growth and cell development, especially in plant height and number of leaves [5]. In this study, the irrigation of water control which are 2, 4 and 6 days did not affect the growth of Mentha arvensis. Based on Figure 1, all plants under 2, 4 and 6 days of water treatment show a slightly increased in their height. Mentha arvensis maintained their growth under severe and moderate drought condition. Thus, this shows that the plants can still tolerate and grow even
though the water was scarce. But if the water was limited in a long period of time, the plant will dehydrate and die. Plants showing improved growth with limited water are considered to be tolerant drought, regardless of how the improvement occurs [2].

![Figure 2](image2.png)

**Figure 2.** Number of branches of *Mentha arvensis*. *M. arvensis* was watered every 2 days, 4 days and 6 days that indicates water stress condition. Number of branches was taken according irrigation intervals by counting manually.

Plant height is related with the number of branches because as the height increases, the branches also grow, and the number of leaves also increases. Based on Figure 2, the number of branches of 2 days plants were increased compare to other plants. For 4 days plant, their number of branches was slightly decreased. This is due to irrigation interval was long enough to inhibit the growth. The number of branches of 6 days plant was rise which the branches grow slowly due to the absence of water.

![Figure 3](image3.png)

**Figure 3.** Number of leaves of *Mentha arvensis*. *M. arvensis* was watered every 2 days, 4 days and 6 days that indicates water stress condition. Number of leaves was taken according irrigation intervals by counting manually.

During drought, plant growth is altered such as lower plant height, a smaller number of leaves, and changes in the reproductive phase [6] due to plants need a large amount of water and nutrients through their life cycle and plant development. However, based on Figure 3 all plants show the increase number of leaves. This shows that *Mentha arvensis* can tolerate with the absence of water and grow normally even the water irrigation was controlled. This is because the soil still holds and stores enough water until the next water irrigation for their growth and development. But, the plant under 2 days and 4 days of water treatment show a slightly fluctuated pattern on their leaves number due to the presence of pest which is Cabbage Semilooper that ate the leaves. Condition of the plants are partially shade to avoid from rainfall make the Cabbage Semilooper existed. The Cabbage Semilopper has been recorded as key pest of *Mentha arvensis* [7].
Figure 4. Root length of Mentha arvensis. M. arvensis was watered 2 days, 4 days and 6 days that indicates water stress condition. Root length was measured after treatment ended.

In drought condition plants optimize the water uptake by improving the root system by means of growing too deeply in the soil area and by stimulating molecular and biochemical pathways to modulate water transport [8]. Based on Figure 4, it shows that 6 days have the shortest root length (10.1 cm) compared to the root length of 2 days plant (11.33 cm). This is due to the root was under water-stress conditions to facilitate water absorption and to maintain osmotic pressure [3]. The root of 4 and 6 days of water treatment have many root hairs to maximize available water uptake in the soil area instead of elongating their root.

Figure 5 shows the root weight decreased. 4 days have the highest root weight (0.056 g) compare to others because the largest increase root dry weight tended to occur in the deeper soil layers. Then, 6 days of water treatment receive less water and their root weight was the lowest (0.029 g) due to the non-availability of water in the soil.

Figure 5. Root weight of Mentha arvensis. M. arvensis was watered every 2 days, 4 days and 6 days that indicates water stress condition. Root weight was weighed after root length was measured.

Relative water content (RWC) is a useful indicator to determine the water balance of a plant and it related with the number of leaves. This is because, when drought occurs, the leaves tend to lower their number of leaves to maintain the RWC and lower the transpiration process [9]. Based on Figure 6, 2 days plants have the highest RWC (83 %) as they always receive enough water compared to 4 days (80 %) and 6 days (59 %). Thus, this shows that 2 days plant can tolerate with water stress in the short period. RWC for 6 days was the lowest because they did not receive water for long time that make it loss more water or dehydrated.
Figure 6. Relative water content (RWC) of *Mentha arvensis*. *M. arvensis* was watered every 2 days, 4 days and 6 days that indicates water stress condition.

4. Conclusion
The application treatment of drought and flood stress in *Mentha arvensis* on their growth rate was successfully achieved. Based on the result, *Mentha arvensis* at 4 days and 6 days of water treatment were more affected by the water stress. This shows that 4 days and 6 days of water treatment undergo slow growth rate in their plant height, number of branches and number of leaves compared to 2 days of water treatment. From the observation of the plant on their physical appearance also found that 2 days of water treatment are fresher compared to 4 days and 6 days of water treatment. Thus, *Mentha arvensis* can tolerate better with water stress and it can grow best in 2 days condition.

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References
[1] Biswas N N, Saha S and Ali M K 2014 Antioxidant, antimicrobial, cytotoxic and analgesic activities of ethanolic extract of Mentha arvensis L. *Asian Pacific Journal of Tropical Biomedicine* 4(10)792–797
[2] Ak Ş and Lösel D M 2006 *Plant Water-Stress Response Mechanisms*. Retrieved from [www.intechopen.com](http://www.intechopen.com)
[3] Lisar S Y S, Motafakkerazad R, Hossain M M and Rahman I M M 2012 *Water Stress in Plants Causes. Effects and Responses Introductory Chapter* in *Water Stress in Plants: Causes, Effects and Responses*
[4] Sharp R E, Hsiao T C, Silk W K, Resources W and California R E S 1990 Growth of the Maize Primary Root at Low Water Potentials1 Role of Growth and Deposition of Hexose and Potassium in Osmotic Adjustment *Plant Physiology* 93(4)1337–1346
[5] Shao H B, Chu LY, Jaleel CA and Zhao CX 2008 Water-deficit stress-induced anatomical changes in higher plants. C. R. Biol. 331 2015–2225
[6] Ciríaco E, Silva D, Albuquerque M, Neto A A, Junior C S and Bosco A B De 2013 *Responses of Organisms to Water* Şener Akıncı (Ed)
[7] Verma J S 2006 Insect Pest Problem In Medicinal Plants - A Review *Agric. Rev.* 27(2) 130–135
[8] Caser M, Angiolillo F D, Chitarra W, Lovisolo C, Ruffoni B, Pistelli L and Scariot V 2016 Water deficit regimes trigger changes in valuable physiological and phytochemical parameters in *Helichrysum petiolare*, Hilliard & B. L. Burtt (Eds) *Industrial Crops & Products* 83 680–692
[9] Genetique U F R De 1997 Relationships between relative water content and growth parameters under water stress in barley: a QTL study *New Phytologist* 137(1) 99–107