Analysis of physiological characters and yield quality of several sweet potato (*Ipomoea batatas* L.) genotypes at various watering levels in rainfed paddy field

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Abstract. Analysis of the physiological characteristics of several sweet potato genotypes at various watering levels in rainfed paddy field indicated that the adaptability of sweet potato genotypes was resistant to drought stress. This research aims to determine the physiological character and yield quality of several sweet potato genotypes (Beta 1 Variety, Perbaungan Accession, and Cengkeh Turi Accession) at various levels of watering (P1 (1 month watering), P2 (2 months watering), and P3 (4 months watering)) in rainfed paddy fields. The research was carried out in the paddy field of Tandem Hilir I Village Deli Serdang and the analysis was carried out in the Tissue Culture Laboratory of the Faculty of Agriculture, the University of Sumatera Utara from March-July 2019. The results of this research indicated that some sweet potato genotypes had no significant effect on the physiological character but had a significant effect on fresh tuber grading. Cengkeh Turi accessions with orange colour tuber had the highest production in the A-class fresh tuber grading category while the Perbaungan accession with orange colour tuber had the lowest production in C-class fresh tuber grading. The watering levels treatment also did not have a significant effect on the physiological character and tuber yield quality.

1. Introduction

Sweet potato is a plant that includes as a secondary crop beside rice, can function as a substitute for staple food because sweet potato is a source of carbohydrates [1]. Increasing sweet potato production can be done in various ways, one of which is the expansion of new planting areas. Expansion of the new planting area is done by using paddy fields. In some production centres, sweet potatoes are planted in paddy fields in the dry season after the paddy harvested. Planting sweet potatoes in paddy fields can provide better benefits as well as functional food providers [2].

Water is a vital component for plants because it is needed in large quantities for plant growth and development [3]. The response of plants to water shortages can be seen based on aspects of physiology, morphology, growth rates, and also productivity [4]. Watering on sweet potato plants in drought consists of three levels of irrigation, namely: P0 (very limited irrigation) = the plants were watered from planting to four weeks with an interval of 10 days, P1 (limited irrigation) = plants were...
watered from planting to eight weeks with interval of 10 days, P2 (optimum irrigation) = the plants were watered from planting to harvest with an interval of 10 days [5].

Efforts that may still be made to increase sweet potato production include using high-yielding seeds and local seeds that are able to overcome problems on dry land. By using superior seeds and local seeds, it is expected to identify the sweet potato clones that are resistant to drought [6]. This research aim was to determine the physiological character and yield quality of several sweet potato (Ipomoea batatas L.) genotypes (Beta 1 Variety, Perbaungan Accession, and Cengkeh Turi Accession) at various watering levels (P1, P2, and P3) in rainfed paddy field.

2. Material and method
The experiment was conducted in March-July 2019 in the rainfed paddy field of Tandem Hilir I Village, Hamparan Perak Subdistrict, Deli Serdang Regency, and the analysis was carried out at the Tissue Culture Laboratory of the Faculty of Agriculture, University of Sumatera Utara. This research used a randomized block design with two factors, the first factor was the local sweet potato genotype (Beta 1 Variety, Perbaungan Accession, and Cengkeh Turi Accession) and the second factor was watering P1, P2 and P3 (months/10 days). This research started from land preparation, planting media preparation, planting, application of watering, taking care of the plants, fertilizing, and analysis of physiological parameters which include total chlorophyll amount, relative leaf water content, superoxide dismutase enzyme, and fresh tuber grading according to SNI number 01-4493-1998 with criteria (A-class: tuber weight > 200 g/tuber, B-class: tuber weight > 100 - 200 g/tuber, and C-class: tuber weight 75 - 100 g/tuber).

Watering is done every 10 days by watering the plants to the soil in accordance with the treatment and soil moisture is measured. Data collection on physiological characters includes total chlorophyll amount, relative leaf water content, superoxide dismutase enzyme which was done when the plants are 4 WAP and 8 WAP (Weeks After Planting). Observation of fresh tuber grading was done when the plant was 16 WAP. Data were analysed statistically by the F test and continued by the Duncan Multiple Range Test (DMRT) at α 5%.

3. Results and discussion
Data presented in Table 1 and Table 2 indicated that the amount of chlorophyll in the three genotypes was not significantly different. Cengkeh Turi Accession had the highest average total chlorophyll compared to other genotypes. This was because the ability of each plant to absorb sunlight is different, including in adapting to the growth environment and formation of chlorophyll. The factors that influence the formation of chlorophyll include, light, genes, elements N, Mg, Fe as catalysts in the synthesis of chlorophyll. While the amount of chlorophyll at various watering levels was also not significantly different [7]. At 1 month and 2 months watering had a low chlorophyll value. It was suspected that the lack of water can inhibit the physiological processes of plants and cause cell damage to plants. The lack of water availability would inhibit chlorophyll synthesis in leaves due to decreased photosynthesis rate and an increase in temperature and also transpiration which led to chlorophyll disintegration [8].

Table 1. Total chlorophyll amount at 4 WAP of some local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype           | Watering 1 Month | Watering 2 Months | Watering 4 Months | Average of Total Chlorophyll |
|--------------------|------------------|-------------------|-------------------|-----------------------------|
| Beta 1 Variety     | 1.97             | 2.14              | 2.51              | 2.21                        |
| Perbaungan Accession| 1.75             | 1.65              | 2.18              | 1.86                        |
| Cengkeh Turi Accession | 2.13        | 2.44              | 2.19              | 2.25                        |
| Average of Watering| 1.95             | 2.08              | 2.29              |                             |
Table 2. Total chlorophyll amount at 8 WAP of some local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype          | Watering       | Total Chlorophyll | 1 Month | 2 Months | 4 Months |
|------------------|---------------|-------------------|---------|----------|----------|
|                  |               | mg/g.             |         |          |          |
| Beta 1 Variety   | 0.94          | 0.87              | 1.25    | 1.02     |
| Perbaungan Accession | 0.91      | 1.06              | 0.50    | 0.83     |
| Cengkeh Turi Accession | 1.00      | 0.81              | 1.46    | 1.09     |

Data presented in Table 3 and 4 indicated that the relative water content of leaves in the three genotypes had no significant effect. This was because the three sweet potato genotypes have a good ability to adapt to its planting environment, hence able to develop a better root system to absorb water and maintain the relative water content of the leaves. Sufficient water, root development will be perfect and can absorb available nutrients hence it can increase plant growth, but if water shortages, it will be inhibited the growth especially in the vegetative phase [9]. The presence of sufficient water during plant growth has an impact on the process of nutrient absorption and a smooth rate of photosynthesis, hence plant growth is increased. Likewise, at various levels of watering the relative water content of leaves also did not have a significant effect. This was because the status of leaf water as a physiological indicator that is widely used resulted in plants poorly in adapting to drought stress. The relative water content is affected by the harvest season and irrigation hence drought stress can reduce the value of relative water content significantly [10].

Table 3. Leaves relative water content at 4 WAP of some local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype          | Watering       | Average of Water Content | 1 Month | 2 Months | 4 Months |
|------------------|---------------|--------------------------|---------|----------|----------|
|                  |               | %                        |         |          |          |
| Beta 1 Variety   | 44.59         | 43.27                    | 4.45    | 30.77    |
| Perbaungan Accession | 53.26      | 52.52                    | 52.53   | 52.77    |
| Cengkeh Turi Accession | 43.99      | 56.33                    | 32.19   | 44.17    |

Table 4. Leaves relative water content at 8 WAP of some local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype          | Watering       | Average of Water Content | 1 Month | 2 Months | 4 Months |
|------------------|---------------|--------------------------|---------|----------|----------|
|                  |               | %                        |         |          |          |
| Beta 1 Variety   | 49.25         | 97.04                    | 50.89   | 65.73    |
| Perbaungan Accession | 50.92      | 48.08                    | 49.83   | 49.61    |
| Cengkeh Turi Accession | 48.44      | 48.28                    | 46.40   | 47.71    |

Data in Table 5-6 indicated that the superoxide dismutase enzyme in the three sweet potato genotypes had no significant effect. Cengkeh Turi Accession had the highest SOD enzyme and Perbaungan accession had the lowest SOD enzyme. This was because Cengkeh Turi Accession was still able to increase resistance in overcoming oxidative stress, namely drought stress. Superior seeds and local seeds were expected to be able to find out the sweet potato clones that were resistant to...
drought [9]. Each plant had different SOD activities, namely high, medium and low activity [11]. These different SOD activities are caused by different flavonoid content and different types of flavonoids, thus providing different antioxidant activity. Likewise, the superoxide dismutase enzyme at various levels of watering (4 WAP and 8 WAP) did not have a significant effect. This was presumably because the plant was physiologically damaged under water stress conditions. Indicated that one of the causes of damage to plants under stress conditions is oxidative stress caused by the accumulation of Reactive Oxygen Species (ROS) compounds such as oxygen (O₂), hydrogen peroxide (H₂O₂), superoxide (O₂⁻) and radicals hydroxyl (OH), due to the inhibition of photosynthesis by closing the stomata causing oxidative damage to photosynthetic organelles [12].

Table 5. Superoxide dismutase enzyme at 4 WAP on various local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype                  | Watering |   |   |     |
|---------------------------|----------|---|---|-----|
|                           | 1 Month  | 2 Months | 4 Months | Average of SOD |
| Beta 1 Variety            | 54.03    | 41.39    | 32.48    | 42.63 |
| Perbaungan Accession      | 17.96    | 62.31    | 39.12    | 39.80 |
| Cengkeh Turi Accession    | 65.08    | 30.56    | 54.15    | 49.93 |
| Average of Watering       | 45.69    | 44.75    | 41.92    |       |

Table 6. Superoxide dismutase enzyme at 8 WAP on various local sweet potato genotypes at various watering levels in rainfed paddy field

| Genotype                  | Watering |   |   |     |
|---------------------------|----------|---|---|-----|
|                           | 1 Month  | 2 Months | 4 Months | Average of SOD |
| Beta 1 Variety            | 50.95    | 26.69    | 27.10    | 34.91 |
| Perbaungan Accession      | 33.97    | 31.64    | 50.32    | 38.64 |
| Cengkeh Turi Accession    | 31.80    | 16.79    | 91.78    | 46.79 |
| Average of Watering       | 38.91    | 25.04    | 56.40    |       |

The observation of fresh tuber grading in several local sweet potato genotypes significantly affected on A and C class (Table 7). Cengkeh Turi and Perbaungan Accession have the highest production when compared to Beta 1 variety. This was presumably because local genotypes are able to adapt to drought stress environments that utilize some of the photosynthesis results which are transplanted into tubers. The high production of a variety is because the variety can adapt to the environment. The genetic potential of a variety is very supportive in the success of farming [13]. While fresh tubers grading at various levels of watering did not significantly affect (Table 8). 1-month watering produced the lowest grading compared to other watering levels. This was because very limited watering can reduce the quality of tuber yields. The amount of tuber yield loss was very dependent on the intensity of stress, the type of soil and the variety/clones used [14]. Under conditions of water stress, plant biomass, leaf area and weight and tuber weight decreased and there was a close correlation between the vegetative part of the plant and tuber yield [15].
Table 7. Fresh tuber grading of several local sweet potato genotypes in rainfed paddy fields

| Genotype                  | Grading |
|---------------------------|---------|
|                           | A       | B       | C       |
| Beta 1 Variety            | 0.00 c  | 1.00    | 0.00 c  |
| Perbaungan Accession      | 3.00 a  | 2.00    | 1.33 a  |
| Cengkeh Turi Accession    | 1.67 b  | 2.33    | 1.00 b  |

Note: Numbers followed by the same letters indicated no significant difference in Duncan's Multiple Range Test at α = 5%.

Table 8. Fresh tubers grading with various levels of watering in rainfed paddy fields

| Genotype                  | Grading |
|---------------------------|---------|
|                           | A       | B       | C       |
| One month watering        | 1.33    | 1.67    | 0.67    |
| Two months watering       | 1.33    | 1.67    | 0.67    |
| Three months watering     | 2.00    | 2.00    | 1.00    |

4. Conclusion
Evaluation of the physiological parameters of the three local sweet potato genotypes in rainfed paddy fields had no significant effect. However, it had a significant effect on A and C class fresh tubers grading, namely on Cengkeh Turi and Perbaungan Accession, while the level of watering had no significant effect on the parameters of physiology and fresh tubers grading.

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