Effect of Drought Stress on Initial Growth of Five Sugarcane Clones in Peat Media

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***Abstract*—** *Sugarcane development on peatlands is constrained by drought conditions when entering the dry season, especially when climate anomalies occur, the dry season period becomes longer, as a result the number of tillers decreases and growth is not optimal. Planting drought stress-tolerant sugarcane clones through growth indicators is one solution to obtain clones that have the potential to be cultivated on peatlands. The use of drought tolerant clones is more profitable in the long term. The results of this study showed that the availability of media water and sugarcane clones had a significant effect on sugarcane plant height at early growth, but did not affect to the number of leaves and number of tillers. Sugarcane stem diameter at initial growth was influenced by a combination of media water availability and five sugarcane clones. PS881 is a clone that can adapt to drought stress conditions in peat media based on growth indicators of plant height, stem diameter and number of leaves.*

***Keywords*— peat, clone, drought, growth, sugarcane.**

I. INTRODUCTION

Sugarcane is a plant that has the potential to be cultivated in West Kalimantan to fulfill sugar needs. In 2018, the average sugarcane production in Kalimantan was 410 kg/ha/year. This means that sugarcane has the potential to be developed in West Kalimantan as support for the government to achieve sugar self-sufficiency in 2024. According to [1] the Kalimantan area is one of the suitable areas for sugarcane production by taking into account the water deficit and harvest time. Efforts to increase sugarcane development can be carried out on sub-optimal land on peatlands with the application of appropriate technology and processing systems [2]. However, drought conditions often occur when entering the dry season due to increasingly limited water supply and climatic anomalies that result in a longer dry season, as a result, plants are stressed in conditions of water shortages so that they cannot grow and develop optimally. Even though the availability of adaptive clones on sub-optimal land is still limited and becomes a problem in the development of sugarcane on peatlands. Drought stress is a limiting factor in the early growth phase of tiller formation [3]. In the vegetative phase, lack of water causes a decrease in the number of tillers, stem elongation which ends in a decrease in sugar yield because in the vegetative phase there is a process of cell division, cell elongation, and the initial stage of cell differentiation which will develop stems, leaves and root systems which will later be used for produce sugar yield.

One strategy to solve the problem of drought is by planting sugarcane clones tolerant of drought stress through growth indicators for several sugarcane clones that have the potential to be cultivated on peatlands. The use of drought tolerant clones is more profitable in the long term. Plants can grow in conditions of stress by adapting to develop their morphological and physiological processes. [4] Resulted plants experiencing drought conditions will survive by reducing CO_2 assimilation by 66% and their transpiration through stomata closure and will increase or recover after irrigation. One of the drought tolerance of sugarcane clones is determined based on its growth.

Research conducted by [5] using five sugarcane clones resulted that the PS881 clone and PS864 clone regression test resulted in a regression coefficient of less than one, which means that both clones can adapt to a less than optimal environment. PS881 clone planted on dry land vertisol soil with a spacing of 30 cm x 100 cm with single bud planting material produced the best productivity [6]. [7] Showed that the initial growth of sugarcane plants can run optimally if the water capacity in the soil is at least 50% and at least 80% in the stem elongation phase. If the soil water content decreases to 40% (suboptimal) it can reduce 50% of the number of tillers formed at 2-4 BST and at 100% optimal soil water content or in a state of field capacity the number of tillers increases from 5.04 tillers/polybag to 7 ,33 tillers/ polybag.

The purpose of this study was to determine the effect and interaction of water availability in media and sugarcane clones on early growth of sugarcane on peat media and clones that are resistant to drought stress in peat media based on growth indicators. Research on the resistance of sugarcane clones to drought stress through growth indicators can be used as a basis for starting sugarcane cultivation on peatlands during the dry season and developing further research.

II. RESEARCH METHODS

The research was carried out at the Greenhouse and Plantation Plant Science Laboratory, Pontianak State Polytechnic, West Kalimantan for 5 months.

2.1 Materials and Equipment

The materials used were peat soil, dolomite, cow manure compost, fungicide, six sugarcane budchip clones, polybags. The equipment used were soil sieve, hoe, ruler, thermometer, test tube, Erlenmeyer, beaker glass, stirrer, microscope, preparations, clear nail polish, 21D spectrometer, analytical balance.

2.2 Research Implementation

2.2.1 Budchip Germination

The planting material used was five sugarcane budchip clones. The budchips are first soaked in water at a temperature of 50◦C for 15 minutes [8] followed by fungicide immersion, after which the budchips are germinated in plastic in a dark room until shoots appear. After that, it is sown using a nursery tray containing peat soil that has been mixed with compost evenly, then maintenance is carried out until the age of 2 weeks [9].

2.2.2 Making Planting Media

The planting medium used is peat soil with saprik maturity. The media was made by mixing evenly the sifted peat soil with cow manure compost in a ratio of 1:1, then added dolomite until the pH reached 6-7. The processed media was put into polybags measuring 30 cm x 30 cm and incubated for one week.

2.2.3 Planting

Budchips that have been sown and have grown into perfect seeds are selected and selected field capacity seeds, free from plant-disturbing organisms. Planting is done in one polybag with one planting hole filled with 1 sugar cane seed. The environmental design used in this research is the Split Plot Design which consists of two factors, namely the first factor is the availability of media water (field capacity/100% and 40% drought stress) which is used as the main plot and the second factor is 5 Sugarcane clones (NX01, BM1612, PS881, BM1617, Local) used as sub-plots. The treatment was repeated 3 times and each replication contained 3 samples.

2.2.4 Drought Stress Treatment Application

Drought stress treatment was carried out by maintaining the soil water content (KAT) and carried out at 1 BST for 1 month. At the beginning of the study, all treatments were conditioned in 100% KAT (field capacity) and then weighed to determine the wet weight of polybag soil (BBP). Then the soil in the polybag is allowed to dry until the KAT is suitable for treatment. The field capacity treatment was maintained at 100% moisture content and 40% for the drought stressed treatment. To maintain KAT according to treatment, each polybag needs to be added with water. The amount of water that must be added

to increase the KAT by 1%, then a soil sample is taken when the KAT is 100% and then weighed (BAC). The soil is oven-baked to obtain its dry weight (BKC) [7].

The amount of water contained in the soil sample (JAC) is JAC = BAC – BKC …… ml

The amount of water contained in each polybag (JAP) is $JAP = \frac{BBP}{BAC} \times JAC$…….…….. ml

The amount of water that must be added to increase KAT by 1% is $TA = \frac{JAP}{100} \times JAC$……..… ml

2.2.5 Maintenance

Maintenance activities are controlling plant-disturbing organisms, fertilization. Weed control is carried out both weeding in and weeding out manually, while pest and disease control is carried out according to the economic threshold. Fertilization was carried out 2 times, when the plants were 3-4 weeks old using NPK 25 g and 12.5 g ZA/polybag and the second time at 3 BST with a dose of 25 g ZA/polybag [10].

2.2.6 Data Analysis

Observational data were analyzed using Analysis of Variance at 5% level and if there was a significant effect, then further tested with Duncan's Multiples Range Test at 5% level.

III. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height is an indicator of growth that can be seen from the increase in plant size as a result of assimilation. Plants will respond through the expression of plant height when under stress condition. Plant growth is characterized by an increase in the size, shape, number and volume of plants.

TABLE 1
THE EFFECT OF DROUGHT STRESS ON THE HEIGHT OF FIVE SUGARCANE CLONES IN PEAT MEDIA

Clones	Plant Height (cm)		
	Field Capacity	Drought	Average
NX01	165.56	123.39	144.47 ab
BM1612	150.73	115.53	133.13 bc
PS881	175.86	129.86	152.86 a
BM1677	167.47	109.61	138.54 b
Local	139.77	105.39	122.58 c
Average	159.88 a	116.76 b	

Note: Numbers followed by different letters in the same column show significant differences according to the Duncan Multiple Range Test at 5% level.

Plant height was not affected by the combination of media water availability and five sugarcane clones. The availability of media water and five sugarcane clones significantly affected plant height although there was no interaction between the two (Table 1). Drought stress caused a significant decrease in the average plant height of 43.12 cm and clone PS881 was the clone that had the highest plant height of 152.86 cm compared to other clones under field capacity conditions and drought stress, followed by clone NX01 with plant height of 144.47 cm (Figure 1). This means that PS881 clones with genetic characteristics of early maturity can adapt to drought stress conditions. One of the responses of plants to stress is to accelerate their maturity with the aim of minimizing the impact caused by stress [11]. In addition, genetics is an innate trait that affects plant growth. Sugarcane growth is determined or is the result of the interaction between genetics and the environment, including drought stress. The genetic properties of different sugarcane clones have a significant effect on the total fresh weight of the plant, this condition is due to differences in responses to the environment [12]. The Indonesian Sugar Development Research Center has developed a PS881 clone with the characteristics of the clone being able to grow well on light to heavy soils. PS881 clone with early ripening characteristics is a clone that is recommended to be planted on land with

a heavy textured land typology [13]. According to [14] drought stress reduced the plant height of barito tabby plants by 10.30%.

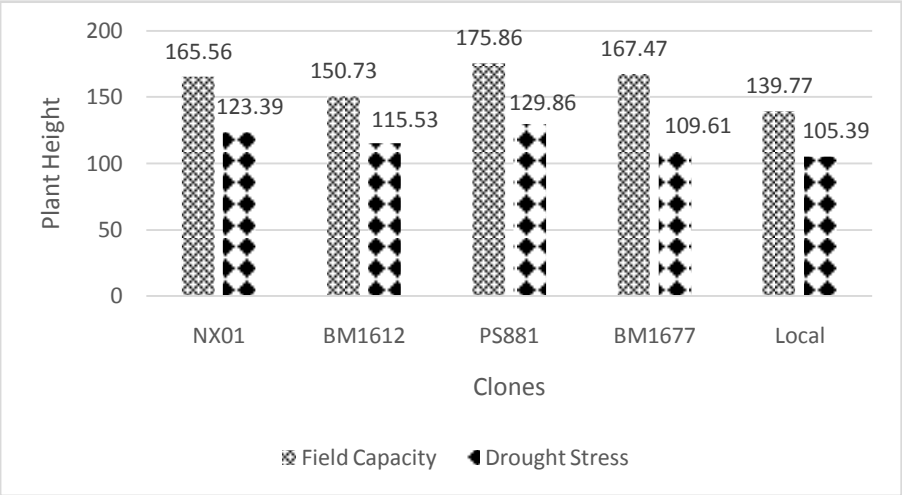

FIGURE 1: Effect of Drought Stress on Plant Height of Five Sugarcane Clones on Peat Media

3.2 Stem Diameter

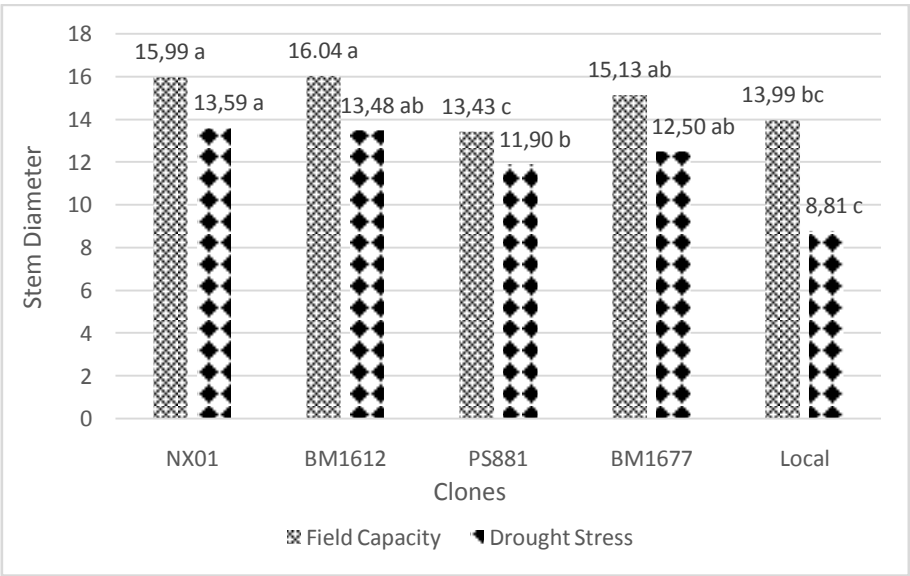

FIGURE 2: Effect of Drought Stress on Stem Diameter of Five Sugarcane Clones in Peat Media

The combination of water availability of planting media and five sugarcane clones affected the stem diameter of sugarcane (Figure 2). Drought stress caused the average stem diameter of five sugarcane clones to decrease. Drought stress caused the average stem diameter of five sugarcane clones to decrease. These results are in line with research conducted by [15] that drought stress resulted in a significant reduction in the size of sugarcane stems by 1.75 mm because cell division and elongation were disrupted. Under conditions of field capacity (100%) water availability, clone BM1612 had the largest stem diameter and was not significantly different from clones NX01, BM1677 as well as under drought stress conditions (40%). However, during drought stress conditions, clone PS881 was the clone that decreased its stem diameter by at least 1.53 cm compared to the other clones. This condition is a form of response to drought stress. This means that PS881 clone can adapt to drought stress conditions in peat media. Drought stress hinders the flow of water from the xylem to the meristematic tissue, resulting in inhibition of mitosis and cell enlargement. The main constituent of plant tissue, especially meristematic tissue, is water, which plays a role in activating physiological processes either directly or indirectly by maintaining cell turgidity. [5] that clone PS881 showed significantly better stem diameter, stem height, stem weight and number of internodes on dry land on ultisol soils.

3.3 Number of Leaves

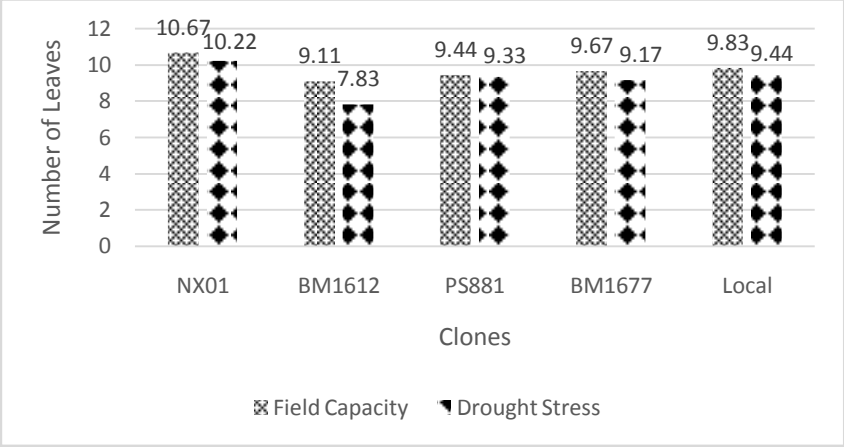

FIGURE 3: The Effect of Drought Stress on the Number of Leaves of Five Sugarcane Clones in Peat Media

Figure 3 shows the results of observing the number of leaves of 5 sugarcane clones in field capacity and dry media water availability. These results showed that the number of sugarcane leaves is not affected by the availability of media water, clones or a combination of both. Based on direct observation on the availability of water in field capacity media, clone NX01 had the highest number of leaves, namely 10.45 and clone BM1612 had the least number of leaves, namely 8.47. Drought stress conditions resulted in a decrease in the average number of leaves in several sugarcane clones. PS881 clones tended to have the least number of leaves decreased compared to other clones under field capacity and dry conditions (40%), followed by local clones and BM1612 clones decreased leaf numbers the most by 1.28. This means that the PS881 clone has the highest resistance to drought stress on peat media compared to the other four sugarcane clones tested. The PS881 clone was able to maintain the growth of the number of leaves under conditions of field capacity water availability in the media (100%) and dry stress conditions of 40%. This indicated that the sugarcane clone PS881 was able to maintain turgor pressure at 40% drought stress. Turgor pressure in plants affects plant cell propagation, leaf and flower development and movement in other plant parts. Turgor pressure can be influenced by the availability of water in the media, as a consequence of drought stress plants will tend to maintain turgor pressure [16].

3.4 Number of Tillers

The combination of media water availability and sugarcane clones had no effect on the number of tillers. The results of direct field observations showed that under field capacity conditions of water availability, clone BM1677 was the clone that had the highest number of tillers, namely 4 tillers and clone NX01 was the clone which had the least average number of tillers, namely 1.67. However, in drought stress conditions, clone NX01 increased the average number of tillers by one tiller, followed by local clones, while other clones, namely BM1612, PS881 and BM1677 under drought stress conditions, decreased the number of tillers by an average of 0.65 (Figure 4). As long as sugarcane plants are in conditions of limited water supply or drought stress, cell development will be hampered so that tiller growth will also decrease [16] [17] [18].

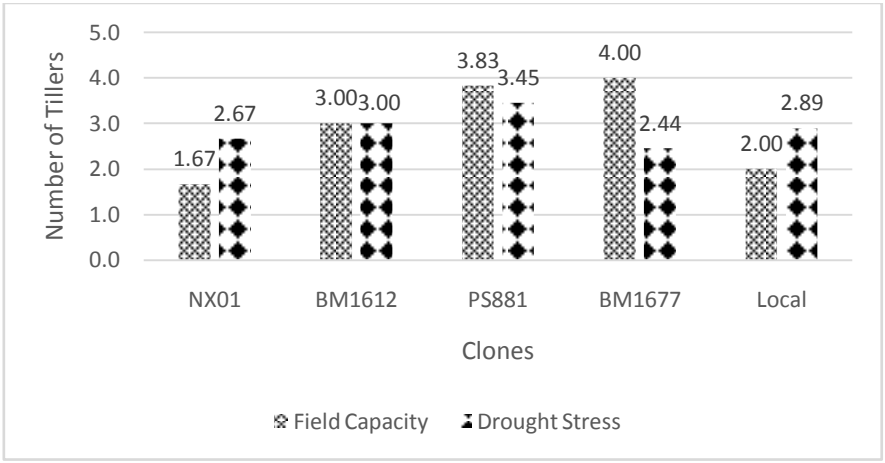

FIGURE 4: The Effect of Drought Stress on the Number Tillers of Five Sugar Cane Clones in Peat

IV. CONCLUSION

The availability of media water and sugarcane clones affected the height of sugarcane plants at initial growth, but did not affect the number of leaves and number of tillers. The diameter of the stems of sugarcane in early growth was influenced by the combination of the availability of media water and five sugarcane clones. PS881 is a clone that can adapt to drought stress conditions (40%) in peat media based on growth indicators of plant height, stem diameter and number of leaves.

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