Original Research Article

The Effect of Accessions on the Growth and Adaptation of Pineapple (*Ananas comosus* (L.) Merr.) Under Drought Stress Conditions

ABSTRACT

The results showed an interaction between pineapple accessions and dry period on stomatal density variables. The effect of accession showed significant differences in plant morphology variables of plant height, number of leaves, root length, root fresh weight, and crown fresh weight. The effect of dry period treatment shows significant differences in plant height, number of leaves, root dry weight, crown fresh weight, and crown dry weight. Giving 15 days of dry period (DDP) showed a decrease in the percentage of plant height growth by 3,79% (accession 10), 22,44% (accession 13), 19,71% (accession 14), and 23,00% (accession 17). Meanwhile, 30 DDP showed a decrease in the percentage of plant height growth by 13,13% (accession 10), 28,89% (accession 13), 16,27% (accession 14) and 12,14% (accession 17). Accessions 14 and 17 showed drought sensitivity index results as medium tolerant accessions at 30 DDP. Meanwhile, accessions 10 and 13 showed sensitive accessions to drought stress for 30 DDP.

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Keywords: *Drought stress, Crassulacean Acid Metabolism (CAM), Drought sensitivity index (ISK), Pineapple, chlorophyll*

1. INTRODUCTION

Pineapple (Ananas comosus (L.) Merr.) is one of the leading agricultural commodities that has great potential and is widely cultivated in Indonesia. Its distribution is quite extensive due to agro-climatic conditions that support its growth in various regions (Boudianingsih *et al.*, 2017). Pineapple production ranks third after banana, orange and mango. As a tropical fruit, pineapple is widely developed because its cultivation and maintenance are quite easy.

Pineapple plants have bright prospects in the development of the agricultural sector in Indonesia. Based on data from the Central Statistics Agency (2022), pineapple production has increased from 2,196,458 tons in 2019 to 2,886,417 tons in 2021. In Bengkulu Province, pineapple production also continues to increase, from 236 tons in 2019 to 384 tons in 2021. Although production continues to increase, pineapple cultivation still faces various challenges, one of which is drought stress. Drought occurs when the water content in the soil is at the minimum limit that still allows plants to grow and produce (Dwi Zulfita *et al*., 2012).

This condition can reduce crop yields due to reduced water availability, low nutrient content in the soil, and non-optimal pH. In the dry season, limited water is often a major constraint to plant growth and development. The optimal soil acidity level (pH) for pineapple growth ranges from 4.5 - 6.5. (Cultivation *et al*., 2024). In addition, pineapple is quite tolerant of drought conditions and grows well with rainfall between 1,000 - 1,600 mm/year (Nurgoho *et al*. 2014), and the optimal temperature for pineapple plant cultivation is between 24 - 32°C (Rahmat *et al*. 2014).

Pineapple naturally has resistance to drought conditions (Xerophytes), because it is included in the group of crassulacean acid metabolism (CAM) plants. CAM plants open stomata at night to absorb CO2 and close stomata during the day to reduce water loss (Rahmat *et al*., 2014). However, the level of drought resistance may vary depending on genetic and environmental factors. Therefore, selecting accessions that have high tolerance to drought is an important step in increasing pineapple productivity in drylands.

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Pineapple accessions come from different locations and the differences in each accession can be influenced by several factors, such as varietal differences related to plant genetic factors and environmental conditions (Pangaribuan *et al*., 2023). The effect of accession is very significant on the growth, development and adaptation of pineapple plants to environmental conditions, especially when experiencing drought stress. This study aims to analyze the effect of accessions on the growth and adaptability of pineapple, and determine the best pineapple accessions that have high tolerance to drought stress.

2. Materials and Methods

2.1 Time and Location of Research

This research was conducted from May to November 2024, the initial nursery was located in the Experimental Garden of Sukamerindu Village, Sungai Serut Subdistrict, Bengkulu City with an altitude of ± 10 meters above sea level (masl). And for the drought period, it was carried out at the Greenhouse of Medan Baru Agricultural Zone, Kandang Limun, Muara Bangka Hulu Subdistrict, Bengkulu City, which is located at an altitude of ±10 meters above sea level (masl).

2.2 Research Stages

The initial stages in this research began with the preparation of tools and materials. The tools used included rulers, measuring cups, digital scales, ovens, calipers, scissors, and stationery. The materials used consisted of planting media with the composition of soil and manure in a ratio of 1:1:1 (v/v), polybags measuring 30 cm × 30 cm, and basic fertilizers in the form of Kiserit, DAP, and NPK. The planting material used was pineapple fruit buds from four different accessions, originating from the lowlands of Prabumulih City, South Sumatra. The use of planting material samples in the form of pineapple fruit buds is based on the results of identification through a survey method conducted by (Pangaribuan *et al*., 2023). The next stage is the nursery of pineapple fruit buds which is carried out for 4 months on the nursery bed. After the nursery period, transplants were made into polybags measuring 30 cm × 30 cm, accompanied by the application of basic fertilizers in the form of Kiserit, DAP, and NPK at a dose of 0.2 grams per plant. Next, the plants were moved to the *Greenhouse.*

2.3 Dry Period Treatment

The dry period treatment was carried out at 3 levels: watering every 2 days (treatment/control), 15 DDP treatment, and 30 DDP treatment. In the control treatment, watering was done every 2 days when the plants were 90 DAT until 150 DAT. After 150 DAT, watering was repeated every 10 days until 160 DAT. And in the 15 DDP treatment, watering was done 4 times, namely when the plants were 105 DAT, 120 DAT, 135 DAT, and 150 DAT. After 150 DAT, watering was done again for 10 days until 160 DAT. In the 30 DDP treatment, watering was done twice, namely when the plants were 120 DAT and 150 DAT. After 150 DAT, re-watering was performed for 10 days until 160 DAT.

2.4 Observation variable

The observation variables carried out in this research are Plant Height (cm), Number of Leaves (strands), Root Length (cm), Root Diameter (mm2), Root Volume (mL), Root Fresh Weight (g), Root Dry Weight (g), Crown Fresh Weight (g), Crown Dry Weight (g), Stomata Density (mm2) and Leaf Chlorophyll (mg/g) which were carried out in the second month (30 DDP).

2.5 Drought Sensitivity Index

Pineapple tolerance to drought was assessed using the drought susceptibility index (Fischer & Maurer, 1978) with the formula:

$$DSI = \frac{(1 - Y/Yp)}{(-\mathrm{X/Xp}}$$

Description:

DSI: Stress tolerance index
Yp: Average of a genotype under stress
Y: Average of a genotype that does not get stressed
Xp: Average of all stressed genotypes
X: Average of all genotypes that do not get stressed

The stress sensitivity index is measured on the variables of root crown wet weight, root crown dry weight. The criteria for determining the level of salinity stress tolerance is if the value of ISK < 0.5, including the category of tolerant genotypes, 0.5 < ISK < 1.0, including the category of moderately tolerant genotypes (medium), and ISK > 1.0, including the category of sensitive genotypes (Widiastuti *et al.,* 2016).

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3. Research Design

This study was designed using a completely randomized design (CRD) consisting of two factors. The first factor was four local lowland pineapple genotypes from Prabumulih City, South Sumatra. The four accessions were Accession 10 from Sungai Duren village, Accession 13 and Accession 14 from Alai village, and Accession 17 from Karang Endah village. The second factor is drought period, which consists of three levels of treatment, namely watering every 2 days (treatment/control), 15 Dry Days Period (DDP), and 30 DDP treatments. Each treatment combination was repeated 3 times, resulting in 36 experimental units (4 accessions x 3 treatments x 3 replications). Each experimental unit consisted of 5 plants, so the total number of plants used in this study was 180.

4. Results

The results of the analysis of variance on all variables observed in Table 1, showed a very significant interaction effect between accession and dry period on stomatal density variables. Meanwhile, the treatment of pineapple accessions showed a significant effect on plant height, number of leaves, root length, root fresh weight, and crown fresh weight. The treatment of the drought period showed a significant effect on the variables of plant height, number of leaves, root dry weight, crown fresh weight and crown dry weight.

Table 1. Results of Analysis of Variance 30 DDP growth observation

Observation Variables	F Value Calculate			KK %
	Accessibility (P)	Dry Period (N)	Interaction (P x N)	
Plant Height	6,34**	6,19**	0,68ns	16,15
Number of Leaves	6,34**	0,91ns	0,46ns	20,53
Root Length	3,23*	0,12 ns	1,49 ns	24,71
Root Diameter	0,46 ns	1,46 ns	1,09 ns	16,62
Root Volume	0,83 ns	0,53 ns	2,03 ns	20,46 T
Fresh Weight Roots	3,71*	2,45 ns	0,93ns	20,89 T
Heavy Dry Roots	3,08 ns	0,89*	1,43 ns	18,6 T
Density of Stomata	1,25ns	0,114ns	3,91**	24,63
Fresh Weight Title	1,54ns	14,28**	1,55ns	20,51
Dry Weight Title	3,83*	6,14**	1,05ns	17,42

Description:: ns= different is not real, *= real difference, **= very real difference, KK= diversity coefficient and T = transformation data.

Observations on stomatal density variables showed a significant interaction between accession and dry period factors. The interaction of accession and dry period showed that each accession responded to drought treatment differently. The control treatment showed a significant difference to accession 14, which had the highest stomatal density of 71.43 mm^2 and the lowest accession 10 of 47.61 mm^2, while accession 13 and accession 17 showed no significant difference. In the dry period of 15 DDP, it showed a significant difference to accession 17 with the highest at 76.53 mm^2 and the lowest accession 13 at 39.11 mm^2, while in the dry period of 30 DDP, it showed a significant difference to accession 10 with the highest at 66.33 mm^2 and the lowest accession 14 at 35.71 mm^2. In contrast, accession 13 and accession 17 were not significantly different. And caused a decrease in the percentage of stomatal density of the four pineapple accessions. Accession 10 experienced a decrease in the percentage of stomatal density of 65.61%, accession 13, 58.66%, accession 14,

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33.70%, and accession 17, 51.68% against the 30 DDP treatment. (Table 2.)

Leaf relative water content showed variation between accessions and treatments. Control treatment, the highest relative leaf moisture content was found in accession 13 at 96.03% and the lowest accession 17 at 93.09%, while the dry period of 15 DDP showed the highest relative leaf moisture content in accession 14 at 94.95% and the lowest accession 17 at 92.43%, then at 30 DDP showed the highest relative leaf moisture content in accession 13 at 91.77% and the lowest accession 17 at 89.75%.

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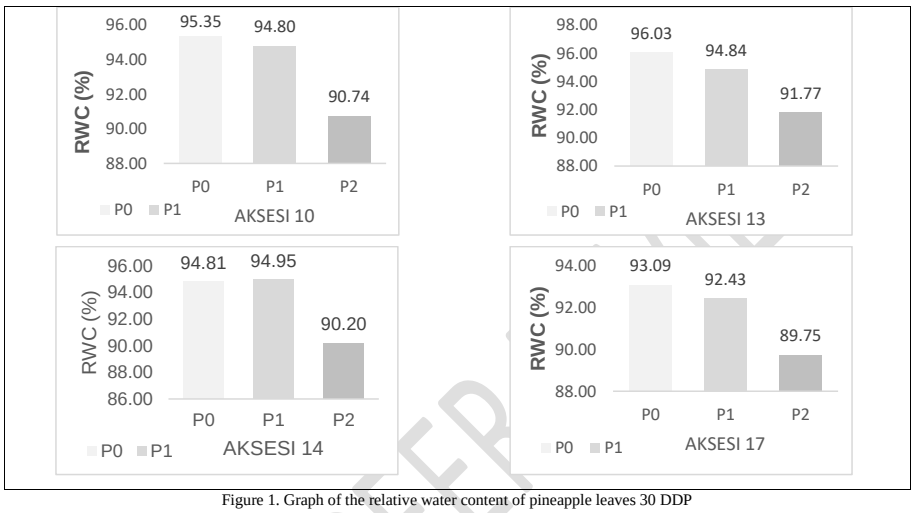

Figure 1. Graph of the relative water content of pineapple leaves 30 DDP

The decrease in leaf relative water content at 15 DDP was the lowest for accession 14 at -0.15%, accession 10, 0.57%, accession 13, at 1.24% and the highest for accession 17 at 0.71%, Meanwhile, the decrease in leaf relative water content at 30 DDP experienced the highest decrease in accession 14 at 4.86%, accession 10, 4.84%, accession 13, 4.43% and the lowest for accession 17 at 3.60%, respectively. This shows that the longer the period of a plant, the greater the percentage of leaf-relative water content.

The 30 DDP treatment showed that accession 13 was not significantly different from accession 14 on the plant height variable of 26.66 cm and 26.33 cm, respectively. Meanwhile, accession 10 was significantly different from accession 17 at 28.66 cm and 22.91 cm. Accession 13 in the control treatment had the highest plant height of 37.50 cm, and accession 17 in the 30 DDP treatment had the lowest plant height of 20.08 cm. The variable number of leaves showed a significant difference in the 15 DDP treatment between accession 10 and accession 13 at 27.33 strands and 17.83 strands, while accession 17 was not significantly different from accession 14 at 17.00 strands and 17.83 strands, whereas, in the 30 DDP treatment showed a significant difference between accession 10 and accession 17 at 25.33 strands and 17.16 strands.

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Table 2: Interaction between pineapple accessions and dry period at 30 DDP observation.

INTERACTION	Observation Variables									
	PH (cm)	NF (strand)	PA (cm)	RD (mm^2)	RL (mL)	RFW (g)	RDW (g)	SD (mm^2)	CFW (g)	CDW (g)

A10P0	33,00 ab	25,16 ab	33,00 ab	1,56 ab	8,33 ab	11,00 a	1,77 abc	47,61 cde	0,6 a	0,08 a
A10P1	31,75 abc	27,33 a	35,66 a	1,53 ab	10,00 a	10,79 a	2,83 ab	51,02 bcde	0,43 bcd	0,07 abc
A10P2	28,66 bcd	25,33 ab	27,66 abcd	1,56 ab	6,66 abc	10,62 a	2,25 abc	66,33 abc	0,32 cd	0,05 cd
A13P0	37,50 a	23,33 abc	28,83 abc	1,53 ab	8,33 ab	8,69 abc	1,40 bc	51,02 bcde	0,60 a	0,08 a
A13P1	29,08 bcd	17,83 c	17,16 d	1,30 b	3,33 c	4,47 c	1,25 c	39,11 ab	0,44 bcd	0,07 abc
A13P2	26,66 bcde	20,50 abc	23,66 bcd	1,76 a	10,00 a	8,94 abc	2,98 a	59,52 abcd	0,32 cd	0,05 cd
A14P0	31,45 abc	21,66 abc	27,5 abcd	1,30 b	6,66 abc	10,23 ab	1,81 abc	71,43 ab	0,43 bcd	0,06 abcd
A14P1	25,25c de	17,83 c	25,00 abcd	1,66 ab	5,00 bc	4,11 c	0,92 c	47,62 cde	0,48 ab	0,07 ab
A14P2	26,33 bcde	18,50 bc	28,16 abcd	1,53 ab	6,67 abc	5,70 abc	1,53 abc	35,71 e	0,39 bcd	0,06 abcd
A17P0	26,08 bcde	18,66 bc	20,33 cd	1,40 ab	6,67 abc	6,32 abc	1,31 bc	54,42 abcde	0,43 bcd	0,06 bcd
A17P1	20.08e	17,00 c	27,16 abcd	1,43 ab	8,33 ab	6,14 abc	1,14 c	76,53 a	0,48 ab	0,06 cd
A17P2	22.91d e	17,16 c	25,66 abcd	1,60 ab	6,67 abc	4,94 bc	1,17 c	52,72 bcde	0,39 bcd	0,05 d

Description: (PH) Plant Height, (NL) Number of Leaves, (RL) Root Length, (RD) Root Diameter, (RFW) Root Fresh, Weight (RDW),Root Dry Weight, (SD) Stomata Density, (CFW) Crown Fresh Weight, (CDW) Crown Dry Weight. (A) Access, (P0) Control, (P1) 15 DDP and (P2) 30 DDP.

Fresh weight of roots in accession 10 showed no significant difference to the control treatment, 15 DDP and 30 DDP accession 10 of 11.00 g, 10.79g, and 10.62g, while accession 17 showed a significant difference to the control treatment, 15 DDP and 30 DDP of 6.32 g, 6.14 g, and 4.94 g respectively. Meanwhile, the root dry weight variable showed a significant effect on the 15 DDP and 30 DDP treatments of accession 13 at 1.25 g and 2.98 g, respectively. (Table 2.)

The effect of accession on growth at 30 DDP showed a significant effect on the variables of plant height, number of leaves, root volume, and crown dry weight. Accessions 13 and 17 showed significantly different plant heights of 31.08 cm and 23.02 cm. Meanwhile, accession 10 at 31.41 cm and accession 14 at 27.67 cm showed no significant difference. Meanwhile, accession 10 showed a significant difference to accession 13 of 25.94 strands and 20.55 strands, while accession 14 and accession 17 showed a significant difference of 19.33 strands and 17.61 strands. The root diameter variable showed no significant difference to accession 10 at 1.55 mm^2, accession 13, 1.53 mm^2, accession 14, 1.50 mm^2 and accession 17, 1.47 mm^2 (Table 3).

Table 3. Effect of accession on 30 DPD growth

ACCESSION	**Observation Variables**									
	PH (cm)	**NF (strand)**	**PA (cm)**	**RD (mm^2)**	**RL (mL)**	**RFW (g)**	**RDW (g)**	**SD (mm^2)**	**CFW (g)**	**CDW (g)**
Accession10	31,14 ab	25,94 a	32,11 a	1,55 a	8,33 a	10,81 a	2,28 a	54,99 a	0,45 a	0,07 a
Accession 13	31,08 a	20,55 b	23,22 a	1,53 a	7,22 b	7,37 a	1,88 a	49,88 a	0,46 a	0,07 a
Accession14	27,67 bc	19,33 b	26,89 a	1,50 a	6,11 b	6,68 a	1,42 a	51,58 a	0,43 a	0,07 a
Accession17	23,02 c	17,61 b	24,39 a	1,47 a	7,22 ab	5,80 a	1,20 a	61,22 a	0,37 a	0,05 b

Description: (PH) Plant Height, (NL) Number of Leaves, (RL) Root Length, (RD) Root Diameter, (RFW) Root Fresh Weight, (RDW) Root Dry Weight, (SD) Stomata Density, (CWF) Crown Fresh Weight, (CDW) Crown Dry Weight

The effect of accession on root fresh weight and root dry weight variables showed no significant difference to the four accessions of 10.81 g, accession 10, 7.37 g, accession 13, 6.68 g, accession 14; and 5.80 g, accession 17. Meanwhile, root dry weight was 2.28 g, accession 10, 1.88 g, accession 13, 1.42 g, accession 14, and 1.20 g, accession 17. Similarly, the crown fresh weight was 0.45 g, accession 10, 0.46 g accession 13, 0.43 g, accession 14, and 0.37 g,

accession 17. Meanwhile, the variable crown dry weight of accession 10 showed significant differences from accession 17 by 0.07 g and 0.05 g, but accession 13 and accession 14 showed no significant difference. (Table 3.)

The dry period treatment showed a significant difference between the control treatment with 15 DDP and 30 DDP on the variables of plant height, crown fresh weight and crown dry weight, where the plant height was (32.00 cm (control), 26.54 cm (15 DDP) and 26.14 cm (30 DDP). The percentage decrease in plant height growth in the 15 DDP treatment decreased by 5.46%, while the 30 DDP treatment experienced a decrease in plant height growth by 5.86%. (Table 4.)

Table 4. Effect of Dry Period on 30 DDP Growth Variables

Dry Period	Observation Variables									
	PH (cm)	NF (strand)	PA (cm)	RD (mm^2)	RL (mL)	RFW (g)	RDW (g)	SD (mm^2)	CFW (g)	CDW (g)
Control	32,00 a	22,21 a	27,41 a	1,45 a	7,50 a	9,06 a	1,98 a	56,12 a	0,52 a	0,70 a
15 DDP	26,54 b	20,37 a	26,29 a	1,48 a	6,66 a	6,38 a	1,57 a	53,57 a	0,42 b	0,06 ab
30 DDP	26,14 b	19,99 a	26,25 a	1,61 a	7,50 a	7,55 a	1,53 a	53,57 a	0,33 c	0,06 b

Description: (PH) Plant Height, (NL) Number of Leaves, (RL) Root Length, (RD) Root Diameter, (RFW) Root Fresh Weight, (RDW) Root Dry Weight, (SD) Stomata Density, (CWF) Crown Fresh Weight, (CDW) Crown Dry Weight.

The effect of the dry period on the variable number of leaves showed no significant difference to the control treatment, 15 DDP and 30 DDP. Where the number of leaves amounted to 22.21 cm (control), 20.37 cm (15 DDP), and 26.14 cm (30 DDP). Similarly, the root diameter variable showed no significant difference in the control, 15 DDP, and 30 DDP treatments of 1.45 mm^2 (control), 1.48 mm^2 (15 DDP), and 1.61 mm^2 (30 DDP), respectively. (Table 4.)

Fresh weight of the crown showed significant differences from the control, 15 DDP, and 30 DDP treatments of 0.52 g (control), 0.42 g (15 DDP), and 0.33 g (30 DDP). And the crown dry weight also showed significant differences from the control, 15 DDP, and 30 DDP treatments of 0.70 g (control), 0.07 g (15 DDP), and 0.06 g (30 DDP).

Table 5. Chlorophyll content of pineapple leaves

Accession	Chlorophyll A (mg/g) FW	Chlorophile B (mg/g) FW	Klorofil Total (mg/g) FW
A10P0	0,50	0,18	0,68
A10P1	0,97	0,25	1,22
A10P2	0,68	0,36	1,04
A13P0	0,96	0,26	1,22
A13P1	0,81	0,20	1,01
A13P2	0,63	0,29	0,92
A14P0	0,65	0,2	0,85
A14P1	0,41	0,14	0,55
A14P2	0,53	0,12	0,65
A17P0	0,68	0,20	0,88
A17P1	0,71	0,29	1,00
A17P2	0,33	0,16	0,49

Description: A (Access), P0) Control, (P1) 15 DDP and (P2) 30 DDP

The total chlorophyll content of pineapple leaves from the four accessions showed a combination of treatment results. In the control treatment, the highest total chlorophyll content was owned by accession 13 at 1.22 mg/g FW, while the lowest was in accession 10 at 0.68 mg/g FW. In the 15 DDP treatment, the highest total chlorophyll content was owned by accession 10 at 1.22 mg/g FW, while the lowest was accession 14 at 0.55 mg/g FW. Meanwhile, the 30 DDP

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treatment showed that the highest total chlorophyll content was owned by accession 10 at 1.04 mg/g FW, and the lowest was accession 17 at 0.49 mg/g FW. (Table 5.)

The variables observed in the drought sensitivity index test were crown and root fresh weight, and crown and root dry weight. The results of the calculation of the drought sensitivity index (ISK) for drought treatment during (15 DDP and 30 DDP) on pineapple accessions showed varying values. Grouping criteria in determining the level of stress tolerance according to (Widiastuti et al., 2016) are divided into three groups, namely if the value of ISK < ISK 1.0 is categorized as a sensitive genotype. (Table 6.)

Table 6. Average Sensitivity Index Results in 15 DDP

Accession	FHW	DHW	WFR	DRW	Average	Result
ACCESSION 10	1,73	1,48	0,04	-14,71	-2,86	T
ACCESSION 13	1,65	2,29	2,25	4,80	2,75	P
ACCESSION 14	-0,43	-1,25	3,54	38,26	10,03	P
ACCESSION 17	1,26	1,70	0,07	5,85	2,22	P

Description: FHW = Fresh Headline Weight; DHW = dry heading weight; WFR = Weight of fresh roots; DRW = Dry root weight; P = branch; and T = Tolerant

Table 7. Average Sensitivity Index Results 30 DDP

Accession	FHW	DHW	WFR	DRW	Average	Result
Accession 10	1,50	1,85	0,18	1,04	1,14	P
Accession 13	1,54	1,52	-0,14	2,57	1,37	P
Accession 14	0,19	0,02	3,97	-0,91	0,82	M
Accession 17	0,95	0,78	1,40	-0,57	0,64	M

Description: FHW = Fresh Headline Weight; DHW = dry heading weight; WFR = Weight of fresh roots; DRW = Dry root weight; P = branch; M = Medium Tolerant; and T = Tolerant

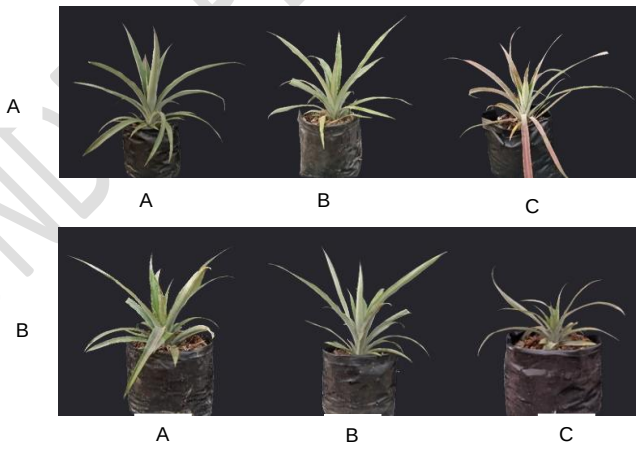

Figure 2. Drought stress behavior of pineapple, A = Accession 13, (Sensitive), B = Accession 17, (Medium), A (Control), B (15 DDP), C (30 DDP).

Drought sensitivity index (ISK) based on the results of the four accessions to the treatment (15 DDP) showed that accessions 13, 14, and 17 were categorized as Sensitive, while accession 10 was grouped as Tolerant. Meanwhile, in the 30 DDP treatment, accessions 14 and 17 were grouped as Medium to the treatment (30 DDP)..(Tables 6 and 7.)

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5. DISCUSSION

Results showed an interaction of stomatal density with accession and dry period. In the Crassulaceae Acid Metabolism (CAM) plant group, stomata open at night and close during the day. Stomatal closure during the day is an adaptation to reduce evaporation in plants growing in dry areas (Yuliasmara *et al.*, 2013). The significant decrease in stomatal density in the four pineapple accessions indicates the influence of genetic differences on plant response to drought. The CAM pathway allows plants to save water by opening stomata at night and closing them during the day, thereby increasing water use efficiency (Azizah *et al*., 2022).

Effect of accession on plant height variables, number of leaves, root volume, and crown dry weight. Differences in plant height showed significant differences between accession 17 and accession 10, that variations in the ability of accessions to respond to the environment for plant growth. Leaf formation in plants is influenced by genetic factors and is also influenced by environmental factors (Mulyani *et al*., 2022). Meanwhile, the dry period treatment showed a significant difference between the control treatment with 15 DDP and 30 DDP on the variables of plant height, crown fresh weight, and crown dry weight, with a decrease in the percentage of plant height growth in the 15 DDP treatment by 5.46%, while in the 30 DDP treatment by 5.86%. Pineapple plants need sufficient sunlight for their growth. Cloudy conditions in the rainy season can inhibit plant growth, resulting fruit is small fruit, the quality decreases and the sugar content. (Rahmat *et al*., 2014).

Based on the sensitivity index to drought in the 15 DDP and 30 DDP periods, it shows that the duration of drought has a significant effect on the four accessions. The longer the drought period, the higher the level of stress experienced by the plant. Accession 14 and Accession 17 showed more tolerance to drought, so they can be considered in plant breeding programs for dryland conditions. Drought stress can cause plants to decrease chlorophyll content because when water shortages, the chlorophyll content in the leaves also decreases (Mustaqim et al., 2023).

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CONCLUSION

This study showed that there was a significant interaction between stomatal density, accession, and dry period in pineapple plants. CAM metabolic pathway helps water use efficiency. Accessions 14 and 17 proved to be more drought-tolerant and have the potential to be developed in drylands. Drought treatment reduced growth and chlorophyll content, indicating the effect of water stress on plant performance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist**.**

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REFERENCES

Assumi, S. R., Nongthombam, S., & Devi, H. J. (2021). Effect of water stress on physiological and biochemical traits in pineapple. The Pharma Innovation Journal, 10(6), 1347 1350. https://www.thepharmajournal.com/archives/2021/vol10issue6/PartS/10-6-175876.pdf

Azizah, A.N., A. Sholihah, C.H.J, A.P. Ryni, S.N. Ardani, et al. 2022. CAM: Crassulacean Acid Metabolism. 5(2): 55-62.
Central Bureau of Statistics and General Directorate of Horticulture. 2019. Production of Fruit Crops by Province, 2017-2020. www.bps.go.id.
Cultivation, J., P. Faculty, P. University, A. Yolanda, M. Pineapple, et al. 2024. Effect of crown weight and accession on the growth of pineapple seedlings in the initial growth phase. 3(1): 180-188.
Mulyani, S., F. Pertanian, U.I. Riau, and C. Author. 2022. Latak daun dan lama penendaman daun the relationship between the length and width of pineapple leaves on the quality of pineapple leaf fiber is based on the location of the leaves. 10(2): 247–254.
Mustaqim, M., A. Dan, and A. Listiawati. 2023. Tumbuhan Orchid Hitam pada Simulated Drought Stress Using Polyethylene Glycol secara In Vitro. J. Daun 10(2): 205–214.
Pangaribuan, R., Yulian, and Fahrurrozi. 2023. Acceleration of Research Results and Optimization of Agrarian Spatial Planning to Achieve Sustainable Agriculture. J. Nas. UNS 7(1): 168-181.
Rahmat, A., A. Afandi, T.K.B. Manik, and P. Cahyono. 2014. Effect of Irrigation and Organic Mulch on Pineapple (Ananas comosus) Plant Growth in Wet Tropical Areas. J. Agrotek Trop. 2(1): 155–158. doi: 10.23960/jat.v2i1.1978.
Widiastuti, E., and E. Latifah. 2016. Growth and Biomass Performance of Soybean (Glycine max (L)) Varieties in Paddy Field with Liquid Organic Fertilizer Application. 21(2): 90-97. doi: 10.18343/jipi.21.2.90.
Yuliasmara, F., and F. Ardyani. 2013. Morphology, Physiology, and Anatomy of Penny Fern (Drymoglossum phyloselloides) and its Effect on Cocoa. Pelita Perkeb. (a Coffee Cocoa Res. Journal) 29(2): 128-141. doi: 10.22302/iccri.jur.pelitaperkebunan.v29i2.60.