



## The Effect of Potassium Addition on Oil Palm (*Elaeis guineensis* Jacq.) Root Anatomic Properties under Drought Stress

Wiski Irawan\* and Eka Tarwaca Susila Putra

Department of Agronomy, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia

\*Corresponding author: [wiskiirawan@yahoo.co.id](mailto:wiskiirawan@yahoo.co.id)

### Abstract

The availability of water is one of the main limiting factors for oil palm growth and production. Potassium (K) is an essential nutrient for plants because of its role in controlling metabolic and physiological activities. This study aimed to examine the effect of different K fertilizer doses on root anatomic properties under drought stress. The experiment was arranged in factorial Randomized Complete Block Design (RCBD) with two factors. The first factor was drought stress, consisting of three levels of fractions of transpirable soil water (FTSW) (FTSW 1 (control: field capacity); FTSW 0.35 (moderate drought); FTSW 0.15 (severe drought)) and the second factor was K dose (sourced from KCl), consisting of five levels (K0: 0%; K1: 50%; K2: 100%; K3: 150%; K4: 200%). The results showed that there was an interaction between the addition of K doses and the tolerance level of oil palm plants to drought stress. The addition of 100% K gave higher results in the parameters of xylem diameter, phloem diameter and cortex cell width compared to the plants without K. The results disclosed that 200% K application on moderate drought stress and severe drought stress in oil palm seedlings could widen xylem diameter, phloem diameters, strengthen cell such as epidermal cells, cortex cells, thickness of endodermic cells, thickness of sclerenchyma cells and increase hardness of cell compared to field capacity. As for the parameters of thick endodermic cells, stele diameter and sclerenchyma diameter, an addition of 50% K could give higher results.

**Keywords:** drought stress; oil palm; potassium; roots anatomy

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### INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is one of the plantation commodity which has an important role for the national economy, especially as a source of income and foreign exchange (Goh et al., 2016). Oil palm is the most important plantation commodity in the agricultural sector. This is because oil palm can produce the greatest economic value per hectare compared to other oil producing plants. In addition, palm oil has many benefits, namely as an alternative biofuel, compost fertilizer material, other industrial basic material such as the cosmetics industry, food

industry and medicine (Laurance, 2007). The market prospect for processed palm oil is quite high, because the demand from year to year has increased considerably, not only for domestic but also for foreign markets. As a tropical country with extensive land areas, Indonesia has a great opportunity to develop palm oil agriculture (Cochard et al., 2009).

Oil palm is the most efficient vegetable oil producing plant in the world when compared to other plants (Basiron, 2007). Its productivity is 8-10 times higher than other vegetable oil producing plants' productivity, and thus, with less land areas,

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vegetable oil can be produced at maximum level. Data on vegetable oil productivity have also revealed that oil palm plantations are most efficient in producing vegetable oil. With these advantages, it is no wonder that palm oil can dominate the global vegetable oil industry by shifting the dominance of soybean, rapeseed and sunflower oils.

The area of oil palm plantations is expected to continue to increase from year to year, although a moratorium on the termination of new licenses for oil palm plantations has not been revoked since it was established in 2010. However, the addition of palm oil continues to be carried out due to the development of licenses that have been issued and the development of independent palm oil by communities in various areas. In the future, the needs of the world community for vegetable oil will increase because it is supported by several factors, one of which is the depletion of petroleum resources so that energy consumption switches to more renewable energy sources (Basiron, 2007). Renewable energy sources are mostly based on biomass, one of which is vegetable oil from palm oil commodities. Therefore, increasing the area of oil palm to increase national vegetable oil production will still be needed in the future.

Oil palm is one of the important plantation crops in Indonesia (Stibig et al., 2014). Oil palm, both in the form of raw material and processed product, has a large business opportunity and opens employment, as well as a source of foreign exchange. Oil palm is a plant that can be relied upon to produce vegetable oil and has high oil productivity over other vegetable oil sources (Fairhurst and McLaughlin, 2009). Oil palm is a plant that requires evenly distributed rainfall throughout the year. The optimal rainfall desired by oil palm is around 2000-2400 mm per year with even distribution throughout the year (Darlan et al., 2016). The insufficient availability of water is one of the main limiting factors for the growth and production of oil palm plants.

Drought stress is an environmental condition that causes an insufficient water for plants. It causes changes in anatomic properties such as decrease in epidermal thickness, vascular tissue diameter and trachea in roots, stems and leaves, as well as decrease in mesophyll thickness and endodermic thickness. In oil palm (Palupi and Dedywiryanto, 2008), drought stress causes a decrease in cortex thickness, stele diameter and xylem diameter. Anatomic changes under drought

generally include a decrease in cell size in roots, stems and leaves as well as cell damage, xylem vessel elongation, increased trichome density (Lipiec et al., 2013) and cell elongation becomes blocked due to disruption of water flow from xylem (Farooq et al., 2009). These changes take place more massively when at the same time oil palm plants experience potassium (K) deficiency. As one of the plant organs, roots play an important role when plants respond to water shortages by developing their root systems so that they are able to reach water resources with limited availability.

Drought stress in plant can cause a shrinkage in xylem root diameter and phloem root diameter, and an increase in membrane leakage. K transport in plant tissue can maintain membrane potential, cell turgor, development of pollen tube, increase in stomatal conductance and expansion of water and nutrient uptake in roots. Decreasing K transport in plant tissue can reduce the uptake of N, P, K, Mg and amino acids (Cochrane and Cochrane, 2009).

Prihastanti (2010) stated that a change in the anatomical structure of the roots of cocoa (*Theobroma cacao* L.) during the drought gripped the elongation of xylem vessels. Elongation of the root xylem vessels indicates root elongation so the ability of root become stronger in the exploitation of water resources (Prince et al., 2017).

In addition to the use of drought-tolerant plant material, one of the efforts to reduce the impact of stress is the application of an agronomic approach in the form of crop nutrition management. One nutrient that is also thought to play a role in increasing plant resistance to drought stress is K. K is an essential nutrient for plants which is one of the determinants of plant production. K can also maintain osmotic and turgor pressure, regulate stomata openings, water potential, cation-anion balance in cytosol and vacuole, and transports assimilates from photosynthesis (Ramadhana et al., 2019).

Nutrient adequacy has an important role in oil palm to avoid the negative effects of drought stress. One of these nutrients is K. K is needed by plants in large amounts. It is the most important nutrient for plants, after Nitrogen. According to Singh and Reddy (2017), the quantity of yield of a plant depends on how much nutrients can be up taken by the roots. K has an important role in the process of photosynthesis and deficiency of K can reduce CO<sub>2</sub> assimilation. Plants' need of K is quite high and if it is not fulfilled, it can inhibit plant

metabolism, causing a decrease in productivity and quality of yield. K is an essential because of its role in controlling metabolic and physiological activities, especially if the plants experience drought stress (Farhad et al., 2010). The role of K can be performed on the oil palm plantation area on a broader scale to further explore the influence of the element of K in enhancing the anatomic characteristics of oil palm and growth in drought stress. Furthermore, the addition of K is useful for making plants resistant to pests and diseases, so that it was improved the optimization plants nutrients and supporting sustainable agriculture. This study aimed to determine the effect of K addition to the anatomic properties of the roots of oil palm under drought stress.

## MATERIAL AND METHODS

This research was conducted from September 2017 until September 2018, in Bendosari, Madurejo Village, Prambanan Sub-District, Sleman Regency, Special Region of Yogyakarta.

Weight of FTSW 1.00	=	1.00 (WFC - WPWP) + WPWP
Weight of FTSW 0.35	=	0.35 (WFC - WPWP) + WPWP
Weight of FTSW 0.15	=	0.15 (WFC - WPWP) + WPWP
WPWP	=	Weight of permanent wilting point
WFC	=	Weight of field capacity

Determination of water requirements for drought stress treatment referred to the FTSW method. FTSW is a method for evaluating gradually increasing drought stress based on the amount of water loss due to transpiration (Ray and Sinclair, 1998). First, the polybags were watered to saturate the water, then the polybags were left to reach the field capacity which was marked by water stopping dripping from the polybag. Polybags that had achieved field capacity

The materials used were seventy-five AVROS oil palm seeds in each trial block, a variety of cultivar seeds considered intolerant to drought from the Palm Oil Research Centre, alfisols, which had low fertility, Urea, SP-36, KCl, Dolomite, 5 kg-sized plastic bags, alcohol, herbicides and pesticides. The planting media used were alfisols from Gunung Kidul. Field experiments were arranged using factorial Randomized Complete Block Design (RCBD) with two factors. The first factor was drought stress, consisting of three levels of fractions of transpirable soil water (FTSW), namely FTSW 1 (control: field capacity), FTSW 0.35 (moderate drought), FTSW 0.15 (severe drought) and the second factor was K dosage derived from KCl, consisting of 5 levels, namely K0: without K (0 grams of K per seed), K1: 50% standard dose of K (8.50 grams of K per seed), K2: 100% standard dosage of K (17.02 grams K per seed), K3: 150% standard dose of K (25.53 grams of K per seed) and K4: 200% standard dose of K (56.72 gram of K per seed).

conditions were wrapped in plastic bags to reduce water loss due to evaporation, then the polybags were left idle until the weight did not return (stable). The weight of each level target of FTSW was determined by the equation according to Ray and Sinclair (1998). The stress level of each plant was expressed as a function of soil moisture content. The groundwater transpiration rate in each polybag on a certain day was calculated as follows:

$$FTSW = \frac{\text{weight of first day polybag} - \text{final polybag}}{\text{weight Initial polybag weight} - \text{final polybag weight}}$$

Drought stress treatment was carried out after the plant was 10 months. Treatment of giving stress on FTSW 0.15 was carried out first, meaning that at the age of 10 months, watering for the seedlings in the FTSW 0.15 treatment was stopped and watering for one week interval FTSW 0.35 treatment was also stopped, so the treatment of FTSW 0.35 and FTSW 0.15 could reach the target weight at the same time, while the FTSW

1.00 treatment was still done. The decrease in polybag weight was monitored by weighing each polybag until it reached the target weight. The observations in this research included the monitoring of xylem diameter, phloem diameter, epidermal cell length and width, and cortical cell width. Tools and materials used in making preparations included *scalpel*, a solution for fixation and root plant organs. Anatomical

observation was done by making root organ preparations (the tip of the root) which were sliced transversely and longitudinally. The preparation was made by paraffin embedding method.

## RESULTS AND DISCUSSION

Xylem is a complex vascular tissue consisting of various types of cells (Qaderi et al., 2019). Xylem plays a role to transport water and mineral substances from the roots to the leaves. Table 1 shows that the xylem diameter of the oil palm root was influenced by the interaction between drought stress and K dosage. Basically, the roots are composed of several different tissues. In conditions of field capacity, the addition of standard 0-200% K did not significantly affect the xylem diameter of the roots in oil palm seedlings. In conditions of moderate drought stress, an increase in the K dose up to 100% significantly increased the xylem diameter of the root. However, if the dose of K was raised again to exceed 100% (the standard dose), it was followed by a decrease in the size of the xylem diameter even though it was still significantly higher compared to without K addition. K is an important mineral that plays a role in stem growth and the formation of tissue wood. Formation of wood tissue occurs because xylem cells undergo differentiation. Jourdan et al. (2000) stated that the differentiated xylem acts as a strong sink in the formation of woody tissue in the trunk. In these conditions, K plays a role in assimilate translocation to the sink organ. Accumulation of assimilates and nutrients causes osmotic levels to increase so that turgor pressure rises and cells undergo expansion.

The same thing was found in severe drought stress conditions. In conditions of drought stress, xylem diameter will decrease (Twumasi et al., 2005). Drought stress in this study reduced xylem diameter, caused by a decrease in turgor pressure (Farooq et al., 2009). According to Anjum et al. (2011), the inhibition of cell extension is due to the disruption of water flow from xylem to surrounding elongated cells and inhibition of mitosis and cell enlargement.

The decrease in diameter, under moderate conditions with the addition of 0-50% K and xylem length on the addition of 100-200% K, is a mechanism of tolerance of these plants to maintain xylem function in drought conditions. The decrease in root xylem diameter in response

to drought is a mechanism to avoid the influence of embolism on xylem (Comas et al., 2013). Embolism is the formation of gas bubbles in the form of water vapors and then become air bubbles trapped in the xylem. This will limit the flow of water that passes through them and this can reduce the capacity of plants to transport water to the canopy. An embolism occurs when xylem water tension rises during high transpiration or dry soil conditions. Embolism can inhibit the flow of water, which can cause canopy deaths, branches and even all plants (Rosawanti et al., 2015).

The reduced size of the vessel layer and xylem pore size at the root of oil palm plants under drought stress are forms of anatomic adaptation in plants that experience drought stress. According to Twumasi et al. (2005), xylem structure with small pore holes will be more useful because it is more resistant to drought compared to the large xylem pore size. Decreasing xylem size is very important in plants exposed to drought stress to increase *water flow resistance* and to avoid *collapse* in cell walls (Lambin et al., 2001).

According to De Schepper et al. (2013), phloem is a vascular tissue that functions to transport and distribute photosynthetic substances from leaves to other parts of the plant. Table 1 shows that the phloem diameter of oil palm roots was influenced by the interaction between drought stress and K dosage. In the field capacity, 0-200% (standard) K did not significantly affect the phloem diameter of the oil palm seedling roots. The same thing was also found in severe drought stress conditions. In conditions of moderate drought stress, an increase in the K dose up to 100% significantly increased the diameter of the phloem diameter. However, if the K dose was raised again to exceed 100% of the standard dose, it would be followed by a decrease in the size of the phloem diameter of the palm oil seedlings, even though it was still significantly higher than the oil palm seeds that were not given K.

Like xylem vessels, the phloem diameter was also seen to decrease due to drought stress. Some previous studies also revealed that *Ctenanthe setosa* and *Triticum aestivum* plants under drought stress had smaller xylem and phloem vessels, to avoid cavitation. Cavitation in vessel tissue decreased water transport and hydraulic conductance, causing death in plants. In addition, the reduction in the diameter of the xylem and phloem also aimed to make the absorption of water and nutrients uptake more effective.

The epidermis is the outermost layer of tissue, which functions as a protector, covering all organs. In conjunction with the process of absorption of water, the epidermis is semi-permeable, easily penetrated by water (Mangena, 2018). In line with its function as a protector of the underlying tissue, the epidermis is thickened so that its structure becomes stronger. On the surface of the epidermis, root hairs grow which are nodules of the epidermis and function to uptake the water and nutrients needed.

Table 1 shows that the length of epidermal cell roots of oil palm seedlings was influenced by interactions between drought stress and K doses. In the field capacity conditions, addition of K at a dose of 50-200% of the standard did not significantly affect the length of the root epidermis of oil palm seedlings, however, a condition without K addition in oil palm seedlings could increase the length of the root epidermal cell. In moderate drought stress conditions, the addition of K 0-200% of the standard did not significantly affect the length of the root epidermal cell. In severe stress, the addition of K at a dose of 0-150% of the standard did not significantly affect the length of the root epidermal cell. However, the increase in the K dose to 200% of the standard could increase the cell length of the root epidermis, although it was not significantly different, compared to the condition without K addition.

Table 1 shows that control plants had a thinner epidermis compared to drought treatment. This is because the thickness of the epidermal is thought to be one form of adaptation plant to minimize the process of water loss (Basu et al., 2016). The increase in the length of the epidermis is often associated with thickening and elongation of epidermal cells through lignification and cell defense mechanisms by cell decay caused by drought. This is a form of plant defense against drought stress by regulating the supply of water and ions into the cortex and counteracting various foreign substances that have the potential to reduce the activity and function of the roots of oil palm seedlings.

Table 1 confirms that there was a decrease in root epidermal cell length. This is thought to be an adaptation of plants with drought conditions so that with smaller epidermal cell, the water entering through the epidermis entered the xylem vessels faster through the cortex tissue. Table 1 shows that the width of epidermal cell roots of oil

palm seedlings was influenced by the interaction between drought stress and K dosages. In the field capacity conditions, the addition of K at a dose of 100-200% from standard and without K addition did not significantly affect the width of root epidermal cells. However, decreasing the K dose to 50% from the standard could increase the cell width of the root epidermis of oil palm seedlings. In moderate conditions, the addition of K 0-50% of the standard did not significantly affect the width of the root epidermal cell. However, increasing the K dose to 100-200% of the standard could increase the width of the root epidermal cell. In conditions of severe drought stress, addition of K at a dose of 50-200% of the standard did not significantly affect the width of the root epidermis. However, oil palm seedlings that were not given K under severe stress conditions could increase the cell width of the root epidermis.

The cortex is a basic network that functions to store photosynthesis products, water and minerals (Gusmalawati, 2017). The cortex is the first skin layer in the inside of the epidermis which consists of many cells and has a thin cell wall. There are spaces between cells as a place for storing air and gas exchange inside. The cortex surrounds the central cylinder and serves as a storage area for food reserves (Samuels and McFarlane, 2012). Table 1 displays that the width of the root cortex cells of oil palm seedlings was influenced by the interaction between drought stress and K doses. In the field capacity, the standard K dose of 50-200% did not significantly affect the width of the root cortex cell. However, oil palm seedlings that were not given K under conditions of field capacity could increase the width of the root cortex cells. In moderate stress, the addition of standard K with a dose of 0-150% did not significantly affect the width of the root cortex cell. However, increasing the standard K dose to 200% would increase the width of the root cortex cell. The same thing as in moderate drought was also found in severe drought stress conditions.

Wide cortical cells in drought stress are thought to be adaptations of plants to improve water use efficiency. This is in line with the study Purushothaman et al. (2012), which stated that roots that experience drought stress have a broad cortex, which consists of tightly arranged parenchymal cells and some have inter-cell cavities. Ninilouw and Linda (2015) stated that parenchymal tissue in plants that experience drought enlarges and thickens. Thickening of cell

size aims to improve waterways and water use efficiency. This is in line with the statement of Melo et al. (2014), that the increase in cortex thickness is a mechanism to multiply cells in the cortex as an effort to store more water. Cortex

thickness is related to the water storage capacity in the root. Increasing the number of cells in the cortex increases the tolerance of plants to drought stress.

Table 1. Diameter of xylem, diameter of phloem, epidermal cell length, epidermal cell width and cortex cell width ( $\mu\text{m}$ ) of oil palm roots under drought stress

	K	Drought stress			Average
		No drought (Field capacity)	Moderate drought	Severe drought	
Diameter of xylem	0%	17.967bc	6.300d	25.153a	16.473
	50%	17.667bc	16.067c	20.467abc	18.067
	100%	21.533abc	23.567ab	25.333a	23.478
	150%	19.233abc	18.200bc	17.800bc	18.411
	200%	17.600bc	20.033abc	18.233bc	18.622
	Average	18.800	16.833	21.397	(+)
	CV (%)	17.927			
Diameter of phloem	0%	5.833d	5.600d	12.972a	8.135
	50%	6.600cd	9.700abc	7.967bcd	8.089
	100%	5.567d	10.700ab	10.967ab	9.078
	150%	5.533d	8.733bcd	11.333ab	8.533
	200%	5.567d	9.333bc	9.800abc	8.233
	Average	5.820	8.813	10.608	(+)
	CV (%)	21.271			
Epidermal cell length	0%	17.900a	5.600d	15.933ab	13.144
	50%	10.367cd	10.700cd	12.533bc	11.200
	100%	10.500cd	10.200cd	8.800cd	9.833
	150%	9.900cd	8.067cd	12.833bc	10.267
	200%	10.600cd	11.833bc	19.100a	13.844
	Average	11.853	9.28	13.840	(+)
	CV (%)	22.632			
Epidermal cell width	0%	7.100cd	4.333d	17.733a	9.722
	50%	18.467a	7.933cd	9.667bc	12.022
	100%	9.967bc	9.467bc	6.600cd	8.678
	150%	9.833bc	9.567bc	9.033c	9.478
	200%	13.300b	8.633c	9.867bc	10.600
	Average	11.733	7.987	10.580	(+)
	CV (%)	21.212			
Cortex cell width	0%	182.233ab	125.133c	146.400bc	151.256
	50%	126.000c	104.833c	122.600c	117.811
	100%	105.600c	117.633c	108.200c	110.478
	150%	107.300c	110.200c	126.100c	114.533
	200%	110.400c	184.467ab	205.400a	166.756
	Average	126.307	128.453	141.740	(+)
	CV (%)	17.568			

Note: Different letters in each column and row show a non-significant effect at  $p \leq 0.05$  by Duncan's New Multiple Range Test (DMRT). (+) indicates the treatment interaction. CV = Coefficient of variation

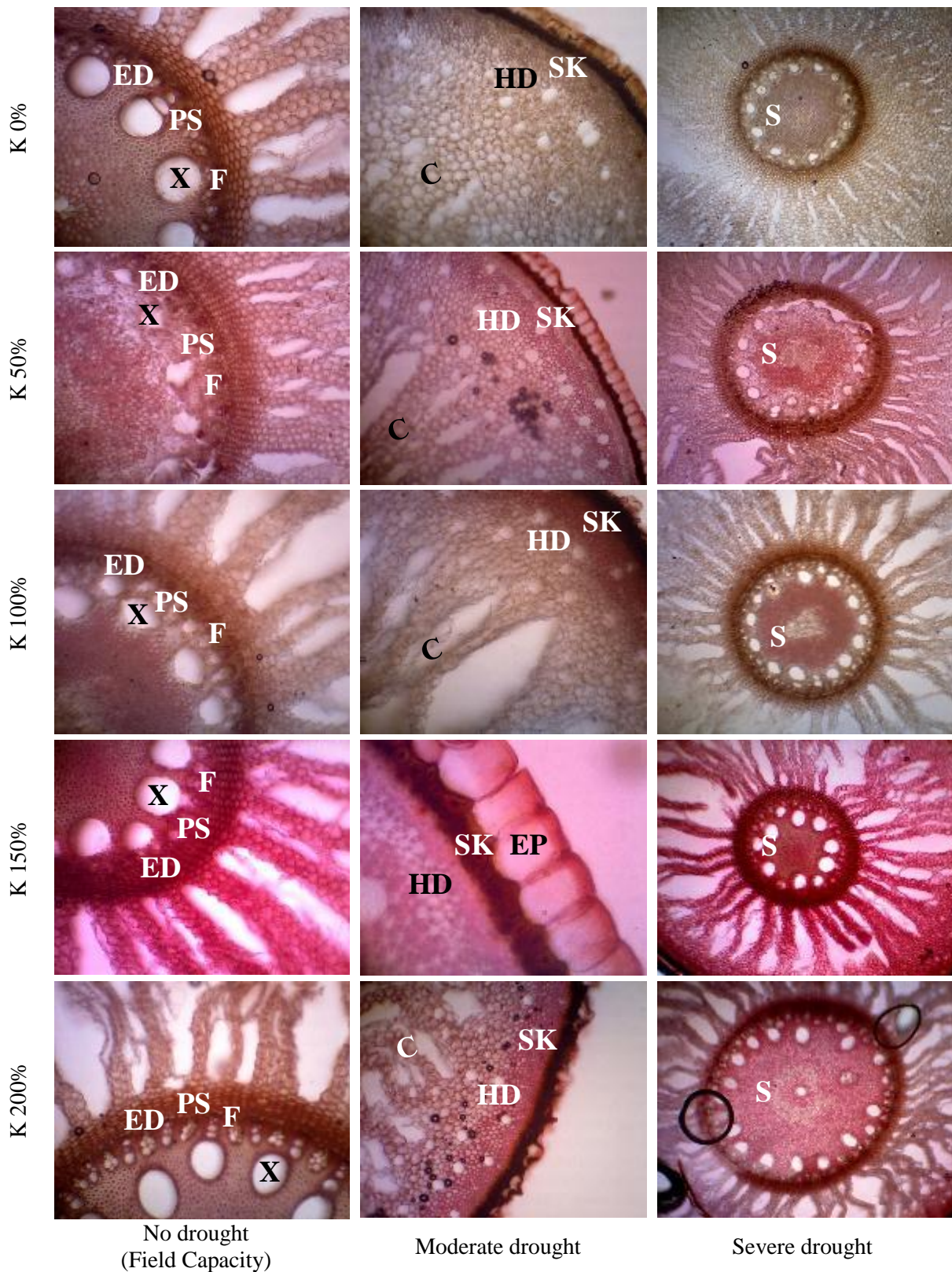


Figure 1. Effect of drought stress and K dose on the root anatomy of oil palm

Note: X = Xylem; F = Phloem; ED = Endodermis; PS = Pericycle; HD = Hypodermis; C = Cortex; SK = Sclerenchyma; EP = Epidermis; S = Stele

Roots are structured of several layers of tissue with specific role (Figure 1), including protecting the inner root tissue from biotic and abiotic influences. Therefore, roots can support other parts of the plant. Root endodermis consists of a thick layer of cells. Endodermis tissue in the root functions as an intermediary factor for water containing nutrients or minerals from the cortex tissue to the central cylinder (Robbins et al., 2014). Table 2 shows that the thickness of the endodermic cells of the oil palm seedlings was influenced by the interaction between drought stress and K doses. In the field capacity conditions, the addition of standard K 0-200% did not significantly affect the thickness of the

endodermic root cells. However, the addition of 50% K from the standard increased the thickness of endodermic cells from the roots of oil palm seedlings, compared to giving 100% K from the standard. The same thing happened in moderate drought stress. Under severe drought stress, the addition of K at a dose of 100-200% standard significantly increased the thickness of endodermic root cells. Decreasing the standard K dose to 50% would decrease the thickness of the endodermic root cells of oil palm seedlings. However, in severe stress without K fertilizer addition, the thickness of endodermic cells increased.

Table 2. Thickness of endodermic cells, thickness of pericyclic cells, diameter of stele, thickness of hypodermic cells and thickness of sclerenchyma cells ( $\mu\text{m}$ ) in oil palm roots under drought stress

	K	Drought stress			Average
		No drought (Field capacity)	Moderate stress	Severe stress	
Thickness of endodermic cells	0%	17.600abcd	7.100g	22.060a	15.587
	50%	20.333ab	11.700efg	10.900efg	14.311
	100%	12.633defg	14.500cdef	18.767abc	15.300
	150%	16.033bcde	10.133fg	15.467bcdef	13.878
	200%	15.667bcdef	10.233fg	20.200abc	15.367
	Average	16.453	10.733	17.479	(+)
	CV (%)	20.180			
Diameter of stele	0%	286.767b	111.733c	220.233b	206.244
	50%	321.300ab	98.600c	400.767a	273.556
	100%	296.867ab	108.700c	279.733b	228.433
	150%	245.400b	98.267c	112.133c	151.933
	200%	316.667ab	253.033b	316.267ab	295.322
	Average	93.400	134.067	265.827	(+)
	CV (%)	24.766			
Thickness of sclerenchyma cells	0%	18.967bcd	16.667cde	17.433cde	17.689
	50%	8.633f	19.733bcd	28.733a	19.033
	100%	12.033ef	14.000def	20.100bcd	15.378
	150%	9.067f	17.367cde	25.367ab	17.267
	200%	21.633bc	21.217bc	22.200bcd	21.683
	Average	14.067	17.797	22.767	(+)
	CV (%)	18.736			

Note: Different letters in each column and row show a non-significant effect at  $p \leq 0.05$  by Duncan's New Multiple Range Test (DMRT). (+) indicates the treatment interaction. CV = Coefficient of variation

This is in line with the research conducted by Robbins et al. (2014) which confirmed that most endodermic cells generally have a ribbon-like part containing cork or lignin substances called Casparian strips. The Casparian strip can be

formed due to thickening of the walls of endodermic tissue cells. This thickening by the cork layer causes the cell walls to be very difficult to pass by water, even though water needs to pass through endodermic tissue to get to the central



cylinder. Therefore, water will pass through endodermic tissue that does not experience thickening, which is usually called a successor cell, so that water can go to the central cylinder.

Stele is a layer found in the middle of the root inside the endodermis. Table 2 demonstrated that the stele diameter of the oil palm seedlings was influenced by the interaction between drought stress and K doses. In the field capacity, the standard K 0-200% addition did not significantly affect the diameter of the stele of oil palm seedlings. In moderate stress conditions, the standard addition of 0-150% K did not significantly affect the diameter of root stele. However, the increase in K dosage to 200% could increase the diameter of the root stele of oil palm seedlings. In severe stress, the addition of K with a dose of 0%, 100% and 200% standard did not significantly affect the diameter of root stele. However, a decrease in the K dose to a standard 50% would increase the diameter of root stele and increasing K dose to 150% of standard would reduce the diameter of the root stele of oil palm seedlings.

The diameter of stele was shorter in the roots of plants under drought stress, both moderate and heavy drought stresses. This is in accordance with what was disclosed by Makbul et al. (2011) that the diameter of the vessel tissue of plants experiencing drought stress will have a smaller size. Purushothaman et al. (2012) revealed that the area of plant vascular tissue will decrease along with the lower soil moisture due to drought stress. Ratmadanti and Maryani (2017) also discovered that the diameter of stele is related to the ability of plants to uptake water and nutrients carried over the leaves that plants need for their metabolism.

The sclerenchyma tissue is a mechanical tissue that supports the internal organs in plants that are already ripe. This tissue functions as a protective tissue of mature organs. Cells in this tissue do not have protoplasts so that the cells can no longer grow. Table 2 displays that the thickness of the sclerenchyma root of oil palm seedlings was influenced by the interaction between drought stress and K doses. In the field capacity, the addition of K at a dose of 50-150% of the standard did not significantly affect the thickness of root sclerenchyma cells. In oil palm seeds that were not given K, an increase in K dosage to 200% from the standard could significantly increase the thickness of root sclerenchyma cells. In moderate drought stress conditions, the addition of K at a

dose of 0-200% of the standard did not have a significant effect on the thickness of root sclerenchyma cells. In the conditions of severe drought stress, oil palm seeds that were not given K and seeds that were given K at a dose of 100-200% of the standard did not significantly affect the thickness of root sclerenchyma cells. However, the decrease in the K dose to 50% from the standard could increase the thickness of the sclerenchyma cells in the roots of oil palm seedlings.

The results show that the more plants are given high-dose K, the more sclerenchyma cells will get thicker. This is in line with the statement Peña-Valdivia et al. (2010), indicating that the secondary walls of cells in the sclerenchyma tissue are thickened by lignin. This thickening occurs in all surfaces of the cell wall, resulting in stronger sclerenchyma tissue.

## CONCLUSIONS

Moderate drought stress and severe drought stress provide better anatomical properties of the roots, leaves and midrib of oil palm seedlings than those in field capacity conditions indicated by high xylem diameter, phloem diameter, epidermal cell length, cortical cell width, endodermic cell thickness and thick sclerenchyma cells in the roots. Addition of a K dose of 200% in oil palm seedlings led to better anatomical properties of roots compared to the addition of a K dose of 0-150% during drought stress.

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