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Dry spell stress footprint on morphological characters, water use efficiency, growth and yield of guinea and napier grasses

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An understanding of morphological plant according water stress usually task for physiologists interested in the topic of drought tolerance. The objectives of these studies were to (1) understand the morphology character under in drought stress of Guinea and Napier grasses, (2) understand ability of Guinea and Napier grasses used lack water for growth and, (3) quantity herbage mass at different period of drought stress. Treatment of drought stress has significant increased leaf rolling score, relative water leaf ratio, but decreased plant height and herbage mass on Guinea and Napier grasses. Furthermore, leaf dying score, drought tolerance and tiller number have not effect by drought stress. Water use efficiency of Guinea grass decrease in three times drought stress (DS258), while on Napier grass WUE have same effect with control. This means Napier grass have more efficient used water. Guinea grass decreased herbage mass at three times drought stress about 25.9% compared to control. While Napier grass decreased 22.20%. There was mean that Guinea grass more tolerance to drought stress.

Keywords: Dry spell stress, grass, water use efficiency, herbage mass.

INTRODUCTION

An understanding of p lant morphology under water stress usually task for physiologists interested in the topic of drought tolerance. According to Al Hakimi et al, (1998) selection for morphology and physiological traits related to moisture water stress, such as root parameter, relative water content and carbon isotope discrimination was possible due to high heretability values and effective. Shoot and root growth were significantly reduced by osmotic stress (-0,6 and -1,0 MPa) induced with polyethylene glycol (PEG 6000) (El Midaout *et al*, 2003). Furthermore, Heschel and Rigions (2005) explained that plant height and diameter growth of stems were highly dependent on the amount of photosynthesis and were very sensitive to environmental conditions.

In Indonesia, Guinea and Napier grasses are two important species of pastures being used mainly in cattle and sheep farms. Guinea (*Panicum maximum*)grass is an annual grass, grown tall and formed tiller (Aganga and Tshwenyane, 2004), containing a 8.8% of crude protein, 33.6% of crude fiber, 2.1% of ether extract , 12.6% of ash and 42.9% of nitrogen free extract ,while the elephant (*Pennisetum purpureum*) has a content of 9.1% of crude protein, 33.1% of crude fiber 2.3% of ether extract, 15.4% of ash and 40.1% of NFE (Hartadi *et al*, 1990).

Water stress occurs when the rate of transpiration exceeds the absorption and the water transportation in the plant (de Barros Lima *et al.,* 2011). The water deficit imposed at the moment of the germination and the tiller of the palisade grass were sufficient to reduce grass tiller of the palisade grass during the evaluation period, in both cultivation systems. When the water deficit was imposed at the moment of the maize tassel, the large number of tillers density was lower only in the plots in exclusive cultivation (de Araujo *et al*, 2011). Drought caused a general reduction in root biomass. The shoot:root ratio in B.*mutica* and B.*humidicola* increased in response to drought tolerance at the expense of a reduction in root yield down to 50 cm depth (Guenni *et al*., 2002).

Water deficit cause symptom in scale of few minutes (cause wilt crop, stomatal closure), weekly (change growth and flowering), monthly (degradation of total biomass) (Tardieu, 1996). Mechanism of plant avoidance from drought condition although three actions, were (1) management of water crop status during stress condition, (2) management function water crop in low water crop status, and (3) recovery water status after water stress (Xiuhai *et al*, 2005). Drought stress caused accumulation proline on potato leaves (Heuer and Nadler, 1998), absisic acid, sugar (sucrose, glucose, and fructose), proline and K salt in Cassava leaves (Alves *et al*, 2004). Drought stress during 12 days improve size of flower and nectar volume of *Epilobium anguistifolium* (Caroll *et al*, 2001). Proline accumulation and chlorophyll fluorescence inhibition were found to be significantly and negatively correlated with drought sustainability index of grain yield, biological yield and thousand kernel weight and tiller index (Ali Dib *et al*, 1994). Water deficit imposed during grain filling in japonica hybrid rice enhanced plant senescence, accelerated grain filling and imposed yield (Yang *et al*., 2002). The objective of this study were (1) understand the morphological characteristics in drought stress of Guinea and Napier grasses, (2) understand ability of Guinea and Napier grasses used lack water for growth, and (3) quantify the forage yields at different times of drought stress.

MATERIAL AND METHODS

The study was carried out at Forage Science laboratory, Department of Feed and Animal Nutrition, Animal Agriculture Faculty, Diponegoro University for 9 months. The study was carried out in pots using a complete random block design arranged in factorial arrangement (2×4) with 3 replications. The first factor was the species of grass; guinea *(Panicum maximum* cultivate*),* and Napier (*Pennisetum purpureum* cultivate) and the second factor was drought stress treatment. The trial was carried out in glasshouse under temperature 25-30^{0}C and 70-80% relative humidity. Ten kilograms Oxisol soil (the Soil taxonomy, 1999) filled in pot (30 cm of diameter and height). Oxisol soil were loam texture (sand: silt : clay= 20.3:31.7:48), pH(1:5) 6.12, 0,21 % N, 5.4ppm P, and 0.68 $cmol_c/dm^3$, 2.47% C organic. One cutting grass plant in every pot. All plant were fertilized with urea (0,5 g N/pot), superphosphate (0,25g P_2O_5/pot), and pottasium chloride (0,25g K_2O/pot). Plant watering 250 mm daily. Uniformly cut up to 0.1 m above the soil was done in 4 weeks. Application drought stress done according Djekoun and Planchon (1991) method with little modification. Djekoun and Planchon applied stress by stopping watering for 4, 8 and 10 days, whereas We have application of drought stress by stop watering for one week. S0= control, the plant watering daily. S1 treatment was drought stress carried by stop watering to plants during one week performed at week 2 (**DS2**); S2 was drought stress carried by stop watering to plants during one week, which done twice at weeks 2 and 5 (DS25); S3 was drought stress carried by stop watering to plants during one week , which done three times at weeks 2.5 and 8 (DS258). Soil water content by gravimetric test was observed in the end of application drought stress(S1 was 50% of field capacity, S2 was 40% of field capacity, and S3 treatment was 30% of field capacity).

Parameters of investigation were:

1. Leaf rolling score (LRS), measured by 0-4 score at noon before re-watering after stress treatment. Score 0 was not any symptom and 4 were all leaves rolling
2. Leaf dying score (LDS), measures by 0-4 score before re-watering. Score 0 was not droght stress indication, and score 4 for 50% of leaves were drought/necrosis.
3. Relative water loss ratio (RWLR), measured according Xiuhai *et al* (2005), done by cutting in the basal leaf the second leaves at 7 days drought stress treatment, and seven days after recovery with re-watering. Leaf put enter plactic bag and balancing every 1 hour until 9 hours. Decreasing mass was RWLR.
4. Drought tolerance, measured survived plant after application drought stress to plant for one week
5. Water use efficiency, measured volume of water used by plant in all live (until 60 days after uniformity pruning), expressed by gram dry matter/gram water
6. Growth (Plant height and tiller number) were performed weekly. Plant height was measured by using a millimeter ruler measuring the vertical distance from the soil in the pot to the curvature of the last expanded leaf. The tiller number were identified with wire in order to avoid recount when tiller emerged in the next evaluations.
7. Herbage mass (fresh biomass above ground) measured in 60 days after uniformity cut.

ANOVA used to analysis all data then differences among between treatments test by Duncan multiple range test (significance level of 5%) according to Steel and Torrrie (1990).

RESULTS AND DISCUSSION

RESULTS

MORPHOLOGY CHARACTERS

Leaf rolling score of Guinea grass increased at treatment DS2, but has same effect on DS25 and DS258. Increasing period of drought stress (DS2 to DS258) has significant increased leaf rolling score of Napier grass. Napier grass showed more leaf rolling at DS258 than

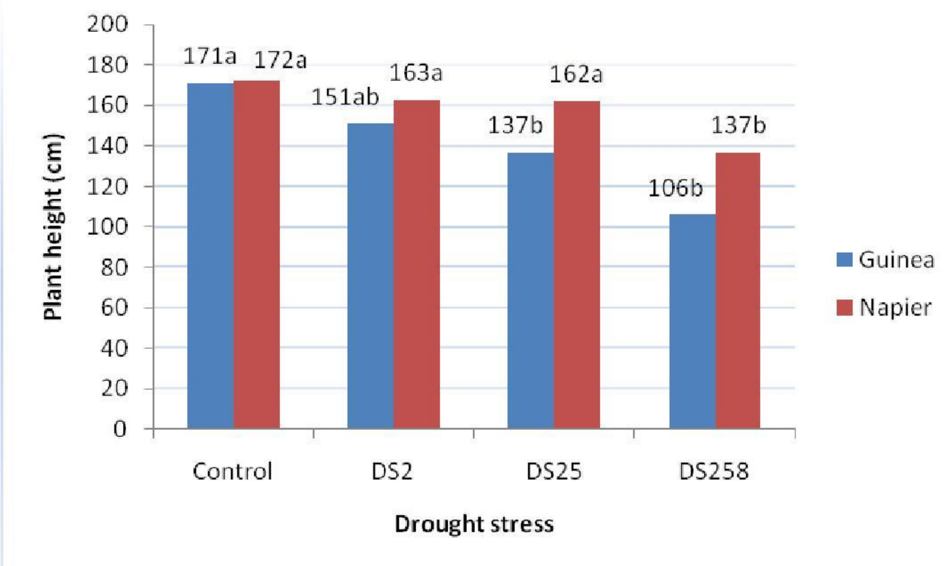

Figure 1. Plant height affect of drought stress on Guinea and Napier grasses
Averages followed by the same letter in plant height of grasses do not differ (P<0.05) by Duncan test.

DS2 and control.

Leaf dying score (LDS) Guinea grass and Napier grass have not significant effect of drought stress treatment. Treatment DS2, DS25 and DS258 have not significant difference with control on Guinea and Napier grasses. Relative water loss ratio affect by treatment of drought stress. Relative water loss ratio showed significant difference with control on Guinea and Napier grasses. Stress period DS2 to DS258 significant increased RWLR on Guinea and Napier grasses.

Drought tolerance on stress period DS258 significant decreased on Guinea grass but have not significant on Napier grass. Water use efficiency has been defined as the ratio of economic yield to total water use or transpiration (Johnson and Henderson, 2002). Water use efficiency (WUE) was volume of water consumed by grass for 60 days after uniformity cut. Three times stress period (DS258) have decreased WUE of Guinea grass compared to DS25, DS2 and control. Napier grass have water use efficiency did not effect by drought stress period, there were not significant difference between DS258 with DS25, DS2 and control.

Growth and Yields

Result of this study showed that application of drought stress have significant effect on plant height of Guinea and Napier grasses. Interaction between kind of grass and drought stress have significant effect too. Figure 1 showed plant height of Guinea decreased with increasing stress period treatment (DS2 to DS258). Treatment DS258 have lower plant height. However, decreasing plant height of Guinea grass in DS25 follow D258 treatment. Napier grass showed decreased plant height in application D258 treatment.

Napier grass have more tiller per pot than Guinea grass (Figure 2). Application DS2 treatment have tiller per pot did not significant difference with DS25 and DS258 treatment. Application drought stress treatment have same effect on tiller per pot of Guinea grass .

Herbage mass of plant affect by all growth factors put on plant(Figure 3). Result of this study was showed that interaction of drought stress and kind of grasses have not effect on herbage mass. Furthermore, kind of grasses treatment showed effect to herbage mass, while drought stress treatment have significant effect to herbage mass.

Decreasing Napier grass herbage mass have not significant difference with all treatment od period stress, while in Guinea grass herbage mass significance decreased by DS258 treatment.

DISCUSSION

The results showed application drought stress had marked effect on morphology characters (leaf rolling, leaf dying, relative water leaf ratio, drought tolerance and water use efficiency), growth and herbage mass. Increasing period of drought stress (2 and 3 times) significant decreased WUE, plant height and herbage mass. Similar result has been reported by Rizhky *et al*,. (2002) suggest a close relation between the closure of stomata, suppression of photosynthesis, enhancement of respiration and increased leaf temperature. Finally,

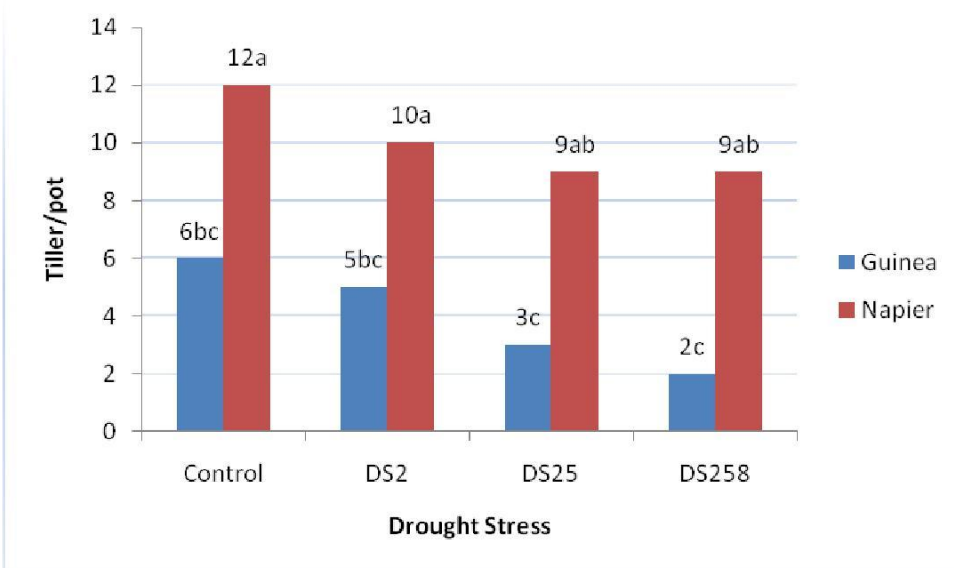

Figure 2. Tiller number of Guinea and Napier grasses affected drought stress Averages followed by the same letter in tiller/pot do not differ (P<0.05) by Duncan test.

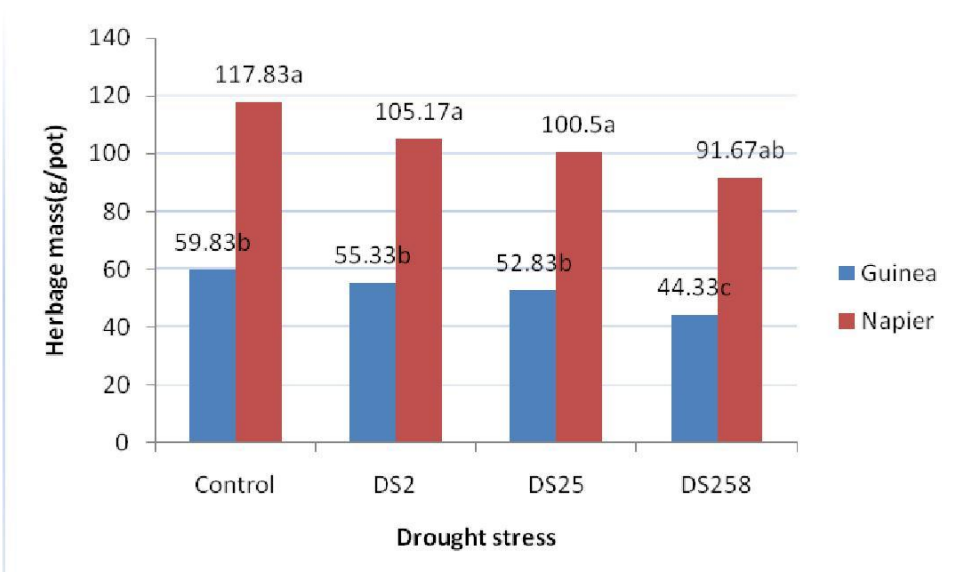

Figure 3. Forage yield of Guinea and Napier grasses affected drought stress
Averages followed by the same letter herbage mass of grasses.do not differ (P<0.05) by Duncan test.

decreasing growth and yield. Application drought stress influence on leaf curling, plant mechanism against and hold out drought stress. Interaction between kind of grass with drought stress showed significant effect. Guinea and Napier grasses at DS258 increased leaves curling 60 and 49.7 % , respectivelly.

Leaf dying score of Guinea have same effect to Napier (Table 1). Application drought stress to Guinea and Napier have same score. Drought stress three times give score LDS not significant difference with control. LDS closely related plant recovery ability after applying drought stress.

Table 1. Leaf rolling score(LRS), leaf dying score(LDS), relative water loss ratio(RWLR), drought tolerance(DT) and water use efficiency (WUE) of Guinea and Napier grasses

Treatment	LRS Score x 100	LDS Score x 100	RWLR (mg)	DT (%)	WUE (g DM/g water)
Guinea					
Control	0 c	23.3a	0 b	100 a	4.01a
DS2	11.0 bc	22.4a	1.33 a	100 a	3.43a
DS25	27.5 b	27.6a	1a	96.7a	3.13a
DS258	27.5 b	28.5a	1a	73.0 b	2.75b
Mean	16.5 b	25.5a	0,83a	92.42b	3.33a
Napier					
Control	0c	22.8a	0 b	100 a	4.55a
DS2	27.8 b	25.2a	1.33 a	100 a	4.21a
DS25	33.2 b	26.2a	1a	100 a	4.02a
DS258	55.3 a	25.7a	1a	100 a	3.95a
Mean	29.07 a	24.9a	0,83a	100 a	4.18a
ANOVA					
Grass	*	ns	ns	*	ns
Drought stress	*	ns	*	*	*
Grass*Drought stress interaction	*	ns	ns	*	ns

Averages followed by the same letter in the line or column do not differ (P<0.05) by Duncan test.

Guinea and napier grasses showed partly leaves seem drought, this matter posiibility of grass able corresponded amount of water required for growth and protein synthesis, however application drought stress effect on plant growth. According to Ouvrad *et al* (1990) suggest response of crop adaptation to drought stress affect from differencies growth factors expression.

Inconsistent response Napier to drought showed in Table 1. Leaf rolling score of Napier higher than Guinea but water use effiency of Napier more efficient than Guinea. We suggest Napier grass have more expanded leaves and stomata distribution than Guinea grass. Application drought stress treatment cause stomata of Napier grass close leading leaf rolling.

Soil water content effect to plant water uptake and leaves water content. Drought stress treatment cause decreased water supply and decreased stomata open leading decreased leaves CO_2 absorption followed decreasing photosynthesis. Finally, plant growth decreased. Razavizadesh and Ehsanpour (2005) suggested the lack of water cause decreased cell turgor pressure. Turgor pressure was instrumental in determining the size of plant, plant cell enlargement and multiply, stomata closure and leaf development. Forthermore, relative water content decreased up to 50% in B.brizantha compared to 7% in the other species. The corresponding reduction percentages at the second drought period of 65 and 80%, respectively, whereas in B.humidicola and B.dictyoneura were reduced less than 65%. (Guenni *et al.,* 2004).

WUE Napier grass have not influence of drought stress (Table 1). Increasing drought stress have not significant difference to WUE. WUE of Guinea grass decreased with increasing period of drought stress (control to DS258) about 31.42%. There was means Napier have more resistant to drought than Guinea grass.

Drought stress applied Guinea and Napier grasses have significant difference in plant height. Plant growth parameters of plant height and tiller per pot decreased with the drought stress treatment given. Tiller number of Napier tend decreased with period of drought stress increased, but have not significant difference. Application drought stress treatment on Guinea did not decreased tiller per pot.

The establishment of tiller affected the nature of immortality, row spacing and environment factors as light, temperature and soil fertility. Lack of water decreased tiller number and plant height as growth parameter. Value of Duncan multiple range test (DMRT) of tiller per pot at P<0.05% yet significant but at p<0.10% significant difference follow increasing drought stress. Grass have more tiller number because of genetic grass form clumps. According Heschel and Rigions (2005) growth process was cell elongation, there was need water and hormone to stretch the cell wall. Due to water absorption and hormone skelter then a lengthening of the cell at the growing tip cells. de Barros Lima *et al*,(2011) reported that reduction plant tillering under water deficit mainly occurs due the low immediate availability of nutrients for the growth conditions because the nutrients are absorbed by the system through the soil solution. The cell expansion is other process that depends on the cell water conditions, also decreasing with the water deficit. The water condition wasis essential for the vegetal growth, mainly for tiller emerging in forage plants. Furthermore, tillering and biomass yield of palisade grass during establishment phase are reduced when water deficit is sufficient to make soil content water reach 25% of relative moisture field capacity, regardless to the season when water shortage takes place. (de Araujo *et al.,* 2010)

Kefale and Ranmukhaarachchi (2006) reported that the shortage of water during the growth of lower growth. Process of plant growth in which plant life was reflected in the growth in size as a result of cell network. Related to Sopandie *et al* (1996) exposing plant to drought stress brought about a decrease a leaf osmotic potential. The decreasing of leaf water potential was followed with increasing proline accumulation and absisic acid accumulation. Fan and Li (2001) reported increasing drought stress were decreased efficiency of nitrogen fertilizer utilization and nitrogen used efficiency.

Forage yield decreased affect of drought stress. Guinea decreased 25.9% affect three times stress compared control. Napier decreased 22.20% forage yield compared control. Forage yield influenced of production growth as soil, climate and management.

Application drought stress on grasses leading carbohydrate and nitrogen accumulation within grass if sufficient water. For a long time plant need more water for growth, nutrient solute and photosynthesis. The lack of water would decreased growth and forage yield. The decline herbage mass in Napier smaller than Guinea grass, this means that Napier was more resistant to stress. According to Sayar *et al* (2008) water loss can lower leaf water potentials, leading to reduced turgor, stomatal conductance and photosynthesis to reduced growth and lighter yield.

CONCLUSION

Treatment of drought stress has significant increased leaf rolling score, relative water leaf ratio, but decreased plant height and herbage mass on Guinea and Napier grasses. Furthermore, leaf dying score, drought tolerance and tiller number have not effect by drought stress. Water use efficiency of Guinea grass decrease in three times drought stress (DS258), while on Napier grass WUE have same effect with control. According decline of water use efficiency and herbage mass yield of two grasses, Napier was more tolerance to drought stress than Guinea grass.

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