Effect of Drought and Inoculation of Arbuscular Mycorrhizal Fungi in Enhancing Productivity and Tolerance Mechanism of Grasses

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Abstract

Drought stress considered to be one of the most important limiting abiotic factors of plant growth and yield in many areas, and Arbuscula Mycorrhizal Fungi (AMF) symbiosis can protect host plants against its detrimental effect. This research was conducted to study the effect of drought and inoculation of Arbuscula Mycorrhizal Fungi on the productivity and tolerance mechanisms of *Stenotaphrum secundatum* and *Ischaemum timurensis* grasses. This research used a completely randomized design with four treatments: D_0(Control), D_1 (with AMF), D_2 (drought), and D_3 (drought and with AMF). Parameters observed were the soil moisture content, leaf water potential, leaf relative water content, shoot and root dry weight, root length, proline, and soluble sugar. The data were analyzed with analysis of variance (ANOVA) and the differences between treatments were analyzed with Duncan range test. The results showed that drought stress significantly ($P<0.05$) decreased soil water content, leaf water potential, leaf relative water content, shoot dry weight in *Stenotaphrum secundatum*. Drought stress significantly ($P<0.05$) decreased soil water content and leaf water potential, but enhanced proline and soluble sugar content in *Ischaemum timurensis*. AMF inoculation did not affect productivity of *Stenotaphrum secundatum*, but in *Ischaemum timurensis* enhanced proline and soluble sugar content but decreased leaf water potential on drought stress. One of the tolerance mechanism in *Ischaemum timuriensis* is by increasing the proline and soluble sugar contents.

Keywords: drought, arbuscular mycorrhizal fungi, grasses, Stenotaphrum secundatum, Ischaemum timurensis

Introduction

Plants in nature are continuously exposed to several biotic and abiotic stresses, water deprivation being one of the commonest. Soils too dry for crop production have been estimated to cover 28% of the earth's land surface (Bray, 2004). Nevertheless, plants have developed several physiological, biochemical, and molecular mechanisms in order to cope with drought stress. Besides the natural responses of plants against drought, it must be considered that most terrestrial plants can establish a symbiotic association with the arbuscular mycorrhizal fungi (AMF). When the AMF symbiosis is established the fungus receives carbon molecules from the plants, and the plants receive nutrients (especially phosphorus) and water from the fungus (Harrison, 2005; Gosling *et al.*, 2006). In this way, AM plants are usually more tolerant to several stresses, including drought, than non-AM plants (Augé, 2001, 2004; Ruiz-Lozano, 2003; Ruiz-Lozano *et al.*, 2006). This research was conducted to study the effect of drought and inoculation of AMF to the productivity and tolerance mechanisms of *Stenotaphrum secundatum* and *Ischaemum timurensis* Grasses

Materials and Methods

The materials used in this study were two types of grasses namely *Stenotaphrum secundatum,* and *Ischaemum timurensis*. The two types of grasses are the result of selection about 30 forage species on preliminary research (Karti, 2010). Other materials used were fiber pots as many as 32 units (diameter = 20, high = 100 cm), Mycofer, growing media in the form of soil and manure, tools WP4 potentiometer, coolbox, and others.

This research used a completely randomized design with four treatments: D_0 (control), D_1 (with AMF), D_2 (drought), and D_3 (drought and with AMF) and four replications. Parameters observed were soil moisture content, leaf water potential, leaf relative water content, shoot and root dry weight, root length, proline (Bates, 1973), and soluble sugar (Dubois *et al.,* 1956 modified by Buysse & Merckx, 1993). The data were analyzed with analysis of variance (ANOVA) and the differences between treatments were analyzed with Duncan range test.

Results and Discussion

Drought stress significantly ($P<0.05$) decreased soil water content, leaf water potential, leaf relative water content, shoot dry weight in *Stenotaphrum secundatum* (Table 1). AMF without drought treatment did not show significant differences, but it showed significant different ($P<0.05$) in drought treatment. Drought stress reduced levels of the soil led to a decrease in water absorption. The low uptake of water caused the shoot dry weight decreased because of declining photosynthesis process. The addition of AMF increased significantly ($P<0.05$) the shoot dry weight, this is due to the ability of AMF in increasing absorption of water so that improving the photosynthesis process.

Table 1. Effect of drought and the addition of AMF to soil moisture, leaf water content, relative water content, shoot dry weight, and root dry weight of *Stenotaphrum secundatum*

Variables	Treatments			
	Do	D1	D2	D3
Soil moisture	38.45 ± 0.46 a	39.14 ± 0.59 a	23.76 ± 1.04 b	22.98 ± 0.79 b
Leaf water potential (-Mpa)	-0.68 ± 0.2 b	-0.51 ± 0.6 b	-6.79 ± 1.6 a	-7.00 ± 1.7 a
Relatif water content (%)	82.28 ± 2.8 a	87.2 ± 6.4 a	29.69 ± 6.4 b	34.51 ± 10.2 b
Shoot dry weight (g/pot)	27.6 ± 3.5 a	29.0 ± 4.7 a	14.7 ± 2.1 c	22.3 ± 2.3 ab
Root dry weight (g/pot)	2.5 ± 1.9	4.8 ± 3.5	2.9 ± 0.7	3.2 ± 1.0

Description: D_0 (control), D_1 (with AMF), D_2 (drought), and D_3 (drought and with AMF).

Table 2. Effect of drought and the addition of AMF to soil moisture, leaf water potential, leaf relative water content, root length, shoot dry weight, and root dry weight, proline and soluble sugar of *Ischaemum timuriensis*

Variables	Treatments			
	Do	D1	D2	D3
Soil moisture (%)	$35,52 \pm 0,58^{a}$	$35,33 \pm 1,97^{a}$	$23,15 \pm 1,28^{b}$	$24,32 \pm 2,01^{b}$
Leaf water potential (-Mpa)	$-1,02 \pm 0,19^{b}$	$-1,36 \pm 0,11^{a}$	$-1,46 \pm 0,17^{a}$	$-1,19 \pm 0,27^{ab}$
Leaf relative water content (%)	$88,25 \pm 3,50^{a}$	88,48 ± 0,90	86,10 ± 1,71	86,78 ± 0,72
Root lenght (cm)	128,0 ± 6,38	128,50 ± 5,80	128,25 ± 4,92	127,75 ± 11,76
Shoot dry weight (g/pot)	38,87 ± 9,21	41,70 ± 18,36	29,10 ± 12,35	30,70 ± 5,88
Root dry weight (g/pot)	5,30 ± 3,77	6,65 ± 4,20	8,30 ± 3,76	10,23 ± 2,99
Proline	$51,68 \pm 7,63^{H}$	$43,36 \pm 7,04^{H}$	$67,48 \pm 7,43^{H}$	$59,05 \pm 17,73^{H}$
Soluble sugar	$6,64 \pm 2,43^{LM}$	$4,78 \pm 1,36^{M}$	$23,09 \pm 2,71^{EF}$	$17,24 \pm 1,88^{GH}$

Description: D_0 (control), D_1 (with AMF), D_2 (drought), and D_3 (drought and with AMF)

In *Ischaemum timuriensis* drought stress significantly (P<0.05) decreased the soil moisture content, leaf water potential, and significantly increased (P<0.05) the proline and dissolved sugar, but did not show significant effect in leaf relative water content, root and shoot dry weight. In drought conditions, plants decreased leaf water potential, but with the addition of AMF the decrease could be minimized compared to that with non-AMF. In these plants, drought treatment did not cause a change in relative leaf water content, root and shoot dry weight. This suggests that these plants include drought resistant crops. Tolerant plants that can increase levels of proline and soluble sugar to maintain water absorption so that the growth process can run well.

Drought resistance mechanisms in *Ischaemum timuriensis* is by secreting proline and soluble sugar. In Figure 1 shows that drought stress increased proline levels in both treatments with the addition of AMF or not. In *Ischaemum timuriensis* a sharp increase in proline was seen after 40th day.

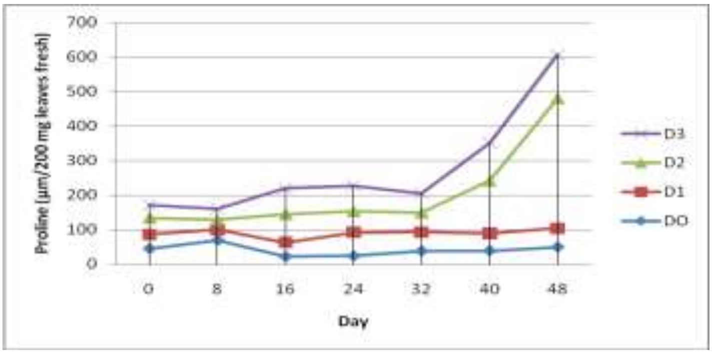

Figure 1. Proline Content of Ischaemum timuriensis.

In *Ischaemum timuriensis* (Figure 2) shows that drought stress showed the highest elevated levels of dissolved sugar. The addition of AMF on drought stress decreased levels of dissolved sugar, it means that the AMF can increase the absorption of water through the hyphae.

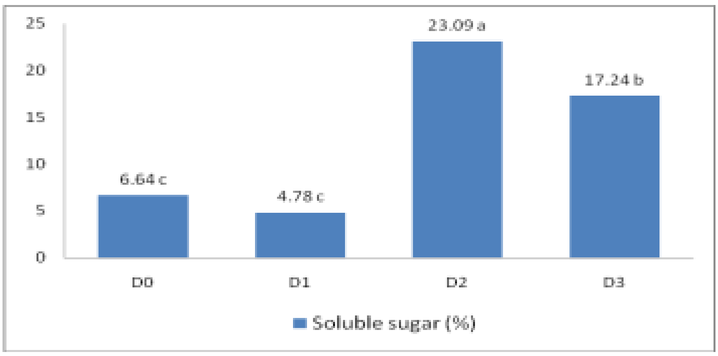

Figure 2. Soluble Sugar of Ischaemum timuriensis.

Conclusion

Drought stress can reduce soil moisture, leaf water potential, leaf relative water content, shoot dry weight in *Stenotaphrum secundatum*. AMF inoculation on drought stress can increase the shoot dry weight. On *Ischaemum timuriensis* drought stress can reduce soil moisture, leaf water potential, and increasing proline and sugar dissolved. *Ischaemum timuriensis* is included in drought-resistant plants with resistance mechanisms through the increased secretion of proline and soluble sugar.

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-- back to Table of Content --