

Mycorrhizal Fungi Influence on Physiological Growth Indices in Basil Induced by Phosphorus Fertilizer under Irrigation Deficit Conditions

Seyed Alireza Valadabadi, and Hossein Aliabadi Farahani

Abstract—This experiment was carried out to study the effect of AMF, drought stress and phosphorus on physiological growth indices of basil at Iran using by a split-plot design with three replications. The main-plot factor included: two levels of irrigation regimes (control=no drought stress and irrigation after 80 evaporation=drought stress condition) while the sub-plot factors included phosphorus (0, 35 and 70 kg/ha) and application and non-application of *Glomus fasciculatum*. The results showed that total dry matter (TDM), life area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) were all highly significantly different among the phosphorus, whereas drought stress had effect of practical significance on TDM, LAI, RGR and CGR. The results also showed that the highest TDM, LAI, RGR and CGR were obtained from application of *Glomus fasciculatum* under no-drought condition.

Keywords—Drought stress, *Glomus fasciculatum*, physiological growth indices

I. INTRODUCTION

MYCORRHIZAL fungi live in a 'symbiotic' relationship with plants.

They grow in close association with the roots and play an important role in the concentration and transfer of soil nutrients to the plant.

In exchange, the plant supplies the fungus with sugars. Although specific fungus-plant associations with respect to drought tolerance are of great interest [12], the exact role of arbuscular mycorrhizal fungi (AMF) in drought resistance remains unclear [1]. More studies are therefore needed to determine the direct or indirect mechanisms which control plant-water relations in AMF-plant symbiosis.

Although the effects of AM fungi on plant water status have been ascribed to the improved host nutrition [8], [11], [7] there are reports that drought resistance of AMF plants is somewhat independent of plant P nutrition status of plants [2], [5], [10]. Although improved host nutrition has been ascribed to AM fungi effects on plant water status, there are reports that the drought resistance of AMF plants is somewhat independent of phosphorous levels. Reference [13] shows that the increased metabolically active fungal biomass in inoculated plants was

independent of phosphorous levels and was not related to phosphorous uptake from the poor nutrients soil [9]. Reference [4] shows that extent of colonization of different barley cultivars was not consistently affected by *Glomus intraradices* and was only variably sensitive to the addition of phosphorous. Drought stress is especially important in areas where crop production is essentially rain-fed. Drought stress causes an increase in solute concentration in the soil and root-zone environment leading to an osmotic flow of water out of plant cells. This in turn causes the solute concentration inside plant cells to increase, thus lowering water potential and disrupting membranes along with essential processes like photosynthesis. These drought-stressed plants consequently exhibit poor growth and yield. In worst case scenarios, the plants completely die. Certain plants have devised mechanisms to survive such low soil moisture conditions.

These mechanisms have been classified as tolerance, avoidance or escape. Drought tolerance is the ability of crops to grow and produce seeds or propagules under conditions of water deficit. A long-term drought stress effects on plant metabolic reactions vary with plant growth stage, water storage capacity of the soil and physiological aspects of plant.

Drought tolerance of cultivated crop plants is different from that of wild plants. When crop plants get encountered with severe water deficit, they often die or seriously lose yield while conversely wild plants face similar conditions of drought, they survive well with often little/no yield loss. Because of water deficit in most arid regions, tolerance of crops to drought has always been of great importance for the plant breeder. Reference [3] shows that one of the main aspects of drought tolerance is the ability of plant cells to survive severe water loss without suffering deleterious damages. When the plant cell dries up, usually the vacuole crumples more than the cell wall and thus results in tearing up of the protoplasm. The authors believe that such damages are the main reasons for cell death which has no tolerance mechanism. Plant yield loss under insufficient water has always been an important issue for plant breeders to improve using drought tolerance indices to select genotypes. Reference [13] shows that investigated variations in SPAD (write long version of the unit- the relative chlorophyll concentration of leaves) meter readings of rapeseed leaves under different treatment combinations of four cultivars (Hayola 401, Hayola 308, Option and RGS) and irrigation regimes (no-stress i.e., irrigation at field capacity-FC; 75% FC, 50% FC and 25% FC) in a pot experiment

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conducted under a controlled glasshouse conditions in Iran. Their results showed that with increasing drought stress, SPAD meter readings were conversely decreasing. Further implications of the results were such that drought stress had a significant effect on net photosynthesis (A), stomata conductance (g_s), intercellular CO_2 concentration (C_i) and leaf area (LA) of rapeseed both at vegetative and flowering stages. In general, Hayola 401, had the highest yield under both conditions of drought and no-drought, followed by Hayola 308, whereas RGS had the lowest yield among the cultivars. The cultivars Hayola 401 and 308 exhibited the highest g_s under no-drought but the lowest under drought stress. The ranking of the cultivars in their overall tolerance to drought was found to follow Hayola 401 > Hayola 308 > Option > RGS. Reference [6] shows that yield and yield components of rapeseed were affected by water shortage occurring from flowering to the end of seed set. Number of seeds per plant was the yield component affected most although some compensation occurred when the water supply was restored. The Thousand seed weight was only affected by low water stress only if it occurs during the period from the stage of siliques were swelling to seeds coloring. The results also demonstrated that a marked reduction in oil concentration was evident when water deficit occurred from anthesis to maturity. Furthermore, they found that oil and protein concentrations were inversely related.

II. MATERIALS AND METHODS

This experiment was carried out to study the effect of AMF, drought stress and phosphorus on physiological growth indices of basil at Iran using by a split-plot design with three replications. The main-plot factor included: two levels of irrigation regimes (control=no drought stress and irrigation after 80 evaporation= drought stress condition) while the sub-plot factors included phosphorus (0, 35 and 70 kg/ha) and application and non-application of *Glomus fasciculatum*. In order to the determination of TDW, from 20 days after cultivation to harvesting time, 10 plants were selected randomly in all plots each 15 days regularly. Samples were placed under 75°C in electrical oven for 48 hours and were weighed by electrical scale and then determined TDW in each sampling stage. To determine LAI, leaves area of upon samples were estimated by leaf area meter before placing in oven and then determined LAI in each sampling stage. Finally, RGR and CGR were determined by the following formulas:

$$RGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1}$$

$\ln W_2 - \ln W_1$ = Logarithm natural of dry matter variations

$$T_2 - T_1 = \text{Time variations as day}$$

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times GA$$

$$W_2 - W_1 = \text{Dry matter variations}$$

$$T_2 - T_1 = \text{Time variations as day}$$

$$GA = \text{Ground Area}$$

Finally, after determination of TDW, LAI, RGR and CGR were supplied their graphs by Excel computer software.

III. RESULTS AND DISCUSSION

The results showed that total dry matter (TDM), life area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) were all highly significantly different among the phosphorus, whereas drought stress had effects of practical significance on TDM, LAI, RGR and CGR. The results also showed that the highest TDM, LAI, RGR and CGR were obtained from application of *Glomus fasciculatum* under no-drought condition.

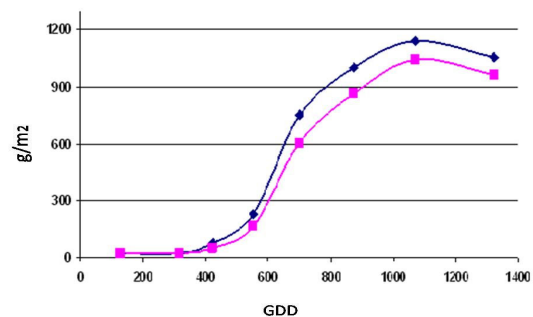


Fig. 1 TDM variations under AMF

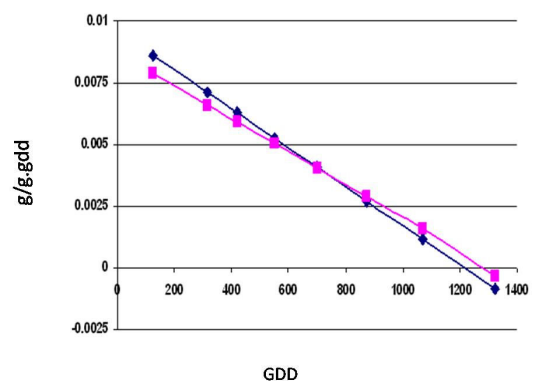


Fig. 2 RGR variations under AMF

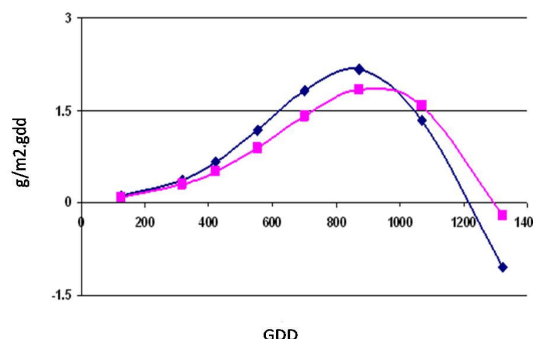


Fig. 3 CGR variations under AMF

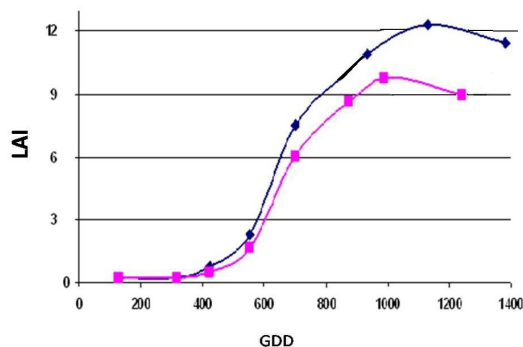


Fig. 4 LAI variations under AMF

REFERENCES

- [1] R. M. Auge, A. J. Stodola, M. S. Brown, and G. J. Bethlenfatvay, "Stomatal response of mycorrhizal cowpea and soybean to short-term osmotic stress". *New phytol.*, vol. 120, 1992, pp. 117-125.
- [2] R. M. Auge, K. A. Schekel, and R. L. Wample, "Osmotic adjustment in leaves VA mycorrhizal nonmycorrhizal rose plant in response to drought stress". *Plant Physiol.*, vol. 82, 1986, pp. 765-770.
- [3] R. M. Auge, "Water relation, drought and VA mycorrhizal symbiosis". *Mycorrhiza*, vol. 11, 2001, pp. 3-42.
- [4] J. B. Baon, S. E. Smith, and A. M. Alston, "Mycorrhizal responses of barley cultivars differing in P efficiency". *Plant and Soil*, vol. 157, no. 1, 1993, pp. 97-105.
- [5] G. J. Bethlenfatvay, M. S. Brown, R. N. Ames, and TR. S. Homas, "Effects of drought on host and endophyte development in mycorrhizal soybeans in relation to water use and phosphate uptake". *Plant Physiol.* vol. 72, 1998, pp. 565-571.
- [6] S. S. Dhanda, G. S. Sethi, and R. K. Behl, "Indices of Drought Tolerance in Wheat Genotypes at Early Stages of Plant Growth". *J. Agron. Crop. Scie.*, vol. 190, no. 1, 2004, pp. 6-12.
- [7] A. H. Fitter, "Functioning of vesicular-arbuscular mycorrhizas under field conditions". *New Phytol.*, vol. 99, 1985, pp. 257-265.
- [8] J. H. Graham, J. P. Syvertsen, and M. L. Smith, "Water relations of mycorrhizal and phosphorus-fertilized non-mycorrhizal Citrus under drought stress". *New phytol.*, vol. 105, 1987, pp. 411-419.
- [9] M. A. Khalvati, *Quantification of Water Uptake of hyphae contributing to barely subjected to drought conditions*. Technical University of Munich, 2005, pp. 8-11.
- [10] M. A. Khalvati, A. Mozafar, and U. Schmidhalter, "Quantification of Water Uptake by Arbuscular Mycorrhizal Hyphae and its Significance for Leaf Growth, Water Relations, and Gas Exchange of Barley Subjected to Drought Stress". *Plant Biology Stuttgart*, vol. 7, no. 6, 2005, pp. 706-712.
- [11] C. E. Nelsen, "The water relations of vesicular-arbuscular mycorrhizal systems", In *Ecophysiology of VA Mycorrhizal Plants*, Ed. G. RSafir, CRC Press, Boca Raton, FL, 1987, pp. 71-91.
- [12] J. M. Ruiz-Lozano, R. Azcon, and M. Gomez, "Effects of Arbuscular-Mycorrhizal Glomus Species on Drought Tolerance: Physiological and Nutritional Plant Responses". *Appl. Environ. Microbiol.*, vol. 61, no. 2, 1995, pp. 456-460.
- [13] A. Vivas, "Physiological characteristics (SDH and ALP activities) of arbuscular mycorrhizal colonization as affected by *Bacillus thuringiensis* inoculation under two phosphorus levels". *Soil. Bio. Biochem.*, vol. 35, no. 10, 2003, pp. 987-996.