

Responses of Physiological Traits of Two un-or Mycorrhizal Leguminous Plants [*Tephrosia vogelii* Hook F. and *Vigna subterranean* (L.) Verdcourt] Under Drought Stress at an Early Growth Phase

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Abstract

Physiological traits of un-or mycorrhizal *Tephrosia vogelii* and *Vigna subterranea* was evaluated in glasshouse under natural light. Completely randomized block design with three factors: two leguminous species, two treatments, four water stress levels were used. Parameters evaluated after 31 days of water stress are: relative water content, hydration degree, water use efficiency, water stress resistance index, plant water content and plant water use. Results obtained show that mycorrhization of plants, improves almost all physiological parameters studied in drought condition. The mycorrhiza thank to its multiple beneficial functions for host plants, allows the two species to maintain their water status, to better tolerate water constraint and to function as in well watered condition. The arbuscular mycorrhizal fungi would be thus a material of choice to mitigate negative effects of water stress on crops, to boost agricultural production and consequently consolidate food safety in area where water is scare.

Key words: *Arbuscular mycorrhizal fungi (AMF)*, *water stress*, *physiological traits*, *early stage*, *symbiosis*

particularly in zones where water is scarce, arid and semi-arid regions (Al-Karaki et al., 2004) and represents the major cause of the loss of more than 50% of the output of plants in world (Wang and al., 2003). Moreover 1/3 of arable lands in the world are touched by frequent and unforeseeable conditions of dryness, allotted to the total climatic adjustment. Recent forecasts indicate that the annual and total average temperature on earth surface will increase by 1.7 to 3.8°C from here to years 2100 (Sun and al., 2011). Such increases in temperature could compromise the agricultural production radically and act negatively on food safety.

Effects of total climatic warming affect all the areas of the world, but the developing countries seem more predisposed because many of them are in arid or semi-arid regions where the cultivable lands are already marginal, vulnerable to the annual climatic fluctuations (Bavec & Mlakar, 2002) and population pressure on the arable lands is already strong (Moran & Showeler, 2005). Water deficit reduces leaves water potential, water use efficiency and consequently decreases leaf stomatal conductance, leaf area, roots biomass and plants total biomass (Schneider et al., 1993). The increase in plants productivity in water deficit condition requires a comprehension of physiological mechanisms by which this stress affects plants growth (Prabawardani et al., 2012).

Several methods were used to mitigate effect of water stress on plants growth and thus to improve their output in drought stress condition (Dixon and al., 1993; Hu and al., 2010; Sassi and al., 2010; Aown and al., 2012; Kassap and al., 2012; Kadian and al., 2013; Hussain and al., 2013; Abdelmoneim and al., 2014; Shabbir and al., 2015); among them, the use of AMF biofertilizers (Dixon and al., 1993; Sassi and al., 2010; Kadian and al., 2013; Abdelmoneim and al., 2014). Mycorrhizae formed

1. Introduction

Stress is regarded as a life situation which deviates significantly of the normal conditions of life (Larcher, 2003). Water stress is one of the environmental constraints most significant, affecting the outputs of agricultural everywhere in the world (Boyer, 1982; Wang and al., 2003; Al-Karaki et al., 2004; Araus and al., 2008; Shahbaz and al., 2011; Hamrouni and al., 2012; Tsoata and al., 2015). Areas where this stress prevails account for 36% of the emerged grounds (Nouaim and Chaussod, 1996). Water stress is prevalent

by the AMF on roots of some plants permits them to gain several advantages: (i) increase in resistance/tolerance to abiotic stresses (Parabawardani and al., 2012; Tsoata et al., 2015; Habibzadeh and Abedi, 2014; Mawardi and Djasuli, 2006), including water stress (Hapsoh and al., 2006); (ii) improvement of the absorption of nutrients (Mawardi and Djasuli, 2006). Nevertheless, under well watered conditions, the effectiveness of mycorrhizal symbiosis depends on the implied fungi species (Zézé and al., 2007), but especially on the genotype of the plant concerned (herbaceous, shrub or tree). It is then useful to intensify research on stressed plants physiology, because AMF are ubiquitous in the environment.

Leguminous plants in general are plants having significant potential on several areas: economic (Westphal and al., 1985), commercial (Bertrand, 2009), agricultural (Akédriin, 2010; Thiébeau and al., 2010), food (Vance and al., 2000; Duke, 1981; Visitpanich and al., 1985a; Anonyme, 2013), Medicinal (El-Sohaimy, 2012; Makoshi and Arowolo, 2011; Bahadoran and Mirmiran, 2015; Tsoata et al., 2015), attenuation of the effects of climatic change (Jensen and al., 2012). Considering significant services rendered to living things and environment, Jensen et al. (2012), think that leguminous plants could be regarded as significant components in the development of futures agroecosystems. *T. vogelii* which is shrubby perennial leguminous plants, exploited primarily to enrich fallow, poor and degraded soils and also as firewood and insecticidal plant (Makoshi and Arowolo, 2011; Tsoata et al., 2015). *V. subterranea* is a herbaceous papilionaceae cultivated for its seeds (Hillocks and al., 2012) and used in various rotations with cultivated gramineae (Ncube and Twomlow, 2007; Tsoata et al., 2015).

Research related to the physiology of *T. vogelii* and *V. subterranea* in water stress condition is scarce, particularly those bearing on their first development stages. Therefore it is pressing need to intensify studies aiming to unveil plants behavior under water stress and highlight measures of attenuation of negative impact of this abiotic stress on crops yield. The goal of this experimentation was to evaluate the physiological response of un-or mycorrhizal *T. vogelii* and *V. subterranea* according to increasing levels of water stress.

2. Material and methods

2.1. Plant material

Seeds of *T. vogelii* and *V. subterranea* selected, sterilized, germinated, are transferred in pots of development placed in glasshouse, according to an experimental design block randomized with three factors (i) two leguminous plant species; (ii) two treatments [un-and inoculated (iii) four levels of water stress according to field capacity of culture substrate: control (zero stress), soft, average, severe stress and five replicates (Tsoata and al., 2015).

2.2. Measured parameters

Relative water content of leaves (RWC in %):

The state of turgidity is estimated by the calculation of RWC: Eq. (1) (Clarck and Mac-Caig, 1982), which represent the fraction of turgid weight that remaining in the tissue. Leaves are cut and weighed immediately to obtain their fresh weight (FW), put thereafter in test tubes filled with distilled water and placed in darkness. After 24 h, leaves are withdrawn, surface dry, then weighed again to obtain the fresh weight at full turgidity (FWT). The samples are finally oven dry 48 h at 80 °C and weighed to have their dry weight (DW).

$$RWC (\%) = (FW - DW / FWT - DW) \cdot 100 \quad (1)$$

Hydration degree (H° in %): H° is the quantity of water present in a tissue (El Jaafari et al., 1993). It is determined using Eq. (2).

$$H^\circ = 100 - 100 (DW / FW) \quad (2)$$

With (DW = dry weight, FW = fresh weight).

Water use efficiency (WUE): WUE is calculated using Eq. (3) (Anyia and Herzog, 2004; Monclus and al., 2006).

$$WUE = PTDM / WU \quad (3)$$

Where WUE: water use efficiency; PTDM: plant total dry mass (g); WU: water used (ml).

Water stress resistance index (WSRI): WSRI is calculated with Eq. (4) Fisher and Maurer (1978).

$$WSRI = TDWSP / TDWNSP \quad (4)$$

Where TDWSP: total dry weight of stressed plant;
TDWNSP: total dry weight of not stressed plant.

Plant water content (PWC in g of water/ g DW):

PWC is obtained with Eq. (5) below (Bajji et al., 2001).

$$PWC = (PFW - PDW) / PDW \quad (5)$$

Where PWC= **plant water content (g)** PFW = plant fresh weight and PDW = plant dry weight)

Plant water used (PWU in ml): PWU is evaluated by the difference between the total quantity of water lost in each pot and the average quantity of water evaporated by substrate (Guissou and al., 2001).

2.3. Data analyses

Data are treated statistically by the procedure of ANOVA using SPSS 18.0 software. The comparison of means is carried out using the test of Duncan, with an experimental error of 5 %). The means are compared according to the irrigation level within each treatment (un-or mycorrhizal), then between treatments having received mycorrhizal inoculum and control according to the level of water supply.

RWC of *T. vogelii* is always lower than that of *V. subterranea*, whatever the level of water stress or mycorrhization (Fig. 1A), it decreases in leaves with the increase in level of water stress for the two species, un-or mycorrhizal. For *T. vogelii* the decline of RWC is significant ($P < 0.05$) for all the levels of water stress and for un-or mycorrhizal seedlings. The fall is not significant for soft, average stress and soft and control, respectively for unmycorrhizal and mycorrhizal seedlings of the two species. The reduction is significantly high for *T. vogelii* compared to *V. subterranea*. When level of stress increases, the inhibition is 7-69 % and 17-63 % for *T. vogelii*; 9-40 % and 10-37 % for *V. subterranea* respectively for unmycorrhizal or mycorrhizal seedlings. However mycorrhization improved RWC of the two species; the stimulation is significant for *T. vogelii*: 15, 5, 25 and 27 % respectively for control, soft, average and severe stress, compared with *V. subterranea*: 1, 7, 6 and 5 % respectively for the same stress levels. The correlation between root colonization (RC) and RWC for *T. vogelii* (r_{Tv}) and *V. subterranea* (r_{Vs}) exhibits following correlation coefficients: $r_{Tv} = 0.585^{**}$ and $r_{Vs} = 0.231$, unveiling a more significant effect of the AMF on this parameter for *T. vogelii* (Table 1 and 2). Thus, the mycorrhization improves RWC of water stressed plants.

3. Results

3.1 Relative water content

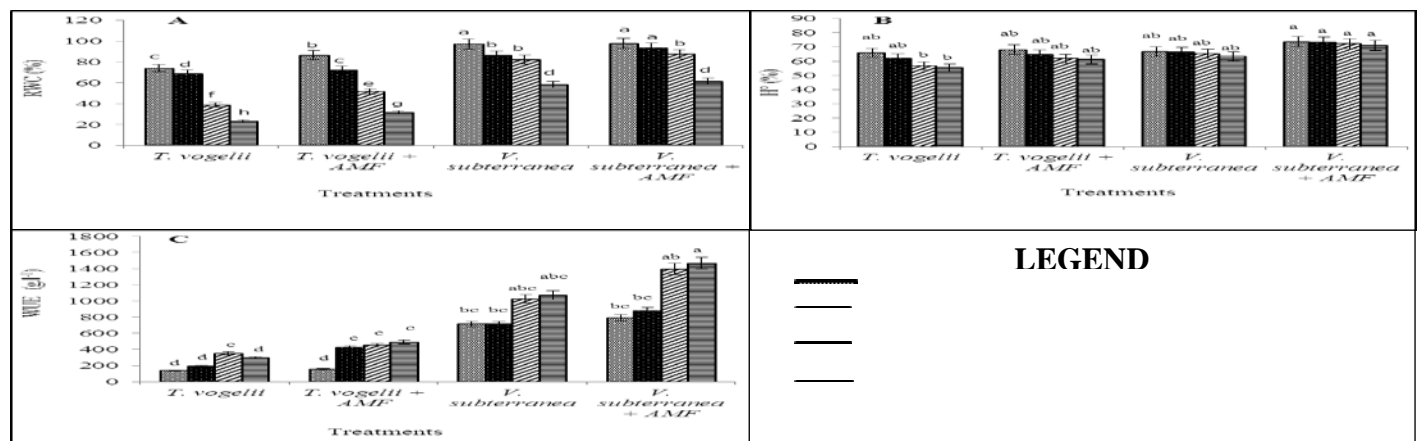


Fig. 1 Relative water content: RWC (A); Hydration degree: H° (B); Water use efficiency: WUE (C) of mycorrhizal and unmycorrhizal *T. vogelii* and *V. subterranea*.

Table 1. Pearson correlation of evaluated parameters of *T. vogelii*: Root colonization (RC); water used efficiency (WUE); water relative content (RWC); plant water content (PWC) and plant water used (PWU).

	RC	WUE	RWC	PWC	PWU	H°
RC	1	-0.255	0.585**	0.176	0.422**	0.213
WUE		1	-0.341*	-0.288	-0.626**	-0.285
RWC			1	0.310	0.538**	0.330*
PWC				1	0.218	0.709**
PWU					1	0.271
H°						1

Note: * significant effect at 5 %, ** significant effect at 1 %

Tableau 2. Pearson correlation of evaluated parameters of *V. subterranea*: Root colonization (RC); water used efficiency (WUE); water relative content (RWC); plant water content (PWC) and plant water used (PWU).

	RC	WUE	RWC	PWC	PWU	H°
RC	1	-0.023	0.231	0.477**	0.302	0.309
WUE		1	-0.102	-0.166	-0.528**	-0.165
RWC			1	0.115	0.375*	0.075
PWC				1	0.055	0.52**
PWU					1	0.271
H°						1

Note: * significant effect at 5 %, ** significant effect at 1 %.

3.2 Hydration degree

The H° of *V. subterranea* leaves is always higher than that of *T. vogelii* whatever the level of stress for unmycorrhizal or mycorrhizal seedlings. It decreases independently of mycorrhization when water stress level increases for the two species. This relatively weak reduction is not significant for *V. subterranea* compared to *T. vogelii*. This inhibition for the soft, average and severe stress is not significant ($p < 0.05$) for *V. subterranea*: 0.5; 2.4; 5.0 % and 0.4; 2.0; 3.5 % respectively for unmycorrhizal and mycorrhizal seedlings. For *T. vogelii*, the fall for the same levels of stress: 6, 14, 16 % and 5, 9, 10 % respectively for unmycorrhizal and mycorrhizal seedlings, is significant compared to control only for average and severe stress. However, for *T. vogelii* and for levels of stress: control, soft, average and severe, mycorrhization increased H° of: 3, 4, 8 and 9 %, the increment being not significant ($p < 0.05$) for average and severe stress; for *V. subterranea* and according to

same levels of stress, it significantly improved H° of 9, 9, 10 and 11 %. The correlation coefficients of $r_{Tv} = 0.213$ and $r_{Vs} = 0.309$ (Table 1 and 2) obtained between RC and H° show that AMF have definitely positive effect on the improvement of H° of two leguminous plants studied in drought stress conditions (Fig. 1B).

3.3 Water use efficiency

WUE of *V. subterranea* is always higher than that of *T. vogelii* independently of the level of stress and mycorrhization (Fig. 1C) and increases with the increase in level of water stress for the two species. Increase in WUE for stress levels: blank, soft, average and severe is: 40, 156, 116 % and 174, 190, 216 % respectively for unmycorrhizal and mycorrhizal seedlings of *T. vogelii*; 0, 44, 50 % and 11, 76, 85 % for same stress levels respectively for the seedlings of unmycorrhizal and mycorrhizal *V. subterranea*. *T. vogelii* records the most significant increases compared to *V. subterranea* in water

stress conditions. Under water stress mycorrhization of seedlings improves WUE for stress levels: blank, soft, average and severe, of 13, 121, 28, 66 % and 11, 23, 36, 37 % respectively for *T. vogelii* and *V. subterranea*. The improvement is increasingly more significant for *T. vogelii* compared to *V. subterranea*. If for *V. subterranea* increase grows with level of stress, for *T. vogelii* the most significant increase is observed for soft stress. The correlation coefficients of $r_{TV} = -0.255$ and $r_{VS} = -0.023$ between RC and WUE (Table 1 and 2) show in this case that evolution of root colonization is inversely proportional to the improvement of WUE of the two Leguminous plants. Thus a reduction in RC in drought conditions drops WUE.

3.4 water stress resistance index

The WSRI (Fig. 2A) for the two species studied is lower than one and decreases independently of the mycorrhization when level of water stress increases. The WSRI of *T. vogelii* and *V. subterranea* mycorrhizal or not are not significantly different for soft water stress, like for severe water stress for *T. vogelii*. Significant differences ($p < 0.05$) are noticed for average stress for the two species mycorrhizal or not and for *V. subterranea* for severe stress. The mycorrhization slightly improves the WSRI for the two species; *V. subterranea* presents weak WSRI under average and severe water stress compared to *T. vogelii*.

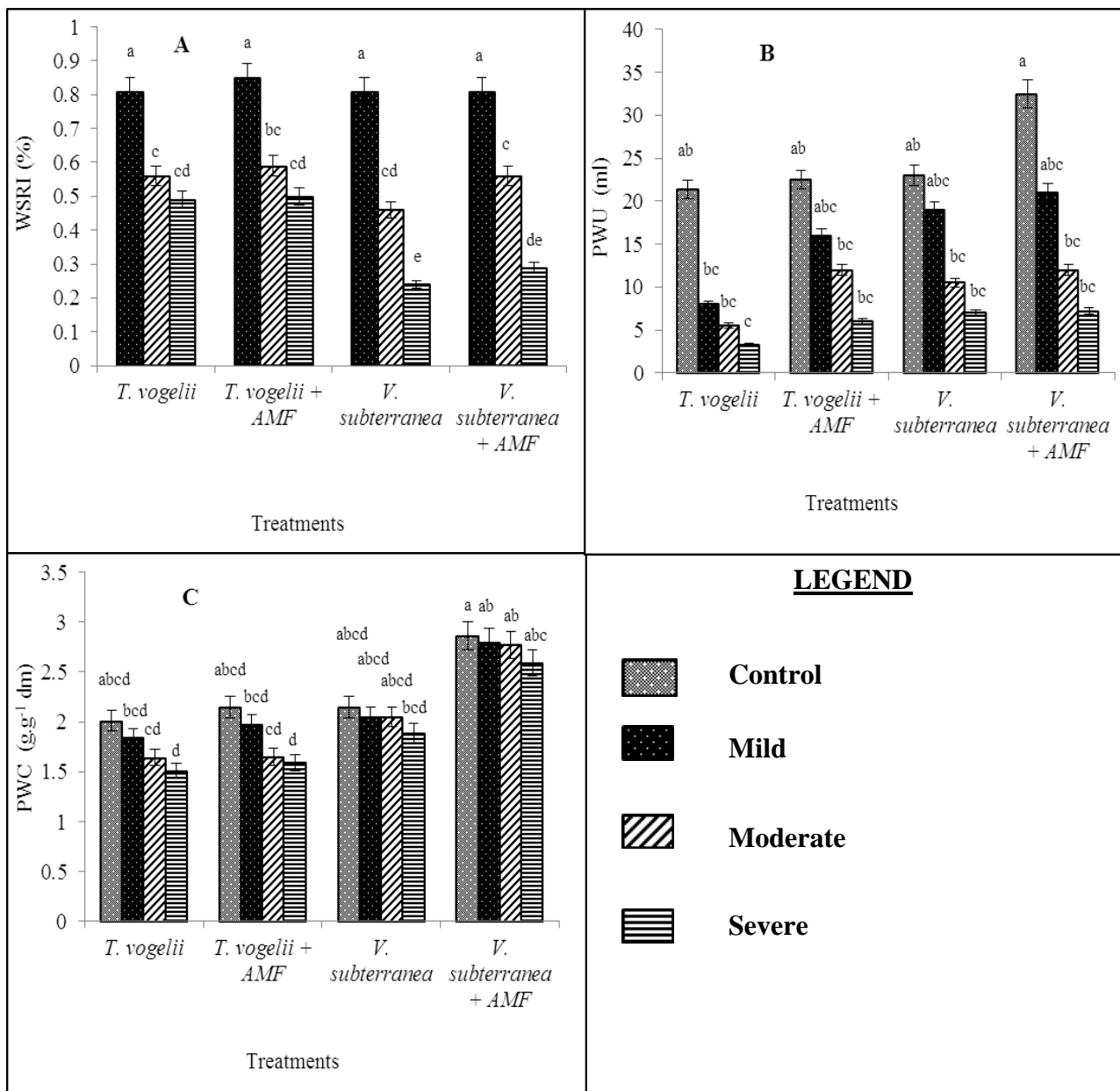


Fig. 2 Water stress resistance index: WSRI (A); plant water used: PWU (B); plant water content: PWC (C) of mycorrhizal and unmycorrhizal *T. vogelii* and *V. subterranea* plants under severe, moderate, mild and well-watered stress.

3.5 Plant water content

The PWC (Fig. 2B) of the two species studied is significantly high for *V. subterranea* compared to *T. vogelii*, except for unmycorrhizal control seedlings. It drops significantly ($p < 0.05$) compared to control for the two species mycorrhizal or not when the drought level grows, except *V. subterranea* mycorrhizal or not for soft and average stress. The mycorrhization does not significantly improve PWC for *T. vogelii* whatever the water stress on one hand; on the other hand for *V. subterranea*, one notes a significant improvement of this parameter: 33, 37, 35 and 37 % respectively for blank, soft, average and severe stress. The correlation coefficients of $r_{TV} = 0.176$ and $r_{Vs} = 0.477$ ** between RC and PWC (Table 1 and 2) show in this case that the evolution of root colonization is proportional to that of water contents of two leguminous plants. Thus a reduction in RC in water stress conditions may lessen PWC.

3.6 Plant water used

The PWU (Fig. 2C) of the two studied species is significantly high for *V. subterranean* compared to *T. vogelii* whatever the treatment and water stress level, that of mycorrhizal seedlings being increasingly higher. One notes a general fall of PWU when the level of stress raises for the two species whatever the treatment. This reduction is not significant ($p < 0.05$) for *T. vogelii* mycorrhizal or not for soft and average stress, and for unmycorrhizal *V. subterranea* for average and severe stress. However the reduction of PWU is significant for *T. vogelii* mycorrhizal or not for severe water stress; whereas for *V. subterranea*, it is significant for unmycorrhizal seedlings only for soft stress and mycorrhizal seedlings for all levels of water stress. The mycorrhization improves PWU for the two species and for all levels of water stress; this improvement is: 5, 100, 118, 85 % for *T. vogelii*; 41, 11, 14, 3 % for *V. subterranea* respectively for blank, soft, average and severe

stress. The correlation coefficients of $r_{TV} = 0.422$ ** and $r_{Vs} = 0.302$ between RC and (Table 1 and 2) show in this case that the evolution of root colonization is proportional to that of water use of the two leguminous plants. Thus lessen RC in water stress conditions may impair PWU.

4. Discussion

The RWC or foliar turgidity is a genotypic characteristic of plant enabling him to maintain leaves cells water content, in order to guarantee the continuity of a normal metabolic activity (Araus and al., 1991 in Bouzerzour and al., 1998; Taiz and Zeiger, 2006). It is for a giving tissue the fraction of turgid weight remaining in it (Chatterjee and Solankey, 2015). The RWC can be regarded as a useful indicator of water balance for a plant as it indicates absolute quantity of water required by the plant to restore its full turgidity (Qariani and al., 2000; Moinuddin and Khanna, 2004; Chatterjee and Solankey, 2015). The maintenance of cellular turgidity and thus high RWC is a physiological feature by which plant manages to express a certain membrane plasticity to avoid plasmolysis. It is an effective mean to tolerate water stress, through raise of osmotic potential, thanks to accumulation of osmolyte in the cytoplasm (Smirnoff, 1998; Cushman and Bohnert, 2001). Osmoregulation is frequently observed in plants and is regarded as one of adaptive strategies to face effects of water stress (Acevedo and al., 1989). This feature of adaptation can constitute an interesting predictive tool in early selection of tolerant species or genotypes to water stress because dryness resistance of a plant is related to its skill to maintain high leaves RWC in conditions of water stress (Faraloni and al., 2011). In the present study, the RWC of *T. vogelii* is lower than that of *V. subterranea*; this result is in agreement with those of Mbarek et al. (2011) on *Cicer arietinum*. It may be considered as a genotypic characteristic; RWC raised in water stress conditions are associated with resistance to dryness (Shaw and al., 2002; Nouri, 2002). Thus *V.*

subterranea, herbaceous leguminous plant, would be more tolerant to water stress than *T. vogelii* papilionaceae shrubby. The RWC lessen when water stress level increases for the two studied species. This decline was already observed in several former works (Lizana and al., 2006; Mbarek and al., 2011; Fu and Huang, 2001; Shaw and al., 2002; Toumi and al., 2014; Bahadur and al., 2009 and 2010; Subramanian and al., 2006). This reduction in RWC would be correlated with differences on the level of skill to absorb ground water by these genotypes, skill to control transpiration water losses at the level of stomata, as well as the variability of the amount of osmolyte accumulated for osmotic adjustment of the two species and consequently normal physiological activity (Baraowa and Gogoi, 2016). In the present experiment *V. subterranea* maintained high % of RWC in all the treatments, this would indicate its best capacity of tolerance against the dryness.

The strong inhibition of RWC observed for *T. vogelii* compared to *V. subterranea*, was already noticed for pea genotypes (Upreti and al., 2000) and could be due to the differences in water stress tolerance of the two species. Indeed *T. vogelii* which has a weak RWC would be more sensitive to negatives effects of water deficit (Toumi and al., 2014) than *V. subterranea*. The RWC is improved for the two studied mycorrhizal species. This result is similar to that of Subramanian et al. (2006) on the tomato (*Lycopersicon esculentum*); Subramanian and Charest (1997) on corn (*Zea mays*); Qiao et al. (2011) on soya (*Glycine max*); Karti et al. (2012) on *Stylosanthes seabrana*. The maintenance of high water statu for inoculated plants could be allotted to the multiple beneficial effects of the mycorrhization. Indeed mycorrhizae functions like a bridge ensuring flow of energy and matter, between the plant and the ground (Cardon and Whitbeck, 2007; Naher and al., 2013); it plays several beneficial roles for the plant like: solubilization of phosphates (Panhwar and al., 2009); increase of active absorbing surfaces and stimulation of the absorption of water as well as nutriments, even in water stress conditions (Naher and al., 2009). It confers to the plant host: better tolerance to drought stress (Abdelmoneim and al., 2014); a better exploration of the soil thanks to the mycorrhizosphere (Porcel and Ruiz-Lozano, 2004). The differences of H° observed for the two studied species independently to treatment and water stress

level would be due to the genotypic differences (Araus and al., 1991 in Bouzerzour and al., 1998); *V. subterranea* which has high H° would be more tolerant to water stress than *T. vogelii* which have low H° in water stress conditions (Shaw and al., 2002). The decline of this parameter observed with the raise of water stress for the two species would be due: to differences in soil water absorption by the two genotypes; to differences in the control of stomata water losses; to different amounts of osmolytes accumulated for the osmotic adjustment (Baraowa and Gogoi, 2016). The improvement of H° for the two mycorrhizal species could be allotted to the mycorrhization which increases active absorbing surfaces, stimulates absorption of water and nutrients even in water stress condition (Naher and al., 2009).

A broad variability in WUE was reported between species (Condon and al., 2002). WUE of *V. subterranea* is higher than that of *T. vogelii* whatever the treatment and the level of water stress. For Charatterjee and Solankey (2015), high WUE constitutes a critical characteristic of the tolerant species to dryness. The difference of WUE observed for the two species would be due to their difference in water stress tolerance; *V. subterranea* having high WUE would be more tolerant to drought stress than *T. vogelii* which exhibit weak one. This parameter increases with rise in water stress level for the studied species; similar results were obtained for: corn (Abbate and al., 2004), *Trifolium alexandrinum* (Lazaridou and Koutroubas, 2004), *Pinus ponderosa* and *Artemisia tridentata* (Delucia and al., 1989); alfalfa (*Medicago sativa*) (Lazaridou and al., 2003); tomato (Subramanian and al., 2006); Martin et Stephen (2006). The increment observed under water stress would be correlated with: the stomata closing to reduce transpiration (Lazaridou and Koutroubas, 2004) in one hand, to the fast fall of stomatal conductance with the rise in water deficit in another hand (Delucia and al., 1989; Chaves and al., 2004). However former works announce a reduction in WUE in water stress conditions: Costa et al. (1997) on the potato; Sarr et al. (2001) on niébé (*Vigna unguiculata*); Singh and Singh (2003) on *Dalbergia sisso*; Egilla et al. (2005) on *Hibiscus rosa-sinensis*; Li et al. (2009) on *Sophora davidii*. The tolerant species stabilize WUE, by reducing water losses, but if the growth of the plant is

strongly broken, WUE is significantly reduced (Farooq and al., 2009).

The mycorrhization of seedlings of the two studied species improves WUE for all levels of water stress compared to control. This result corroborates those of Subramanian et al. (2006), which noted a significant improvement and increasing of WUE in mycorrhizal tomato plants, with the severity of water stress. However the yield rise under water limited conditions is generally associated to WUE reduction, mainly because water is used in great quantity (Charterjee and Solankey, 2015). We can therefore think that mycorrhization improved the degree of tolerance to drought stress and water status of the species studied in stress condition and consequently, the quantity of water used reduced. For a large number of plant species indeed a reduced water use is associated to high WUE, thus constituting a saving water strategy for plants growing where water is scarce (Charterjee and Solankey, 2015).

The values of WSRI are lower than one and decrease when the level of water stress rise for the two studied species, which show that the total dry biomass of the stressed plants is always higher than that of not stressed one. The water stress inhibits dry matter production of *V. subterranea* and *T. vogelii*, this inhibition is proportional to the level of stress. This result is in agreement with those of former works (Liu and al., 2012; Zokaee-Khosroshahi and al., 2014). This decrement of dry matter production for stressed plants would be the consequence of a considerable lessen of photosynthesis and growth of plant (Shao and al., 2008), inducing consequently the fall of the photosynthetic activity. The difference of WSRI observed for *V. subterranea* and *T. vogelii* would be due to their different sensitivity to this stress. Thus with average and severe water stress *V. subterranea*, presenting weak WSRI would be more sensitive to drought stress than *T. vogelii* which has high WSRI (Fischer and al., 1983). The mycorrhization improves the WSRI of the stressed host plants, surely by its multiple beneficial effects like: improvement of water status and tolerance to the stress (Smith and Smith, 2012), enrichment in mineral nutrients (Abdelmoneim and al., 2014) as well as the role of biofertilizer, and can reduce diseases incidence, importance of root diseases

through biological processes (Hindumathi and Reddy, 2012; Gao and al., 2012).

The difference of PWC observed between *V. subterranea*, herbaceous plant and *T. vogelii*, woody plant could be due to the fact that water requirements of the two genotypes are different. The PWC drops for the two studied species when the water stress level rise. In previous works, under water stress, a decline of water potential was observed for corn and rice (Siddique and al., 2001), a reduction of 57 % of the total water contents for *Opuntia ficus-indica* (Nerd and Nobel, 1991), a reduction of turgidity potential for *Hibiscus rosa-sinensis* (Egilla and al., 2005). This result could be correlated with the fact that under water stress almost all the plants close their stomata (Cornic and Massacci, 1996) to reduce transpirational water losses (Mansfield and Atkinson, 1990), consequently leaves turgidity and /or water potential fall (Ludlow and Muchow, 1990; Bajji and al., 2001).

The improvement of PWC at the level of mycorrhizal plants for the two species is noted. This result is in agreement with those of Qiao et al. (2011) on soya bean. It could be justified by the capacity of AMF to raise tolerance of plants to water deficit. Indeed plants colonized by the AMF improve active absorbing surfaces, thus contributing to increase the absorption of water and nutrients (Porcel and Ruiz-Lozano, 2004). The improvement of PWC is not significant for mycorrhizal *T. vogelii*; this difference could be due to the fact that the mycorrhizae settles and becomes fully functional for *V. subterranea* faster than for *T. vogelii*.

The PWU are different for the two studied species independently of the level of stress. This difference would be justified by the fact that requirements of water are different for the two genotypes; *V. subterranea* would require more water for its growth and development than *T. vogelii*. The increase of water stress levels, significantly lower PWU for *T. vogelii* and *V. subterranea*. This result is in consistent to those of Li et al. (2009) on *Sophora davidii*; Anyia and Herzog (2004) on *Vigna unguiculata*. This fall would be explained by the reduction in the volume of water in the rhizosphere, because of the various levels of stress applied. The mycorrhization improves the PWU of *T. vogelii* and *V. subterranea* in this work. This

result is in agreement others works which showed that water consumption increases for mycorrhizal plants (Kothari and al., 1990; Davies and al., 1996; Porcel and Ruiz-Lozano, 2004; Asrar et al., 2012). This increase in the water consumption of the plant host would be due to the increase in their tolerance to water stress, improvement of water and mineral absorption following mycorrhizae establishment (Abdelmoneim and al., 2014).

5. Conclusion

The goal of this work was to study the response to water stress of physiological traits of two leguminous plants un-or mycorrhizal. Results obtained show that mycorrhization of the two leguminous plants, improves almost all physiological parameters studied in water stress conditions. Mycorrhizae thanks to its multiple beneficial functions for host plants, allows the two species to maintain their water status, to better tolerate water constraint and to function as in well watered conditions. AMF would be thus considering as choice material to mitigate negative effects of drought stress on crops, in order to booster agricultural production and consequently consolidate food safety everywhere where water is scare.

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