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Effect of Mycorrhiza on Growth, Biochemical Constituents and Yield of Snap Bean Plants under Water Deficit Conditions

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Abstract: A field experiment was carried out during two successive growing seasons of 2013 and 2014, at The Experimental Farm, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Egypt. The aim of this study was to investigate the effect of mycorrhiza on vegetative growth and yield productivity of snap bean (*Phaseolus vulgaris* L.) under water deficit conditions. Results indicated that irrigation at 60 or 45 % of water holding capacity reduce all vegetative growth parameters such as plant height, branches number per plant, shoot fresh weight and shoot dry weight in both seasons as compared with irrigation at 75% of water holding capacity. Mycorrhiza gave a significant effect on enhancing growth vegetative characteristics, so its effect was clearly significant increment on snap bean yield. For the biochemical constituents, mycorrhiza increased total sugars, total protein, N, P, K, Mg, Ca, Fe, Zn, Mn and Cu concentrations in snap bean leaves under all irrigation treatments as compared to non mycorrhizal plants in both seasons. In contrast, mycorrhiza reduced proline concentration in snap bean leaves as compared to non mycorrhizal plants in both seasons. Mycorrhiza increased number of pods per plant, pod weight, pod length and pod yield per plant under all water treatments in the two tested seasons. Generally, the interaction between irrigation at 75 % of water holding capacity with mycorrhiza gave the highest values for all growth parameters, yield traits and biochemical constituents except the highest concentration of proline which resulted when snap bean irrigated at 45 % of water holding capacity without mycorrhiza in both seasons.

Key words: Snap bean · *Phaseolus vulgaris* · Water deficit · Mycorrhiza · Drought tolerance

INTRODUCTION

Drought causes morphological, physiological, biochemical and molecular changes that negatively affect plant growth and yield. Productivity of plants also depends on available nutrients in the soil solution and air and on nutrient uptake and use by plants. The ability to uptake and allocate nutrients is a key factor in plant tolerance to drought [1]. Exposure to drought stress induces a cluster of physiological changes and has detrimental effects on several cell functions. Common bean is sensitive to drought stress, which can cause yield losses of more than 50 % [2].

Mycorrhiza are an important symbiotic relation between fungi and plant roots, Arbuscular mycorrhiza (AM) enhance the growth, development and health of colonized plants [3]. AM play crucial roles in both natural and agricultural situations, including agricultural systems in which the high P- fixing capacities of soils and the unavailability or high cost of P fertilizer limits crop production, situations in which it is essential to reduce soil fertilizer application rates significantly because of environmental concerns [4]. Moreover, mycorrhiza improves the plant tolerance against both of biotic and abiotic stresses by regulating the physiological and biochemical process of plants [5-7].

The root colonization by the mycorrhiza increases active absorptive surface area and stimulates water uptake even in water stress conditions, it could increase the drought tolerance via the increased soil water movement to the plant roots. Moreover, AM enhance the permeability cells of root, resulting an increase in water absorption and nutrients uptake especially phosphorous and micronutrients [8, 9].

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Common bean could be grown as a seed legume in dry land rotations with winter wheat to increase production diversity [10, 11]. Common bean is one of the most important food crops in Egypt and consumed as a cooked vegetable either as dry seeds or green pods. It plays an important role in human nutrition as a cheap source for protein, vitamins and minerals such as Fe, Zn, P, Ca, Cu, K and Mg and are excellent sources of complex carbohydrates [12, 13].

Snap bean plants (*Phaseolus vulgaris* L.) is considered one of important vegetable crops cultivated in Egypt for local market and it has a great importance for exportation. However, bean plants are relatively sensitive to environmental stresses especially drought compared to most vegetable crops which negatively affects its growth and yield through a decline of leaf water potential, stomatal conductance, photosynthesis rate and all growth, productivity and quality of pods of bean plants [14, 15].

Aim of this study was to enhance growth, yield productivity and some biochemical constituents of snap bean plants using mycorrhiza under water deficit conditions.

MATERIAL AND METHODS

In this study, the field experiment was carried out during the two successive seasons of 2013 and 2014, at The Experimental Farm, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Egypt to investigate the effect of mycorrhiza on vegetative growth, productivity and some biochemical constituents of snap bean plants (*Phaseolus vulgaris* L.) under drought stress conditions.

Cultivation: Seeds of snap bean "Bronco" cultivar were sown at clay loam soil on the 1st of March of both 2013 and 2014 seasons. The area of the experimental plot was 14 m^2 consisted of five rows; each row was 4 m length and 0.7 m width. The plant distance was 7 cm apart on one side, an alley (1 m wide) was left as a boarder between irrigation treatments. The chemical properties of the experimental soil site 30 cm depth were analyzed in (Table 1).

Fertilizers Protocol: Calcium super-phosphate (15.5 % P_2O_5) was added at 200 kg/fed, ammonium nitrate (33.5 % N) at 250 kg/fed and potassium sulphate (48 % K_2O) was applied at rate of 50 kg K_2O/fed. All additions of mineral fertilizers were followed according to the recommendations of Agriculture Ministry, Egypt.

Arbuscular mycorrhiza (AM) inoculum was obtained from Microbial Inoculum Activity facility, Faculty of Agriculture, Ain Shams University. AM inoculum consisted of a mixture three species of mycorrhiza (*Glomus etunicatum, G. intraradices* and *G. monosporum* spores at concentration of 10^4 spores/ml. Mycorrhiza was applied by mixing with irrigation water immediately after sowing.

Treatments:

- Irrigation at 75 % of water holding capacity.
- Irrigation at 75 % of water holding capacity + arbuscular mycorrhiza (AM).
- Irrigation at 60 % of water holding capacity.
- Irrigation at 60 % of water holding capacity + arbuscular mycorrhiza (AM).
- Irrigation at 45 % of water holding capacity.
- Irrigation at 45 % of water holding capacity + arbuscular mycorrhiza (AM).

Water Holding Capacity (WHC) Estimation: Laboratory determination of water (moisture) content of soil by mass from the following equation. Water holding capacity % = $[mass_{wet} - mass_{dry}] / mass_{dry} * 100$ [16].

Studied Characteristics

Vegetative Characteristics: plants were chosen at random from three replicates (from the inner rows) at 50 days from sowing to study the following parameters: plant height, number of branches/ plant, shoot fresh and dry weights (g) determined from five plants each replicate.

Biochemical Constituents Estimation: At 50 days after sowing, leaf samples (full expanded leaf, the forth leaf from the top) of snap bean plants were collected to determine total sugars, proline, chlorophyll reading,

Table 1: The chemical analysis of the experimental soil

		Macro elements (ppm)		Cations meq / l				Anions meq / l			
pH	EC ds/m	N	P	K^+	Ca^{+2}	Mg^{+2}	Na^+	HCO_3^-	CO_3^{-2}	Cl^-	SO_4^{-2}
7.61	0.72	55	85	0.8	1.20	1.10	3.51	0.7	-	3.50	0.4

Central Soil and Plant Analysis Laboratory, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

protein and mineral nutrients as N, P, K, Mg, Ca, Fe, Mn, Zn and Cu concentrations.

Estimation of Total Sugars, Proline and Total Chlorophylls: Total sugars were extracted according to the method described by A.O.A.C. [17] and estimated by the phenol sulphoric acid method as described by Chow and Landhäusser [18]. Proline was determined by acid-ninhydrin according to Bates *et al*. [19]. Total chlorophyll reading (SPAD value) of the snap bean leaves were determined using chlorophyll meter (SPAD–502) according to Soil Plant Analysis Department Section, Minolta Camera Co., Osaka, Japan as reported by Minolta [20].

Nutritional Elements Estimation: Leaf samples were taken for nutritional studies; 0.1 gram dry samples of ground plant materials were wet digested using (H_2SO_4/H_2O_2) mixture as described by Cottenie [21].

Total nitrogen concentration (N) was determined in the dried leaves according to the method described by A.O.A.C. [22] and the crude protein % was calculated by multiplying total nitrogen % by factor of 6.25.

Total phosphorus (P) in plant was determined calorimetrically using ascorbic acid method described by Watanabe and Olsen [23].

The concentration of potassium (K) was determined in the digested material using flame photometer as described by Eppendrof and Hing [24].

The concentrations of calcium, magnesium, iron, manganese, zinc and copper were determined by inductively coupled plasma atomic emission spectroscopy [25].

All nutrients were determined in the Central Soil and Plant Analysis Laboratory, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Yield Components: Number of pods per plant was counted, the average pod weight, pod length and pod fresh weight per plant were recorded by using 10 plants from each plot.

Statically Analysis: Experiments were complete randomized block design with three replicates. The statistical analysis of data was done by SAS [26]. For separation between means, tukey test was applied.

RESULTS AND DISCUSSION

Data presented in Table (2) show that growth parameters including plant height, number of branches per plant, shoot fresh weight and shoot dry weight were linear decreased under water deficit levels 45 % and 60 % of WHC in non AM plants when compared with arbuscular mycorrhiza treated plants and irrigated at 75 % of WHC in both seasons. Generally, mycorrhiza stimulate plant height, number of branches per plant, shoot fresh weight and shoot dry weight under all irrigation treatments in both seasons. The highest values of plant height, number of branches per plant, shoot fresh weight and shoot dry weight resulted in AM plants irrigated at 75% from water holding capacity as compared to other treatments but the lowest significant values in vegetative growth characters were recorded in non AM plants which irrigated at 45% of water holding capacity.

Table 2: Effect of mycorrhiza on plant height, branches number/plant, shoot fresh weight and shoot dry weight of snap bean plants under water deficit conditions in both seasons

	Plant height cm)		Branches number/plant		Shoot f.w. (g)		Shoot d.w.(g)	
Treatments	non AM	AM	non AM	AM	non AM	AM	non AM	AM
				Season 2013				
At 75 % WHC	48.33AB	54.33A	2.33AB	3.33A	33.33D	61.67A	5.49CD	10.55A
At 60 % WHC	47.00B	51.00AB	2.00AB	2.67AB	27.33DE	51.67B	5.35CD	9.07B
At 45 % WHC	39.67C	45.67BC	1.67B	2.33AB	21.67E	43.33C	4.650D	6.50C
MSD	6.2672		1.4454		7.4267		1.2967	
				Season 2014				
At 75 % WHC	45.00BC	54.67A	2.66AB	4.33A	36.00D	66.33A	6.22CD	10.77A
At 60 % WHC	43.66BC	51.67A	2.66AB	3.33AB	30.00DE	54.00B	5.50CD	9.18B
At 45 % WHC	40.33C	45.66B	2.33B	3.33AB	24.00E	44.00C	5.00D	6.66C
MSD	4.8373		1.9392		7.1106		1.5104	

WHC = Water Holding Capacity AM= arbuscular mycorrhizal plants

Table 3: Effect of mycorrhiza on chlorophyll reading, total sugars, proline and protein concentration of snap bean leaves under water deficit conditions in both seasons

	Chlorophyll value (SPAD)		Total sugars mg/g f.w.		Proline ug/ g f.w.		Total protein (%)	
Treatments	non AM	AM	non AM	AM	non AM	AM	non AM	AM
				Season 2013				
At 75 % WHC	46.33AB	50.66A	11.80AB	12.16A	0.87C	1.15BC	4.55B	9.234A
At 60 % WHC	42.00BC	47.33A	10.58BC	11.03AB	1.35B	1.25B	4.775B	5.072B
At 45% WHC	38.00C	42.00BC	9.50C	9.75C	1.68A	1.35B	3.164B	4.165B
MSD	5.0071		1.2405		0.3248		3.7456	
				Season 2014				
At 75 % WHC	48.33AB	51.33A	11.80AB	12.53A	1.03B	1.05B	5.703B	9.931A
At 60 % WHC	43.66BC	50.00A	9.66CD	10.92BC	1.33AB	1.08B	5.475B	5.482B
At 45% WHC	39.33C	44.00BC	8.25D	9.42D	1.57A	1.20B	3.520B	4.490B
MSD	5.9596		1.4375		0.3022		3.0951	

WHC = Water Holding Capacity AM= arbuscular mycorrhizal plants

Table 4: Effect of mycorrhiza on macronutrients concentration of snap bean leaves under water deficit conditions in both seasons

	N %		P %		K %		Mg %		Ca %	
Treatments	non AM	AM	non AM	AM	non AM	AM	non AM	AM	non AM	AM
					Season 2013					
At 75 % WHC	0.73B	1.48A	0.423B	0.741A	0.331A	0.36A	0.419B	0.657A	0.419B	0.657A
At 60 % WHC	0.764B	0.811B	0.371B	0.476B	0.317AB	0.328AB	0.398BC	0.521AB	0.398BC	0.521AB
At 45% WHC	0.51B	0.666B	0.328B	0.365B	0.141B	0.208AB	0.273C	0.477B	0.273C	0.477B
MSD	0.5993		0.1939		0.1901		0.1394		0.0178	
					Season 2014					
At 75 % WHC	0.912B	1.589A	0.427B	0.724A	0.334A	0.355A	0.424B	0.658A	0.1154A	0.121A
At 60 % WHC	0.876B	0.877B	0.376 B	0.497AB	0.285AB	0.329A	0.399BC	0.522AB	0.1151A	0.120A
At 45% WHC	0.563B	0.718B	0.329B	0.450B	0.152C	0.189BC	0.273C	0.482B	0.094B	0.112A
MSD	0.4952		0.2666		0.1314		0.1439		0.0164	

WHC = Water Holding Capacity AM= arbuscular mycorrhizal plants

Table 5: Effect of mycorrhiza on micronutrients concentration of snap bean leaves under water deficit conditions in both seasons

	Fe (mg/kg d.w.)		Zn (mg/kg d.w.)		Mn (mg/kg d.w.)		Cu (mg/kg d.w.)	
Treatments	non AM	AM	non AM	AM	non AM	AM	non AM	AM
				Season 2013				
At 75 % WHC	652.33B	807.67A	107.00AB	121.33A	8.33A	18.67A	3.67BC	11.67A
At 60 % WHC	628.67BC	660.33B	107.00AB	110.00AB	7.00A	13.33A	3.00C	10.67AB
At 45% WHC	519.33C	588.67BC	99.00B	108.33AB	6.00A	12.33A	2.00C	8.00A-C
MSD	132.21		18.556		19.755		7.5936	
				Season 2014				
At 75 % WHC	653.33B	813.33A	112.00AB	120.00A	9.00AB	19.33A	5.00BC	13.00A
At 60 % WHC	631.67BC	666.00B	111.67AB	116.67A	5.67AB	18.67A	3.33C	11.67A
At 45% WHC	515.00C	592.00BC	96.33B	112.00AB	4.00B	9.00AB	3.33C	9.33AB
MSD	134.42		16.531		14.25		5.6353	

WHC = Water Holding Capacity AM= arbuscular mycorrhizal plants

Table 6: Effect of mycorrhiza on pods number/plant, pod length, pod weight and pods weight/plant of snap bean plants under water deficit conditions in both seasons

	Pods number/plant		Pod length (cm)		Pod weight (g)		Pods yield/ plant (g)	
Treatments	non AM	AM	non AM	AM	non AM	AM	non AM	AM
				Season 2013				
At 75 % WHC	9.00C	16.66A	9.66B	13.33A	16.33AB	21.00A	154.00B	250.00A
At 60 % WHC	8.00C	13.00AB	8.33BC	9.66B	12.66BC	16.00AB	100.33CD	171.67B
At 45% WHC	7.33C	9.33BC	7.00C	8.33BC	9.00C	12.00BC	75.00D	138.33BC
MSD	3.7134		1.8283		5.4468		39.978	
				Season 2014				
At 75 % WHC	10.00C	19.33A	10.00B	13.33A	17.67B	24.00A	166.00BC	268.33A
At 60 % WHC	9.33C	14.33B	9.33B	10.66B	13.33CD	16.33BC	113.33CD	211.67AB
At 45% WHC	7.66C	10.33C	8.33B	10.33B	9.67D	12.67CD	74.00D	143.00B-D
MSD	3.1001		2.6652		3.8242		78.469	

WHC = Water Holding Capacity AM= arbuscular mycorrhizal plants

Some Biochemical Constituents: Data presented in Table (3) show a clear reducing in chlorophyll values (SPAD), total sugars and total protein concentrations by the shortage in water irrigation treatments (irrigation at 60 % and 45 % of WHC) in both seasons. The highest concentrations of chlorophyll values, total sugars and total protein were showed in AM plants which irrigated at 75% of water holding capacity as compared to the rest treatments but the lowest values in chlorophyll values, total sugars and total protein were resulted in non AM plants which irrigated at 45% of water holding capacity. In contrast, results indicate that proline concentration was increased by water deficit treatments in both seasons. Mycorrhiza led to reduce proline concentration in snap bean leaves under different water holding capacity as compared to non AM plants in both seasons.

Minerals Concentration: Data presented in Tables (4 and 5) show that mycorrhiza gave a significant increase in N, P, Mg, Ca and Fe concentrations in snap bean plants irrigated at 75 % of water holding capacity when compared with the rest treatments in both seasons.

Application of mycorrhiza treatment to snap bean plants irrigated at 75 % of water holding capacity gave the highest concentrations in all estimated macro and micronutrients but the lowest concentrations of N, P, K, Mg, Ca, Fe, Zn and Cu were recorded in non AM plants which exposed to water deficit conditions which irrigated at 45 % of water holding capacity in both seasons.

Data presented in Table (6) indicate that water deficit treatments decreased snap bean yield and it components included, number of pods per plant, pod length, pod weight and pod yield/plant in both seasons. Mycorrhiza gave significant increment in the yield and it components for plants irrigated at 75 % of water holding capacity as compared to non AM plants and the rest treatments in both seasons. The highest yield components of snap bean produced in AM plants irrigated at 75% of water holding capacity as compared to other treatments in both seasons.

In this study we focused on the benefit effects of arbuscular mycorrhiza (AM) to enhance the growth and yield of snap bean plants exposed to water deficit conditions. The mycorrhizal fungi, which we use is consisted of a mixture of *G. etunicatum, G. intraradices and G.monosporum* spores that have a wide spread genus in neutral to alkaline soils, that alkaline conditions cause fixing P in the soil. Results about snap bean growth and yield presented in Tables (2 and 6) supported that water deficit reducing all vegetative growth parameters and decrease yield and its components in both seasons, these data are agree with many authors [27- 32].

Plants have developed several mechanisms in order to cope with drought stress including morphological adaptations, osmotic adjustment, optimization of water resources, antioxidant systems able to diminish the harmful effects of reactive oxygen species (ROS) linked to drought and induction of a variety of stress-responsive genes and proteins [33, 34].

Water deficit reduced the relative water content, leaf wet weight, leaf dry weight, leaf area index and plant leaf numbers until 8, 34, 31, 22 and 19 percentages, respectively. By contrast, leaf temperature and leaf angle of all genotypes increased up to 2 °C and 24 degrees [35]. Like that pods number per plant and 100-seed weight were significantly reduced in all common bean populations by drought stress which reduced pods number per plant by 60% and 100-seed weight by 13% [29].

Also drought stress is one of the limiting factors in crop growth and yield which reduces dry matter production, yield and yield components through decreasing leaf area and accelerating leaf senescence [31]. Furthermore, De Souza *et al.* [36] concluded that severe drought accelerated leaf senescence by reducing leaf nitrogen and chlorophyll contents. Reducing leaf N concentration producing a decrease in photosynthesis rate [37].

Moreover, Baker and Rosenquist; Lawlor and Cornic [38, 39] observed that drought reducing photosynthesis after three weeks of exposure to drought conditions, the stress manifested itself *via* the decrease of the photochemical quenching, which can be a direct consequence of stomatal closing and lower mesophyll CO_2 concentration. Severe drought stress can also induce biochemical damage by reducing calvin cycle activity (CCA), the decrease in chlorophyll under drought stress is mainly due to damage to chloroplasts caused by active oxygen species.

Limited nutrient uptake is a general phenomenon in crop plants grown under water deficit. Subramanian *et al*. [40] found reduced in nitrogen (N) and phosphorous (P) contents in roots and shoots of tomato seedlings grown under drought. Moreover, nutritional imbalance under drought conditions depresses plant growth and therefore productivity by affecting nutrients uptake, transport and distribution [41].

Under limited water supply, nutrients uptake by roots decreases because a decline in soil-water potential slows the diffusion rate of nutrients between the soil matrix and roots surface [42]. Impaired enzyme activity involved in nutrient assimilation under drought stress also disturbs nutrient acquisition. The activity of nitrate reductase in leaves and nodules of common bean (*Phaseolus vulgaris* L.) and dhainicha (*Sesbania aculeata* L.) is substantially decreased under drought [43].

Also in *P. vulgaris* drought stress was reported to reduce nodulation and nodule activity [27]. Therefore, Imposition of water deficit conditions for 45 days to 15-day-old plants of *Phaseolus vulgaris* and *Sesbania aculeata* reduced shoot mass and nodule mass of both species, but the reduction was more pronounced in *Phaseolus vulgaris* than in *Sesbania aculeata.* Nitrate reductase activity was reduced more in the leaves and nodules of *Phaseolus vulgaris* than in *Sesbania aculeata.* Soluble proteins in the nodules of *Sesbania aculeata* were more decreased as compared to that in *Phaseolus vulgaris*. Free amino acids increased in all parts of both species due to water deficit, but a higher increase was observed in leaf and nodules of *Phaseolus vulgaris* than in *Sesbania aculeata*. Osmoprotectants such as proline and glycine betaine increased more in the nodules and other parts of *Sesbania aculeata* under drought stress conditions [43].

Also, drought stress can lead to increase reactive oxygen species (ROS) production, induced stomatal closure inhibits CO_2 uptake, which under high light conditions results in over-reduced electron transport chains leading to photo-oxidative stress [44]. Moreover, ROS destroy normal metabolism through oxidative damage of lipids, proteins and membranes' construction, furthermore, the reduction in vegetative growth may be attributed to decrease of cyclin-dependent kinase activity results in slower cell division under water deficit conditions [45].

Moreover, Beebe *et al*. [46] believed that proline accumulation may associate with osmotic adjustment resulting inhibition of protein synthesis. Some of the several biochemical indices of water deficit injury, proline accumulation and decline in protein synthesis have been reported in many plants [43]. In addition, Sanchez *et al*. [47] reported that the relationship between N availability and proline accumulation is usually positive. Proline accumulation is one of the mechanisms of crop resistance to stress conditions such as drought [48, 49]. In this respect, Fresneau *et al*. [50] stated that drought induces changes in a number of physiological and biochemical processes including inhibition of protein synthesis. It has been observed that increased amounts of free proline in wheat cultivars could be associated with more effective mechanisms of dehydration tolerance and drought avoidance. Amino acid concentration increased under drought conditions apparently due to hydrolysis of proteins [43].

Osmotic adjustment is the key adaptation of plants at the cellular level to minimize the effects of drought-induced damage in crop plants [51]. Also, helps plants under drought in two ways: (1) it helps maintain leaf turgor to improve stomatal conductance for efficient intake of CO_2 and (2) it promotes the root's ability to uptake more water [52, 53]. Moreover, Osmotic adjustment, antioxidant activities and altered growth regulators are among the major physiological adaptations of plants under drought stress. Increased accumulation of osmoprotectants such as proline, glycine betaine (GB), amino acid and sugars are involved in osmoregulation. Scavenging of ROS by enzymatic and non-enzymatic systems, cell membrane stability, expression of aquaporin and stress proteins such as late embryogenesis abundant (LEA) are also vital mechanisms of dehydration tolerance [54].

Nakayama *et al.* [37] found decreased N accumulation in the leaves of studied cultivars under drought. Under drought conditions, common bean varieties showed markedly higher levels of accumulation of leaf N and proline, proline content of all genotypes was increased by 105%. In contrast, that drought stress induced progressive increases in the growth inhibitor abscisic acid (ABA) which triggers ethylene that responsible for plant senescence and abscission [55].

Results about growth and yield presented in Tables (2 and 6) were supported that AM colonizing plants stimulating all vegetative growth parameters and increment yield components of snap bean in the two tested seasons, these data are agree with many authors [28- 30].

Alizadeh and Parsaeimehr [56] indicated that, the colonization of the plant roots by mycorrhizal fungi will lead to a successful growth of *Sorghum vulgare*. The mycorrhizal fungi can assist plants to exploit the soil nutrients and may help them to resist drought stress in the shoots. AM can decrease the stressful effects of soil drought on sorghum growth by enhancement the process of nutrients uptake, Mycorrhiza benefits the plant host through mobilization of phosphorus from non available sources, whereas rhizobia fixes N_2 [57]. One of mycorrhiza colonizing benefits is enhancement of root branching through, AM differentiate to form branched tree-like structure (arbuscules) [58, 3]. Many authors in this concern, as Bucher *et al*.; Jia *et al*.; Tajini *et al*. [28, 30, 32] demonstrates that the increment in plant growth parameters by the inoculation with AM may be due to nutrients uptake and affecting on the efficiency of absorption and utilization of phosphorus in plants are related to colonization by AM.

Arbuscular Mycorrhiza (AM) might play an important role in stress tolerance by establishing mutualistic relationships vital for nutrients and water absorption and regulating several genes as those for aquaporin's to regulate the defense and adaptation mechanisms in common bean plants during the water deficit period [59]. In addition, results in several studies under drought stress conditions indicated that the plant biomass, chlorophyll contents and rate of transpiration were greater in plants inoculated with AM compared with plants without AM infection [60, 61].

AM symbiosis has usually increased host growth rates during drought by affecting nutrients acquisition and possibly hydration [61]. AM symbiosis usually confers improved acquisition efficiency to the plants of P and Zn, particularly under soil conditions, when the availability of these elements for plants is low [62- 64]. Next to the nutritional effects, multitude of other benefits have been attributed to AM symbiosis, such as more AM symbiosis play an important role in alleviating the injurious effects of drought on crop yield *via* increased dehydration-avoidance and increased tolerance, efficient utilization of P fertilizers by the plants, improved root development, increased tolerance of plants to drought and to heavy metals pollution [15, 65, 5, 6, 66]. On the other hand, plants supply the AM fungi with reduced carbon originating from their photosynthesis.

Like that, the AM symbiosis may also improve the plant osmotic adjustment by accumulation of different compounds such as proline, sugars, free amino acids, etc. in plants as response to drought conditions [7]. Moreover, AM increment K and Ca concentration in faba bean plants under salinity conditions [67]. Moreover, under saline conditions using mycorrhiza for treated wheat plants showed enhanced concentration of N, P, K, Ca, Mg, Zn, Mn and Fe than non-mycorrhizal treated plants [68, 69]. Also, AM fungi absorb N, P, K, Ca, S, Cu and Zn from the soil and translocate them to associated plants [70- 72]. The fungi enhance immobile nutrient uptake by increasing the absorptive surfaces of the root. Moreover, that AM symbiosis can also alter plant water relations and responses to drought stress [61, 66].

Also, Evelin *et al*. [7] indicated that AM fungi can improve the tolerance of the host plant to drought stress by achieve several physiological effects in plants such as water uptake and maintenance of root hydraulic properties, reduction osmotic potential in tissues and avoiding water loss and keeping plant gas exchange.

Conclusion: Mycorrhiza application led to stimulate snap bean growth, yield, macro and micronutrients concentration under water deficit conditions. So, we can support and recommended the importance role of inoculation with AM to improve snap bean tolerant to water deficit conditions.

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