

Symbiotic Response of Three Tropical Sorghum Varieties to Arbuscular Mycorrhizal Fungal Inoculation in Marginal Soil

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Abstract - The effect of three *Glomus* species on growth parameters in term of shoot length, root length, dry weight proximate composition and quantitative evaluation of mycorrhizal dependency of three sorghum (*Sorghum bicolor* L.) varieties i.e. SS-1 Johar, PARC SS-2 and SP-462 were evaluated. The AM inoculated plants showed significantly better performance than the non-inoculated plants in terms of plant height, number & length of leaves, root length, number of seminal roots and dry weight. Proximate analysis showed enhancement in crude protein, fat, moisture and ash content in mycorrhizal plants except carbohydrate and crude fibers. Regarding mycorrhizal dependency (M.D), maximum value was noted in SV2 (74.30%) variety while least was observed in SV3 (21.30%). This study clearly indicates the potential of using indigenous AM fungi (*Glomus* species) as biofertilizer in sorghum crop in low fertility soils hence reduce chemical fertilizer input and proved to be environment friendly.

Keywords – AM, Host Growth Responses, Mycorrhizal Dependency, Proximate Analysis, Sorghum Varieties.

I. INTRODUCTION

Mycorrhizas are universal mutualistic associations between soil fungi and vascular plants and are essential in improving plant fitness and soil quality. It improves the resilience of plant communities against environmental, nutritional and drought stresses (Barea *et al.*, 2011).

Arbuscular mycorrhiza (AM) is the common biotic factor of ecosystem which establish symbiotic relationship with terrestrial plants, which help increase plant growth, plant protection, quality of the soil and mineral and water uptake (Maillet *et al.*, 2011).

AM fungi are known to be of great importance due to their great capability to increase growth, yield and crop quality through efficient nutrient acquisition in infertile soils & therefore lessen the prerequisite for phosphate-based fertilizers (Sawers *et al.*, 2008; Roy-Bolduc & Hijri, 2010). In turn, the fungi get carbon from the host plant. AM fungi are able to absorb and transfer all of the 15 major, macro and micro nutrients essential for plant growth (Lester, 2009).

Sorghum is also one of an important cereal crop of Pakistan. After wheat, rice and maize it ranks fourth in position in Pakistan. Its total production is 0.19 million tones and the yield is 606 kg ha⁻¹. It is grown on 0.31 million hectares approx. per annum (FAO, 2005).

Soils of Pakistan like most of the arid and semiarid soils of world are mostly Phosphorus (P) deficient due to their alkaline and calcareous nature, affecting the maize crop adversely (Memon *et al.*, 1992; NFDC, 2001).

Throughout the world scientists are now focused in developing alternative technology to minimize the dependence on chemical fertilizers. Although remarkable research work has been done on various aspects of AM, but the issues of Asian countries including Pakistan such as nutrient deficiency and host growth responses of various crops are least addressed.

Keeping the importance of AM fungi as bio-fertilizers present investigations was carried to find out the feasibility of inoculation of some high yielding tropical sorghum varieties with indigenous tropical AM fungi.

II. MATERIAL AND METHODS

The study was conducted at the Department of Botany, University of Peshawar. Seeds of three sorghum varieties i.e. SS-1 Johar (SV1), PARC SS-2 (SV2) and SP-462 (SV3) were obtained from National Agricultural Research Centre NARC, Islamabad, Pakistan. The soil used was sandy loam with pH 7.8, electric conductivity 0.675 ds/m², Nitrogen 0.032% and Phosphorus 0.8mg/kg with low organic matter 0.6%.

Thirty earthen pots were filled with 8kg of soil. Each sorghum variety was represented by ten replicates i.e. five control pots and five test pots arranged in RCBD having factorial arrangement with two treatments (controlled and uncontrolled). The test pots were inoculated with soil containing spores of *Glomus* Spp. Harvesting of sorghum plants was done after 80 days. After harvesting different growth parameters were taken including plant height, number & length of leaves, root length and number of seminal roots. In the laboratory dry weight of plants was taken by drying the plants in the oven at 65C⁰ for 72 hours. Mycorrhizal inoculum preparation, placement and application were done by the method given by Gaur and Adholeya (2002). Mycorrhizal dependency was also calculated by the following formula. Experimental data was statistically analyzed by applying ANOVA test; the means were subjected to LSD test. While, proximate analysis (moisture content, ash, protein, fats and crude fibers) were determined by standard methods of AOAC (2006).

III. RESULT AND DISCUSSION

Growth Parameters and Mycorrhizal dependency

In the present study in all measured parameters of mycorrhizal plants showed significant differences (P < 0.05) as compared to the control. It is evident from mean data (Table 1, Fig. 1) that MSV2 responded better followed by MSV3 and then MSV1 in terms of plant

height in mycorrhizal plants as compared to control (Plate. 1-3). The results are supported with the work of Laei *et al.* (2011) who reported that in *Sorghum bicolor* stem height in mycorrhizal plants were higher than the control plants.

Growth stimulation by AMF in terms of plant height is generally attributed to enhancement of mitotic activity of the stem cells (Tarafdar & Marschner, 1995) and uptake of low mobility nutrients (P, Cu, Zn and Fe) (Al-Karaki, 2000; Chandanie *et al.*, 2009). It may be due to extra-radical mycelia which grow beyond the depletion area of the soil (Mengel and Kirkby, 2001).



Plate1. Effect of AM inoculation on the growth of sorghum variety (V1)



Plate2. Effect of AM inoculation on the growth of sorghum variety (V2)

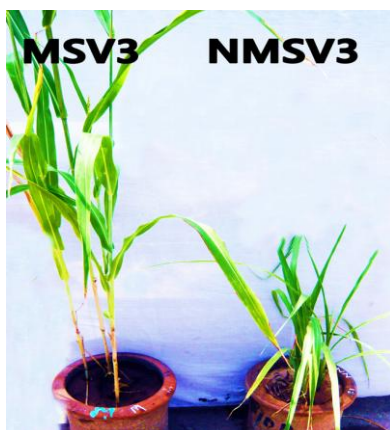


Plate3. Effect of AM inoculation on the growth of sorghum variety (V3)

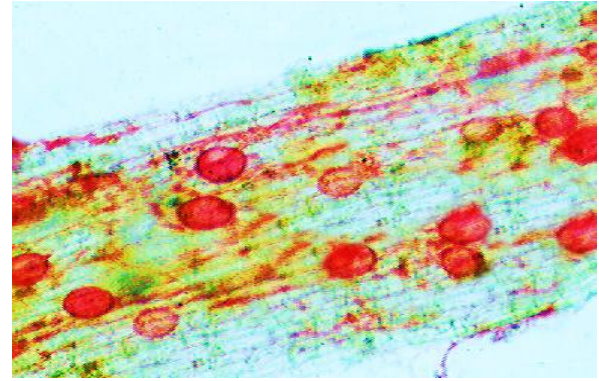


Plate 4: Vesicles in the roots of sorghum



Plate 5: Spore of *Glomus aggregatum*

The result regarding length and number of leaves of sorghum (Table 1, Fig. 2, 3) showed that maximum leaf length (63cm) was recorded in MSV3, while least (113.8mm) was observed in MSV1 (57cm) and increase in number of leaves in mycorrhizal plants range from 0 - 25% in sorghum varieties. These results are also in agreement with the finding of Wu *et al.* (2008) in *Poncirus trifoliata* who reported that VAM inoculation resulted in greater number of leaves per plant as compared to the control plants.

The positive effect may be attributed to the enhancement of P nutrition (Henrike *et al.*, 2007) and water uptake by hyphae (Faber *et al.*, 1991). Ghazi & Zak, (2003) investigated that improved plant growth in terms of leaf length, leaf water turgidity and stomatal activities might be due to enhanced uptake of water and nutrients like Zinc (Zn) and Copper (Cu).

Our present results (Table 1, Fig. 4) evidently showed that in sorghum varieties, the maximum root length (332.6mm) was recorded in MSV2, while least (79.26 mm) was observed in MSV3. Our findings are in agreement with the work of Taylor *et al.* (2008) and Ayoob *et al.* (2011).

Marschner, (2002) described that the higher root growth, is due to higher nutrient supply as the AM fungus competes with the roots for photosynthates.

Regarding number of seminal roots in, sorghum varieties mycorrhizal plants showed greater number than control plants. The number of seminal roots in sorghum varieties was increased by 33.33%, 25% and 10% in MSV2, MSV1 and MSV3 respectively.

The results (Table 1, Fig. 5) are in consistent with the fact that mycorrhizal inoculation changed the root morphology (Subramanian *et al.*, 2008) and bring about stimulation for development of the root system, generally by increasing the formation of lateral roots (Berta *et al.*, 2002).

The present results (Table 1, Fig. 6) clearly showed that AMF increased the dry weight of mycorrhizal plants than non-mycorrhizal plants. In sorghum varieties the dry weight was increased by 289.15%, 75.94% and 27.23% in MSV2, MSV1 and MSV3 respectively in mycorrhizal plants. These results correlate with the results of Laei *et al.* (2011) who found that dry weight in AMF inoculated *Sorghum bicolor* plants were higher than control plants.

The possible explanation of AM fungi on dry matter growth may be due to enhanced uptake of nutrient to shoot than non-inoculated one (Rydlova *et al.*, 2010).

IV. MYCORRHIZAL DEPENDENCY

In present research work three varieties of millet were investigated for mycorrhizal dependency (MD) (Fig. 7). The degree of mycorrhizal dependency was found maximum in SV2 (74.30%) and least was found in SV3 (21.30%). The results of our investigation have showed that cereals were more dependent on mycorrhiza association for better growth in nutrient deficient soil. Root branching determines plant dependence on the symbiosis (Barakah and Heggo, 1998). The results showed that all varieties were found to be differs in their mycorrhizal dependency as also shown by Xavier & Germida, (1998) and Sawers *et al.*, (2008). They found that the mycorrhizal dependency is not the same in plant species and even in their cultivars also. This difference in general is related with root geometry, soil type, soil phosphorus, plant growth rates and mycorrhizal species (Plenchette *et al.*, 1983; Hatrick *et al.*, 1993).

V. PROXIMATE ANALYSIS

Dried powders of the plants were analyzed for moisture, ash contents, crude protein, crude fiber, fats, and carbohydrate on dry matter basis and the results are given in (Table 2). The present results evidently showed that mycorrhizal plants enhanced the amount of crude protein, crude fat, moistures and ash contents as compared to non-mycorrhizal plants (Fig. 8).

As evident from the result that amount of crude protein enhanced in mycorrhizal plants as compared to non-mycorrhizal plants. The data revealed that increase of crude protein was 25.23%, in MSV2, as compared to control. Our results are supported with the findings of other workers (Khalafallah & Abo-Ghalia, 2008; Manoharan *et al.*, 2008) who observed that the crude protein content is higher in AM than non-AM plants. Similarly, highest rate of increase of crude fat was 8.09% in MSV2. Our results agreed with the work of Omomowo *et al.* (2009) who found that AMF (*Glomus mosseae*) inoculated cowpea has higher fat content than uninoculated control. An increase of 30.32% ash content was recorded in MSV2 of inoculated sorghum variety. Our results are supported with the findings of Elsheikh & Mohamedzein, (1998).

While the crude fiber and carbohydrate content showed a relative decrease of -3.70% (MSV2) and --15.45% (MSV2), respectively in mycorrhizal plants. Similar, decrease in crude fiber contents were also reported by Adewole & Ilesanmi, (2011), while Manoharan *et al.* (2008) reported contradictory results to our findings.

The reason behind decrease in carbohydrate content is believed that carbohydrates are transferred from host to the fungal partner (Johnson *et al.*, 1997). However, our results are contradictory to Khalafallah and Abo-Ghalia, (2008) who reported that mycorrhizal plants shows maximum amount of carbohydrates content of wheat plant than non-mycorrhizal under well watered conditions.

Table 1: Plant height, number & length of leaves, root length, number of seminal roots and dry weight (g.) of mycorrhizal (M) and non mycorrhizal (NM) sorghum varieties. Each value is a mean of five replicates. Values followed by different letters are significantly different ($p < 0.05$)

Varieties	Treatments	Plant height (cm)	No. of leaves	Leaves length (cm)	Root length (mm)	No. of seminal roots	Dry weight (gm.)
SV1	M	117.4 ^a	10.00 ^a	57.52 ^{ab}	130.2 ^a	15.00 ^a	7.900 ^b
	NM	83.86 ^b	9.00 ^b	51.50 ^b	75.92 ^a	12.00 ^b	4.49 ^{bc}
SV2	M	128.4 ^a	10.00 ^a	59.06 ^{ab}	332.6 ^a	12.00 ^b	9.69 ^a
	NM	78.86 ^b	8.00 ^c	50.90 ^b	70.00 ^a	9.00 ^d	2.49 ^c
SV3	M	117.9 ^a	9.00 ^b	63.10 ^a	103.4 ^a	11.00 ^{bc}	6.54 ^b
	NM	95.28 ^b	9.00 ^b	51.70 ^b	79.26 ^a	10.00 ^{cd}	5.14 ^{bc}
LSD at 5%		21.57	0.6817	8.190	283.3	1.897	3.779

Table 2: Effect of AM on Proximate analysis of Sorghum varieties

Treatments	Percent on dry matter basis					
	Moisture	Ash	Crude fiber	Crude Fat	Crude protein	Carbohydrate
MSV ₁	10.75	9.97	30.83	3.88	7.23	37.34
NMSV ₁	9.87	9.18	31.50	3.66	7.01	38.78
MSV ₂	11.32	9.97	29.90	3.47	7.99	37.35
NMSV ₂	7.53	7.65	31.05	3.21	6.38	44.18
MSV ₃	9.44	8.85	37.55	3.90	8.05	32.21
NMSV ₃	8.70	8.46	38.53	3.78	6.99	33.54

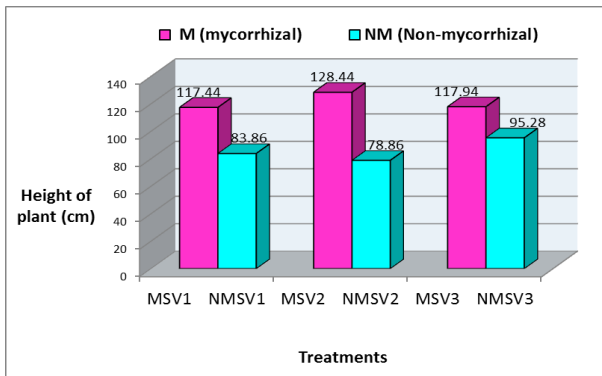


Fig.1. Effect of mycorrhiza on plant height (cm) of *Sorghum bicolor* L.

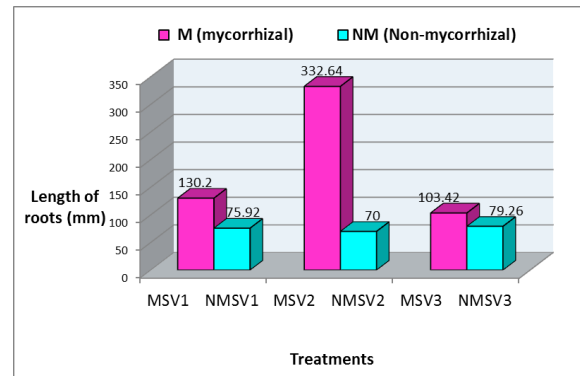


Fig.4. Effect of mycorrhiza on length of roots (mm) of *Sorghum bicolor* L.

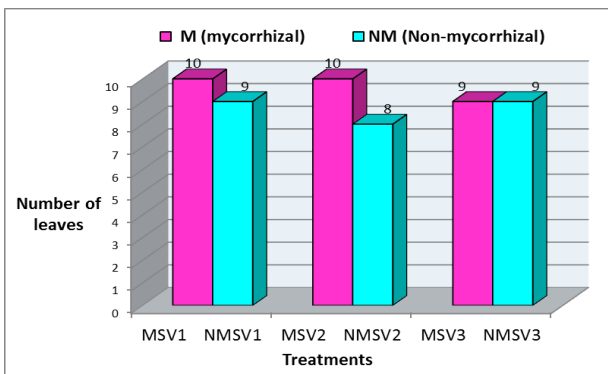


Fig.2. Effect of mycorrhiza on number of leaves of *Sorghum bicolor* L.

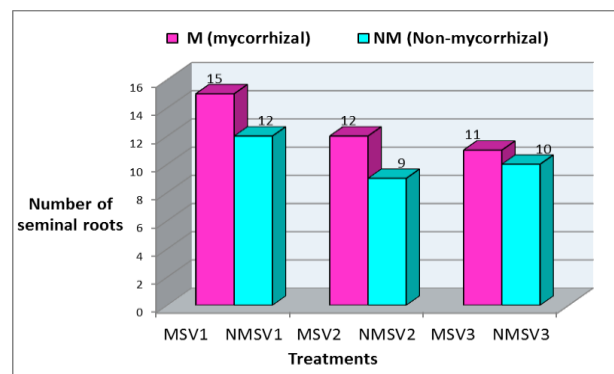


Fig.5. Effect of mycorrhiza on number of seminal roots of *Sorghum bicolor* L.

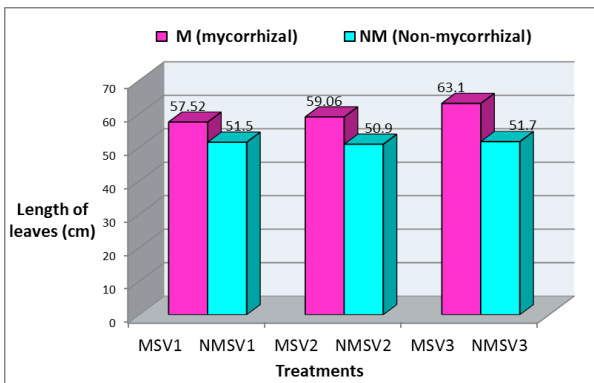


Fig.3. Effect of mycorrhiza on length of leaves (cm) of *Sorghum bicolor* L.

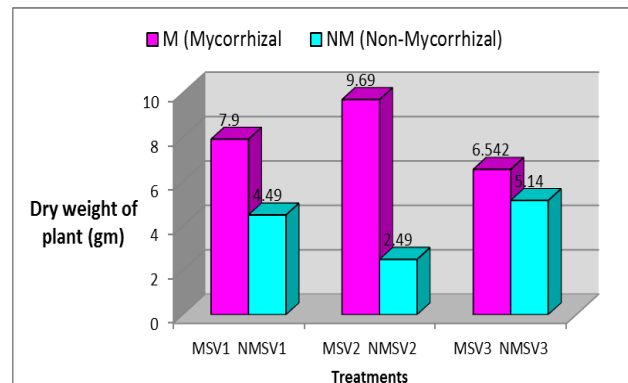


Fig. 6: Effect of mycorrhiza on dry weight of plant (gm) of *Sorghum bicolor* L.

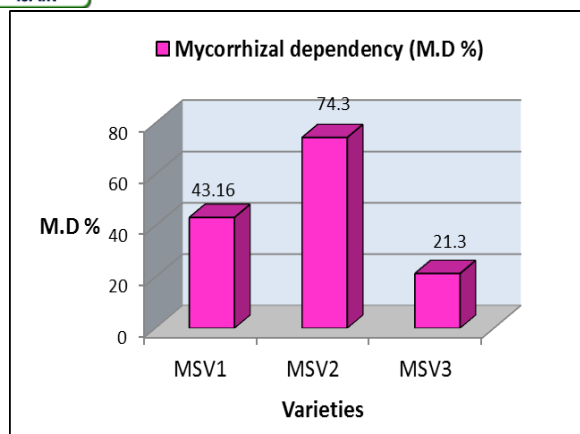


Fig.7. Mycorrhizal dependency index (MD) of sorghum varieties

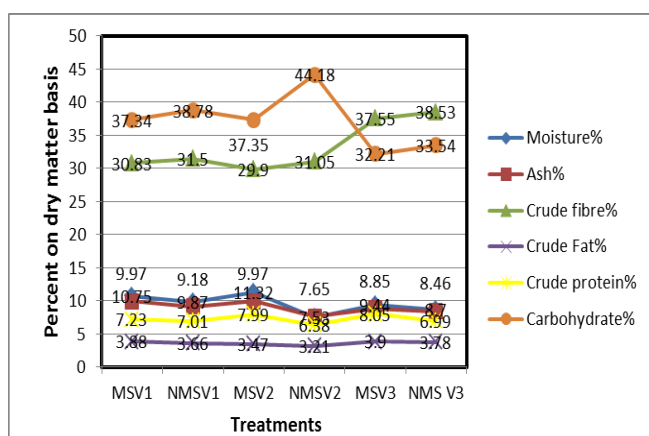


Fig.8. Proximate analysis of sorghum varieties

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