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Effect of Arbuscular Mycorrhizal Fungi on Chemical Properties of Experimental Barren Soil with Pearl Millet (*Pennisetum Glaucum* L.) Crop

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ABSTRACT

The agricultural sustainability could be viewed as maximum plant production with minimum soil loss. The establishment of plant cover is the most important step in restoration of degraded areas. Plant and soil health are dependent upon the interactions of biological, physical, and chemical components of the soil. Arbuscular mycorrhizal (AM) fungi form endomycorrhizal associations with the root of 70-90% of all known vascular plant species. The symbiotic relationship between roots and Arbuscular Mycorrhiza (AM) fungi may also benefit the formation of soil structure and plant growth. This study was conducted to determine the effects of three different indigenous AM fungi i.e. *Glomus mosseae, Glomus fasciculatum* and *Gigaspora decipiens* either single and in combination inoculation with pearl millet, effect on soil quality grown in the pot experiment under barren soil conditions. Pot trial results showed that AM fungi treated plants barren soil improved their chemical properties as compared to control (non-mycorrhizal) treatments.

Keywords: Arbuscular Mycorrhizal Fungi, Barren Soil, Degraded soil, Soil chemical Properties, Restoration.

I. INTRODUCTION

Agricultural land degradation is an increasing worldwide problem that leads to poor soil health. Natural regeneration and revegetation are very slow in a highly disturbed barren soil. Present world demands the production of high quality food in a most sustainable way causing least damage possible to the ecosystem [1]. In soil, the natural microbial populations are activated to grow around developing plant roots, giving rise to the so-called 'rhizosphere'. Microorganisms are most abundant members of the soil biota. The soil organisms that develop beneficial symbiotic relationships with plants roots and contribute to plant growth are called mycorrhizal fungi. The most common and top known of these relations are the Vesicular Arbuscular Mycorrhiza (VAM) fungi [2]. Arbuscular mycorrhizal fungi comprise intra- and extraradical structures. In Glomeromycota, intraradical hyphae can penetrate the outer cell wall of root and grow between or inside of the root cell wall and plasma membrane where they develop the intraradical structures, arbuscules and vesicles. The extra radical structures are hyphae and spores that develop outside of the roots in the soil [3]. The hyphae grow within the plant root and extend out into the surrounding soil acting as an extension of the root system. This relationship greatly increases the absorptive surface area of the root system and with the help of the fungus; the plant is able to obtain mineral nutrients from the soil [4]. In return the plant provides carbohydrates and other nutrients to the fungus. The benefits of glomalin is, in increasing aggregate stability which leads to better soil structure and in turn leads to increase water holding capacity of soil and thus overall improve soil quality and better plant production [5, 6].

Therefore, the reason of the present study was to investigate the effect of AM fungal species *Glomus mosseae*, *Glomus fasciculatum* and *Gigaspora decipiens* on plant growth and in changes in soil chemical properties after pot experiment with pearl millet crop subjected to barren soil conditions.

II. MATERIALS AND METHOD

Pot trial with Pearl millet -

Pot trial of Summer Crop Pearl millet (*Pennisetum glaucum* L.) with VAM fungi- The experiment was conducted in earthen pots filled with the steam sterilized soil from barren lands [Tonk road (Site- I) and Delhi road (Site- II) of Jaipur region].

The barren soil has loamy sand texture, with the following average initial physicochemical characteristics: pH 8.01; Ec, 0.27 ds/m; organic carbon, 0.10%; nitrogen, 85 kg/ha; phosphorus, 15 kg/ha; potassium, 198 kg/ha; zinc, 0.40 mg kg^{-1}; iron, 3.82 mg kg^{-1}; copper, 0.27 mg kg^{-1} and manganese, 2.64 mg kg^{-1}.

The pots were filled with air dried sterilized soil with 5-10 per cent of the VAM starter inoculums as a layer of one- two inches below the soil level and surface sterilized seeds of Pearl millet (*Pennisetum glaucum* L.) were planted (sowing).

Table 1. - Different treatments were maintained with AM fungal species.

S. no.	*Treatments*	*Treatments with VAM fungi species*
1	T_1	*Glomus mosseae (single)*
2	T_2	*Glomus fasciculatum (single)*
3	T_3	*Gigaspora decipiens (single)*
4	T_4	*Glomus mosseae + Glomus fasciculatum*
5	T_5	*Glomus mosseae + Gigaspora decipiens*
6	T_6	*Glomus fasciculatum + Gigaspora decipiens*
7	***Control*** (T_0)	Without VAM inoculation

T= treatment

Different treatments were maintained i.e., T_0- Control (non-inoculated), T_1- *Glomus mosseae* (single), T_2- *Glomus fasciculatum* (single), T_3- *Gigaspora decipiens* (single), T_4- *Glomus mosseae + Glomus fasciculatum,* T_5- *Glomus mosseae + Gigaspora decipiens* and T_6- *Glomus fasciculatum + Gigaspora decipiens.* A set of control was also maintained in similar condition without any inoculums.

Analysis of chemical properties of pot trial soil-

The soil chemical properties were analysed after the completion of pots trials of summer crop with different AM fungal species treatments.

Soil testing is one of the most important tools to determine the status of plant nutrients in a soil. The rhizospheric soil of Pearl millet plant was dug out with a trowel to a depth of 0-10 cm after scrapping away the top 1 cm layer of soil. The collected soil samples were taken in sealed plastic bags, labelled and transported to the laboratory in an insulated container. Before processing, all the treatments soil were sieved (< 2 mm mesh size) to remove coarse roots and other litter.

The air dried and sieved soil samples were analysed for various parameters like pH (digital pH meter), Electroconductivity (conductivity meter), Organic Carbon by Chromic Acid Method [7], Nitrogen by Kjeldahl Method [8], Phosphorous by Olsen's Method [9], Potassium by flame photometer method and micronutrients Copper (Cu), Zinc (Zn), Iron (Fe) and manganese (Mn) by Atomic absorption spectroscopy.

III. RESULTS AND DISCUSSION

In the present studies, an attempt was to analyze the chemical and soil nutrients properties of soil present in the pots after the completion of pots trial with summer crop and different am fungi treatments as compared to control.

Table 2- Chemical properties of experimental soil after completion of pot trial with pearl millet crop (Site I).

S.no	Sample	pH	EC (dS/m)	OC %	Macro and micronutrients						
					N (kg\h)	P(kg\h)	K (kg\h)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Site-I	T1	7.4±0.34	0.08±0.01	0.25±0.01	131±4.36	32±2.51	259±1.73	0.87±0.01	4.71±0.01	0.40±0.01	3.55±0.04
	T2	8.0±0.35	0.12±0.03	0.24±0.02	129±2.08	32±2.00	256±1.73	0.89±0.01	4.69±0.02	0.38±0.01	3.53±0.03
	T3	7.8±0.40	0.13±0.02	0.19±0.03	121±1.53	25±1.53	223±2.00	0.67±0.00	4.42±0.02	0.34±0.02	3.19±0.01
	T4	7.7±0.23	0.08±0.00	0.27±0.01	131±3.05	34±2.08	261±2.52	0.88±0.01	4.69±0.01	0.41±0.01	3.53±0.02
	T5	8.1±0.26	0.11±0.01	0.24±0.02	127±2.08	30±1.15	250±1.15	0.84±0.02	4.63±0.02	0.35±0.01	3.45±0.02
	T6	7.3±0.43	0.09±0.02	0.22±0.01	124±1.73	28±1.53	244±2.64	0.82±0.02	4.60±0.02	0.33±0.01	3.34±0.04
	TO	7.5±0.35	0.13±0.01	0.12±0.01	103±5.29	18±0.58	205±3.05	0.46±0.03	3.87±0.03	0.31±0.03	2.93±0.03

Data represents an average of 3 replicates indicates Means ±SD, T: Treatment with diff, VAM fungi spp., EC: Electrical Conductivity, N: Nitrogen, P: Phosphorus, K: Potassium, Zn: Zinc, Fe: Iron, Cu: Copper, Mn: Manganese

Table 3- Chemical properties of experimental soil after completion of pot trial with pearl millet crop (Site II).

S.no	Sample	pH	EC (dS/m)	OC %	Macro and micronutrients						
					N (kg\h)	P(kg\h)	K (kg\h)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Site-II	T1	7.6±0.65	0.10±0.01	0.25±0.01	129±2.08	31±2.51	256±2.00	0.90±0.01	4.69±0.01	0.38±0.01	3.53±0.03
	T2	8.1±0.30	0.09±0.02	0.24±0.01	132±3.51	30±2.30	253±2.08	0.87±0.03	4.65±0.04	0.39±0.02	3.49±0.02
	T3	8.2±0.32	0.13±0.02	0.20±0.02	118±2.89	25±1.00	220±2.08	0.69±0.01	4.38±0.03	0.32±0.02	3.17±0.04
	T4	7.5±0.30	0.07±0.01	0.26±0.01	129±2.51	32±2.00	257±4.16	0.90±0.00	4.68±0.02	0.42±0.02	3.51±0.01
	T5	8.2±0.31	0.08±0.00	0.23±0.01	124±0.58	28±1.52	243±1.52	0.85±0.02	4.61±0.02	0.35±0.01	3.42±0.02
	T6	7.4±0.60	0.10±0.01	0.22±0.01	123±0.58	27±1.52	240±1.58	0.83±0.02	4.58±0.03	0.33±0.01	3.31±0.03
	TO	8.0±0.20	0.12±0.01	0.13±0.02	98±2.08	17±2.08	209±2.00	0.47±0.02	3.85±0.03	0.29±0.02	2.90±0.02

Data represents an average of 3 replicates indicates Means ±SD, T: Treatment with diff, VAM fungi spp., EC: Electrical Conductivity, N: Nitrogen, P: Phosphorus, K: Potassium, Zn: Zinc, Fe: Iron, Cu: Copper, Mn: Manganese

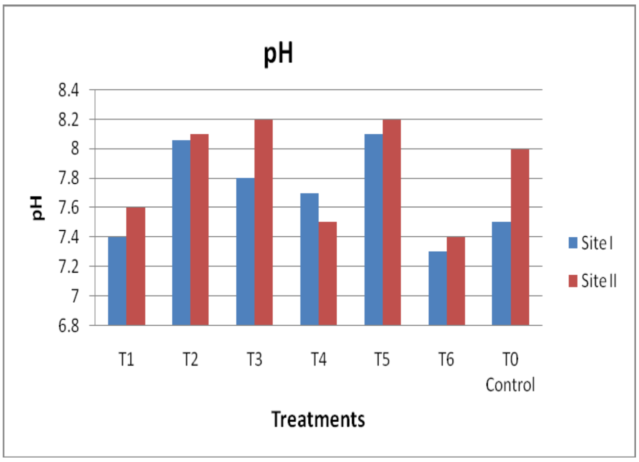

Figure- 1. Pot trials soil pH value of site (I) and (II).

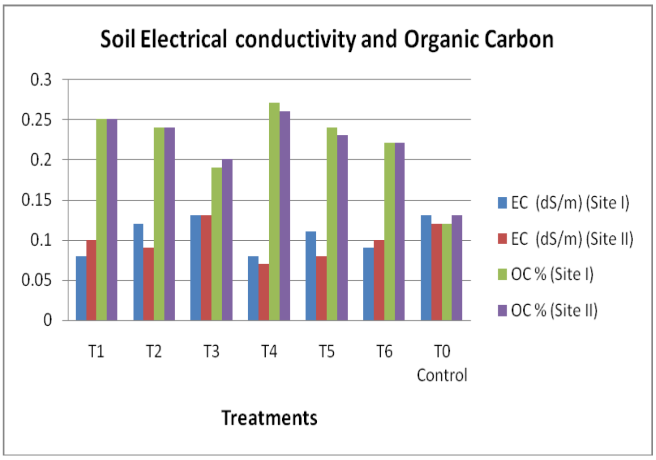

Figure- 2: Pot trials soil Electrical conductivity and Organic carbon properties of site (I) and (II).

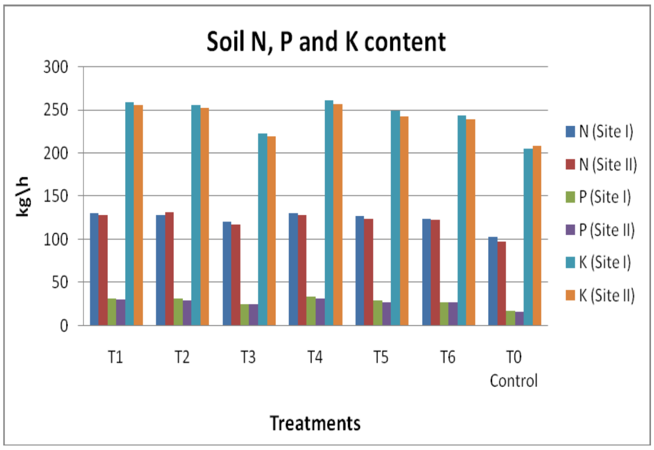

Figure- 3. Pot trials soil Nitrogen (N), Phosphorous (P) and Potassium (K) nutrients contents of site (I) and (II).

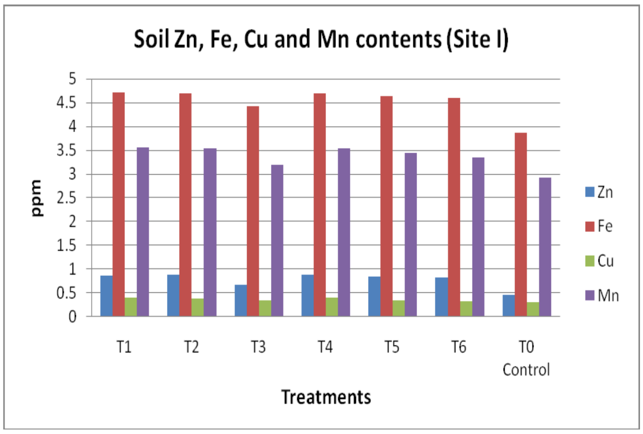

Figure- 4. Pot trials soil Zinc (Zn), Iron (Fe), Copper (Cu) and Manganese (Mn) micronutrients properties of site (I).

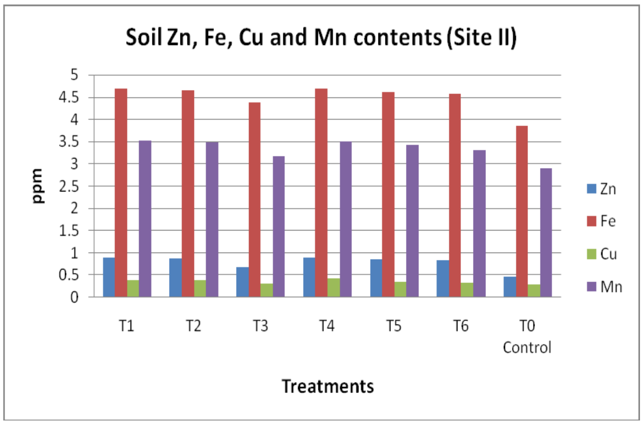

Figure- 5. Pot trials soil Zinc (Zn), Iron (Fe), Copper (Cu) and Manganese (Mn) micronutrients properties of site (II).

Soil is a major source of nutrients needed by plants for growth. The comparative analysed of chemical properties of pot trial soils of summer crop with Am fungi and without AMF treatments (control) of both sites.

The Improvement of quality of soil like organic carbon content was influenced by the AM fungal treatments as compared to control and the highest rise in improvement was observed in *G. mosseae+ G. fasciculatum* treatment (site I) (0.27%) followed by *G. mosseae+ G. fasciculatum* (0.26%) (Site II) treated soil (Table 2 and 3), Such an increase in carbon pool is due to the strong influence of mycorrhizal fungi [10]. Also the phosphorous contents was influenced by the AM fungal treatments compared to control and the highest was observed in *G. mosseae+ G. fasciculatum* treatment respectively (site I) (34±2.08 kg/h) followed by *G. mosseae* (32±2.51 kg/h) at site I treated soil (Table 2). The micronutrients are copper, iron, zinc and manganese, these plant elements are used in very small amounts, but they are just important to plant development. The Am fungal species of *G. mosseae and G. fasciculatum* was the most efficient for its ability to increase plant growth and soil nutrient.

IV. CONCLUSION

The present study showed that the inoculation of AM fungi with plants provides an important enhancement of soil quality that's lead for better plant growth. Although beneficial fungi such as AM fungi play a fundamental role in producing important ecosystem services such as soil fertility, they have received little attention. This research will helps to farmers for restoration of their barren land by the treatments with indigenous AM fungi.

V. REFERENCES

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