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STUDIES ON *ARBUSCULAR MYCORRHIZAL* FUNGI (AMF) STATUS WITH *SORGHUM BICOLOR*, L. IN DHARASHIV DISTRICT, MAHARASHTRA (INDIA)

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ABSTRACT:
The present study was conducted in semi-arid regions such as Ter, Waruda, Naldurag, and Bamble of Dharashiv district of Maharashtra. Variations in AMF root colonization and spore density were depicted in different cultivars of *Sorghum bicolor*. AM fungal spores were identified. Spore density and diversity was enumerated. *Sorghum* cultivars showed a significant variation in AMF colonization and spore density. The highest root colonization percentage was 89.5% in the cultivar Dagdi, whereas the lowest colonization was found 62.3% in the cultivar Dukrii. Spore density varied from 482 to 578 spores/100g soil, with *Glomus* and *Acaulospora* being the dominant genera. In the mixed soil (533/100g soil), mycorrhizal fungal communities were found to be different. The genus, *Glomus* was found to be dominant with the species *G. moculosum, G. fistulossum, G. deserticola, G. multicaule, G. fasciculatum,* and *G. macrocarpum*. The analysis demonstrated that root colonization was positively correlated with soil organic matter, pH, and available phosphorus content. Alkaline soils (pH 7.8–8.2) were found to harbor higher AMF spore densities compared to acidic soils. This variation indicates that soil environment and crop genotype strongly influence fungal diversity and colonization. AMF associations significantly improved nutrient uptake, especially phosphorus and zinc, while enhancing drought tolerance and water-use efficiency in *sorghum* cultivars. The fungal symbiosis also promoted soil aggregation and carbon sequestration, making AMF an important component of sustainable agriculture in semi-arid ecosystems. The present research highlights the potential of AMF in sustainable *sorghum* production, emphasizing the need for inoculation-based management strategies to improve soil health and yield under resource-limited conditions. Future investigations should focus on testing the efficiency of native AMF inoculants, cultivar-specific AMF interactions, and their long-term ecological impacts on *sorghum*-based agroecosystems.

Keywords:- *Sorghum*, AMF Root colonization, Spore Density, Sustainable Agriculture.

INTRODUCTION:

Sorghum bicolor L. is one of the most important cereal crops in the world for its adaptation to arid areas (Smith & Read, 2010). An African crop, *sorghum* is a highly adaptable plant that has withstood hardship and trials and has reliably delivered food, fodder, and fuel (Brady & Weil, 2002). *Sorghum bicolor* generally cultivated in Kharif or Rabi monsoon agricultural lands (July–October) in the Dharashiv district and a few other localities of Marathwada in Maharashtra (Phillips & Hayman, 1970). The average annual rainfall in the region is about 679 mm, and the rainfall during the study period was about 840 mm, which is above-average (Schenck & Pérez, 1990). Stress on the ecological and soil factors specific to the Dharashiv district is warranted (at a latitude of approximately 18.1867° N and a longitude of 76.0419° E). It found its way as the foremost crop among others for sustaining food requirements in the developing countries, bestowing the farmers with quick cash, considering its hardiness to drought, salt in soil, and low fertility of soil (Smith & Read, 2010). *Sorghum bicolor*, being a C4 plant, has a good photosynthetic efficiency and water use efficiency, allowing the plant to grow best under high temperature and low water availability. The traits make it an important crop for averting climate change-induced challenges to agriculture (Brady & Weil, 2002; Muthukumar et al., 2005). *Sorghum* also conserves soil by preventing

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erosion with its deep roots and improving soil structure (Mosse & Bowen, 1968).

This study aims to investigate the rhizosphere soil samples of the species taken from fields cultivating three varieties of *Sorghum*, namely Dagdi, Maldandi, and Dukrii. The study sought to establish the relationship between soil properties, fungal colonization, and crop performance to delineate the soil environment of *Sorghum bicolor* (Koske et al., 1986). In sustainable farming, the bond between crops and tiny organisms plays a bigger part in boosting soil health and crop yields (Giovannetti & Mosse, 1980). Arbuscular mycorrhizal fungi (AMF) are helpful microbes that team up with *Sorghum bicolor* roots. These fungi help the plant absorb key nutrients like phosphorus and zinc, while making it better at taking in water and dealing with stress (Muthukumar et al. 2005). What's more, AMF make the soil healthier by clumping it together and adding organic matter (Schenck & Pérez, 1990). AMF plays a key role in sustainable farming systems, so it's crucial to grasp their variety and function in the area around *Sorghum bicolor* roots (Brady & Weil, 2002). This research sets out to examine how much AMF colonizes roots and the number of spores in various *Sorghum* types linking these factors to soil features and how well the plants grow.

MATERIALS AND METHODS

Study Site and Sample Collection:

Study was conducted in semi-arid regions such as Ter, Waruda, Naldurag, and Bamble of Dharashiv district 18.2070° N, 76.1784° E of Maharashtra. 100gm of two samples of rhizosphere soil and root samples were collected from each locality. The sample is collected in zip lock bag from three distinct *Sorghum bicolor* cultivars grown in different locations during the Kharif or Rabi. The samples were transferred to the laboratory, same part of samples were preserved in 5% formalin. Soil samples were sent for analysis of pH, organic matter, and nutrient content to Krishi Vigyan Kendra (KVK) Baramati.

Root Colonization Analysis:

Roots were treated following the method by Phillips and Hayman (1970), staining with trypan blue to identify vesicles, arbuscules, and hyphae under a compound microscope at 40X and 100X. The root colonization was determined using the formula:

$$\% \text{ Root Colonization} = \frac{\text{Total no of root segments colonized}}{\text{Total no of root segments examined}} \times 100$$

During the preparation, root samples were first washed well in order to free soil particles and later cleaned in 10% potassium hydroxide (KOH) to remove pigments and other cellular debris. After this, they were acidified in 5% hydrochloric acid (HCL) prior to staining. The roots were stained with 0.05% trypan blue in order to visualize structures such as vesicles, arbuscules, and hyphae through a compound microscope (Giovannetti&Mosse,1980). The assessment of root colonization was carried out by dividing the roots into 2–3 cm pieces to ensure uniform staining and observation. Vesicular structures, were observed as key indicators of AMF activity (Koske et al., 1986). Hyphal networks, were also analyzed to understand the extent of fungal spread. The degree of colonization was categorized as low, medium, and high, depending on the density and distribution of fungi in the roots. For each sample, the root colonization was evaluated in 25 root segments per inoculum.

SPORE ISOLATION AND IDENTIFICATION:

The AMF spores were extracted using wet sieving and decanting techniques as described by Gerdemann & Nicolson, 1963. This process involves suspending 100g of rhizosphere soil in 1 liter of water, followed by vigorous shaking to

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separate spores from soil particles. Spore density was determined per 100g of rhizosphere soil. Identification of spores was carried out based on morphological characteristics using the International Collection of Vesicular Arbuscular Mycorrhizal Fungi (INVAM) database, 2009. The suspension was passed through a series of sieves with mesh sizes ranging from 50 µm to 250 µm to capture spores of various sizes (Mosse & Bowen,1968). Data were analyzed to determine correlations between AMF colonization, spore density, and soil properties (Giovannetti & Mosse, 1980).

IDENTIFICATION OF SPORE:

Referring to the morpho-taxonomic criteria given by INVAM and several mycorrhizal manuals such as those of (Schenck et al., 1990) and (Rodrigues et al., 2009), AM fungal spores were identified. Spore density and diversity were enumerated from these references. Identifications of *Glomalean* spores were based on the recommendations of (Mosse and Bowen, 1968; Walker, 1983; Koske et al., 1986; Schenck and Pérez, 1990; Schüssler, 2000; Muthukumar et al., 2005; Bukhari and Rodrigues, 2006), as well as from the culture database of INVAM (http://invam.wvu.edu/the-fungi). Relative abundance and frequency of occurrence of AM fungi were determined using spore population data. Relative abundance and frequency were determined by the formula suggested by Giovannetti and Mosse (1980).

$$RA\ (\%) = \frac{\text{Number of AM fungal Spores of a particular Species} \times 100}{\text{Total no of AM fungi spore in species}}$$

$$F\ (\%) = \frac{\text{Number of soil sampel possesing spores of a particular AM species} \times 100}{\text{Total no ofsoil samples analysed}}$$

STATISTICAL ANALYSIS:

Data obtained after isolation and identification was analysed to determine correlations between AMF colonization, spore density, and soil properties.

RESULTS AND DISCUSSION :

Root colonization and spore density:

Sorghum cultivars showed a significant variation in AMF colonization and spore density. The highest root colonization percentage was 89.5% in the cultivar Dagdi, whereas the lowest was 62.3% in the cultivar Dukrii. Spore density varied from 482 to 578 spores/100 g soil, with *Glomus* and *Acaulospora* being the dominant genera. In the mixed soil (533/100 g soil), mycorrhizal fungal communities were found to be different. *Glomus moculosum*, *Glomus fistulossum, Glomus deserticola, Glomus multicaule, Glomus fasciculatum*, and G*lomus macrocarpum*, hence we found that the *Glomus* genera were dominant in both rhizospheres, which were stated by (Bhale et al., 2014). Johnson et al. (1991) assumed that differences in the myco-community in soils cultivated with different histories of cropping were because of the variations in the physical, chemical, and microbial environment within the rooting zones of the crops such as corn and soybean. Similarity, the physical, chemical, and microbial environments can manipulate the myco-community of the cultivated soils with the crop *Sorghum bicolor*.

Soil Properties and AMF Interaction

A positive correlation soil organic matter and AMF colonization showed the involvement of organic improvement in the promoting fungal activity. Spore density was found to be higher in alkaline soils compared to acidic soils at a pH range of 7.8 - 8.2.

Ecological and Agricultural Implications:

AMF association had improved nutrient uptake, especially for phosphorus and zinc, improving biomass production while enhancing drought tolerance in *Sorghum bicolor*. The fungus also contributed to soil aggregation as well as sequestration of carbon, facilitating sustainable agriculture.

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Tables and Figures

Table 1. (Data indicates strong positive correlations between soil nutrients and AMF colonization/spore density)

Parameter	Dagdi	Maldandi	Dukri	r-value (correlation)	Significance (p<0.05)
Soil pH	8.1	7.9	7.8	+0.78	Significant
Organic Carbon (%)	0.81	0.72	0.65	+0.69	Significant
Available P (kg/ha)	38.2	35.6	29.5	+0.8	Significant
Available Zn (ppm)	1.21	1.15	0.92	+0.74	Significant
Spore Density (100g soil)	578	525	482	+0.83	Significant

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Table 2. Showing Percentage root colonization, spore density and Types of colonization in *Sorghum bicolor* L. cultivars.

***Sorghum* Cultivar**	**Root Colonization (%)**	**Spore Density (spores/100 g soil)**	**Types of Colonization**
Dagdi	89.5	578	Vesicles, Arbuscules
Maldandi	82.1	525	Arbuscules and Hyphal
Dukrii	76.3	482	Vesicles and Paris

Fig 1. Field Photographs of Three Cultivers of *Sorghum*

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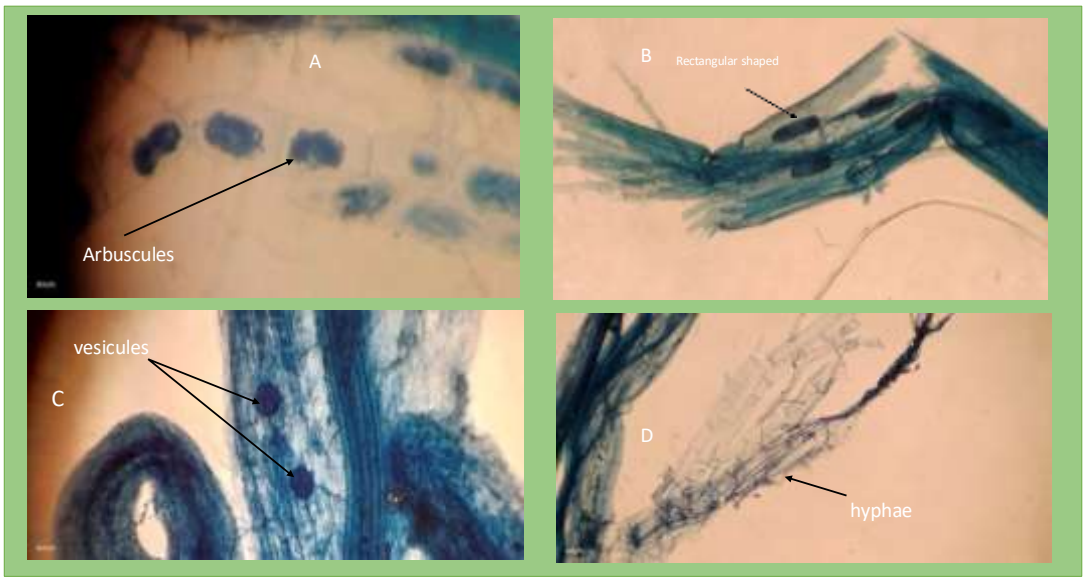

Fig 1. Showing seasonal variations controls the AMF root colonization (X=100) V= Vesicle, H=Hyphae, A= Arbuscules

Fig.2. Showing Diversity of AM fungal spores isolated from the rhizosphere of *Sorghum bicolor* (x = 400) A = *Glomus fistulosum*, B= *Glomus moculosum*, C= *Glomus deserticola*, D= *Glomus multicaule*, E= *Glomus macrocarpum*, F= *Glomus fassiculatum*

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