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MYCORRHIZAL DIVERSITY AND ECOLOGICAL RESTORATION IN RHIZOSPHERIC SOIL OF DRYLAND OF SELECTED VILLAGES OF RAIBAG TALUKA, BELAGAVI DISTRICT, KARNATAKA STATE, INDIA

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INTRODUCTION

An ecosystem comprises a collective of biological entities residing and engaging within a designated habitat. Ecological restoration is defined by the Society for Ecological Restoration Primer (2004) as the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed." Within the arid reaches of the northern Deccan Plateau in Karnataka, India, one finds scrub and thorny forest formations. These environments are characterized by an annual precipitation level below 750 mm (30 in) and elevated summer temperatures. Consequently, the flora is dominated by xerophytic shrubs, spiny trees, and arid grasslands. Globally, such dry lands represent 41 percent of the total landmass. The specific study area, Raibag taluka, is situated at 16.48° North and 74.78° East, at an elevation of 590 meters in northwestern Karnataka. Over the past forty years, the intensified application of synthetic pesticides and fertilizers has bolstered agricultural productivity, yet these practices have simultaneously induced significant soil and water contamination. This environmental crisis necessitates urgent ecological interventions focused on biodiversity recovery and the utilization of organic amendments, including vermicompost, farmyard manure, and various microbial inoculants like mycorrhizal fungi and nitrogen-fixing bacteria. Soil serves as a primary matrix for life, with plant root systems offering specialized niches for diverse pedological microorganisms. The introduction of symbiotic and non-symbiotic microbes into the rhizosphere is a critical strategy for enhancing crop productivity. These soil-dwelling organisms are vital for nutrient cycling and the preservation of agro-climatic stability, thereby improving soil structure, functionality, and biological diversity. Such microbial activity facilitates a synergistic impact on plant vitality and nutrient absorption. Mycorrhizal Dependency of Plants: The term mycorrhiza refers to the mutualistic relationship established between fungi and plant roots, a concept originally introduced by Frank (1885) regarding vesicular arbuscular mycorrhizal (VAM) fungi. These organisms generate "arbuscules," which are branched, aseptate hyphal formations facilitating nutrient transfer, alongside "vesicles," which serve as lipid-storing fungal organs. VAM fungi are globally distributed and interact with over 90% of terrestrial vascular plants, though they typically exhibit host specificity (Bowen, 1987). Research by Harley and Smith (1983) documented these associations across a broad spectrum of flora, including gymnosperms, angiosperms, and lower plants such as bryophytes and pteridophytes. Currently, literature identifies more than 164 VAM species. Their prevalence is dictated by environmental variables including soil pH, moisture, temperature, and concentrations of nitrogen, phosphorus, and heavy metals (Daniels and Trappe, 1980). Upon colonizing a host, they develop internal structures like hyphal coils, intercellular hyphae, and arbuscules. Extensive research over recent decades confirms that VAM fungi significantly promote plant development, primarily through the enhanced acquisition of soil phosphorus (Bagyaraj and Manjunath, 1980). Acknowledging the aforementioned ecological pressures, this study focuses on the quantification and screening of VAM spore populations within the rhizosphere of specific dryland villages in Raibag Taluka, Belagavi District, and Karnataka. A central objective of this research is the restoration of these mycorrhizal communities.

REVIEW OF LITERATURE

The initial documentation of VAM spores within the rhizospheric soil of specific fruit-bearing trees was provided by Barbara Mosse in 1956. Scholarly consensus suggests that the evolutionary emergence of VAM fungi coincided with the early development of vascular plants (Simon et al., 1993). Regarding taxonomy, Gerdemann and Trappe (1974) established a detailed classification of Endogonaceae spores founded upon the morphological characteristics of their resting structures. Further ecological research by Muthukumar et al. (2000) documented the prevalence of VAM spores within the semi-arid regions of India's Western Ghats. In a similar vein, the periodic variations of VAM fungi in the agricultural lands of Karnataka's Dharwad district were analyzed by Lakshman et al. (2000). Broadening the environmental scope, Harinikumar and Potty (2002) identified VAM spores across diverse habitats, including agricultural and fallow lands, humid forests, woodland areas, scrub thickets, savannas, grasslands, coastal dunes, and arid regions. While approximately 160 species of AM fungi have been formally characterized to date, Morton et al. (2001) posit that the actual diversity of this fungal group might extend to 2,700 species. For the specific identification of VAM fungi located in the arid villages of Raibag, the taxonomic framework established by Scwarzott et al. (2001) serves as the primary basis for categorization.

MATERIALS AND METHODS

Specimens of rhizospheric soil were obtained from arid agricultural settlements within the Raybag taluka region. These samples, which included root systems, were extracted from a depth range of 0 to 20 cm and subsequently preserved in decontaminated, airtight polymer containers. Analytical procedures established by Jackson (1973) were employed to evaluate various physico-chemical parameters including the soil's fundamental composition, classification, pH levels, organic carbon content, and accessible phosphorus concentrations. To quantify fungal spores, the wet sieving and decanting methodology developed by Gerdemann and Nicolson (1963) was implemented. The identification of the isolated spores was facilitated by consulting specialized manuals and taxonomic frameworks established by various researchers, including Schenck and Perez (1990), Frank and Mortan (1994), Mehrotra (1997), and Schwarzott et al. (2001). Diagnostic criteria for classification encompassed sporocarp characteristics, spore morphology, dimensions, configuration, and the nature of the peridium, alongside sporocarp pigmentation, surface ornamentation, subtending hyphae, and attachment mechanisms.

The extent of mycorrhizal infection within the plant root systems was assessed using the protocols described by Phillips and Hayman (1970) and Giovannetti and Mosse (1980). The calculation for the degree of colonization was performed utilizing the following mathematical expression:

$$\textbf{Per cent of root colonization} = \frac{\textbf{No. of root bits showing colonization}}{\textbf{Total number of root bits observed}} \times 100$$

FINDINGS AND ANALYSIS

Rhizospheric earth specimens were obtained from 16 arid settlements within the Raybag Taluk, situated in the Belgaum District of Karnataka. These substrates were analyzed to isolate vesicular-arbuscular mycorrhizal (VAM) spores. Diversity in both spore morphology and VAM spatial distribution was evident across the various sampling sites.

The identified fungal genera comprised Acaulospora, Glomus, Sclerocystis, Scutellospora, Gigaspora, and Entrophospora. A majority of the collected rhizosphere specimens demonstrated fluctuating spore densities throughout the soil profiles. Physical compositions varied significantly: coarse sand concentrations ranged from 13% in Girinakwadi to 31% in Bastwad, while fine sand proportions spanned 14% in Bhendwad to 26% in Bastwad. Silt content fluctuated between 18.39% at Devapurhatti and 9.7% at Itnal, whereas clay measurements were recorded from 14.66% in Bekkeri to 42.50% in Bhendwad. Electrical

conductivity measurements reached a minimum of 0.330 M mhos/cm in Mavinhunda and a maximum of 0.663 mhos/cm in Devapurhatti. Soil pH values, ranging from 6.07 to 6.83, indicated a predominantly acidic character across the study area. Organic matter levels spanned 0.41% to 0.76%, and phosphorus concentrations were documented between 0.26% in Byakud and 0.55% in Bhendwad. Total VAM spore counts per 50 g of substrate varied from 116.00 to 270.33, while root colonization rates were established between 43.91% in Mavinhunda and 69.88% in Bhendwad.

Bhendwad village exhibited the peak VAM spore density (270.33 per 50g) and the maximum colonization rate (69.88%), whereas Mavinhunda village recorded the lowest values for both parameters (116.00 spores and 43.91% colonization). Significant numerical variation was noted, particularly within the Glomus genus, followed by Acaulospora. Conversely, the presence of Entrophospora, Gigaspora, Sclerocystis, and Scutellospora remained minimal across all sites. No instances of newer genera, such as Archaespora or Paraglomus, were detected. Glomus species demonstrated the highest frequency of occurrence at 87.73%, markedly exceeding Acaulospora (3.85%), Sclerocystis (0.58%), Entrophospora (0.49%), and both Gigaspora and Scutellispora (0.037% each), with unidentified taxa accounting for 5.56%. The data suggests that Glomus was the predominant genus across most surveyed villages. In total, 35 distinct VAM species were characterized, consisting of twenty-two Glomus species, eight Acaulospora, two Enterophospora, two Sclerocystis, and a single Gigaspora species.

DISCUSSION

The current investigation was performed to analyze the spatial distribution and population fluctuations of vesicular-arbuscular mycorrhizal (VAM) spores within the rhizospheric soil of arid villages located in Raibag Taluk, situated in the Belagavi District of Karnataka State. Analysis of the total VAM spore assemblage indicated that Glomus species were the most prevalent across the majority of sites, while the genera Acaulospora, Sclerocystis, Entrophospora, Gigaspora, and Scutellispora also exhibited significant presence. These findings align with prior research conducted by Mulla (2002) and Lakshmipathy et al. (2003).

The empirical data demonstrated substantial variations in spore development across the dryland rhizospheric soils of Raibag Taluka, Belagavi District, Karnataka State. The diversity of arbuscular mycorrhizal (AM) fungal spores identified in these substrates confirmed the primary dominance of the Glomus genus. Specifically, species such as Glomus aggregatum, G. albidum, G. ambisporum, G. australe, G. caledonium, G. citricola, G. fasciculatum, G. fistulosum, G. fragilistratum, G. geosporum, G. gerdemannii, G. flavisporum, G. globiferum, G. glomerulatum, G. macrocarpum, G. maculosum, G. multicaule, G. occultum, G. microcarpum, G. taiwanensis, and G. tenebrosum were found to be ubiquitous and possess the potential for large-scale propagation.

Over the preceding forty years, the intensified application of synthetic fertilizers and pesticides has negatively impacted VAM populations. Efforts to rehabilitate arid regions involve strategic, concentrated plantings designed to optimize resource utility for the achievement of VAM recovery objectives. The degradation of these environments frequently results in the alteration of critical physical soil parameters, including pH levels, thermal conditions, and mineral concentrations.

Several variables contribute to the degradation of dryland ecosystems, primarily stemming from anthropogenic influences such as construction activities, monocultural agricultural practices, and the utilization of chemical fertilizers and pesticides. Furthermore, the disruption of natural landscapes, demographic pressures, global warming, diminished precipitation, and a general lack of ecological awareness further exacerbate the damage to these environments.

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