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Mycorrhizal Status of Queensland Arrowroot (*Canna edulis* Ker-Gawler) in the Ultisols of Thiruvananthapuram, Kerala

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Abstract: *Canna edulis* Ker-Gawler is a tropical, herbaceous, perennial root crop that yields the high quality 'canna starch' from their rhizomatous rootstocks. In the present study, assessment of its arbuscular mycorrhizal (AM) fungal status in a few ultisols in Thiruvananthapuram district of Kerala, South India has been undertaken. Rhizosphere soil and root samples from plants, growing naturally under field conditions in different localities were analysed. Soil physicochemical characteristics like pH, moisture, organic C and available P were also studied. Analysis of soils indicated significant levels of mycorrhization in the rhizosphere. Spore density/100g rhizosphere soil ranged from 286 to 370. All the plants showed AM fungal structures (hyphae, vesicles and arbuscules). Root colonization percentage ranged from 47-67%. Four morphotypes of AM fungi belonging to three genera viz. *Glomus, Acaulospora* and *Scutellospora* were characterised and identified. *Glomus* was the most frequent genus (62.5%) with two identified species - *G. aggregatum* and *G. constrictum*. The dominant species recovered was *G. aggregatum*.

Key words: Arbuscular mycorrhizal fungi · Arbuscules · *Canna edulis* · Mycorrhization · Rhizosphere · spore density

INTRODUCTION

The mounting awareness on the real need for sustainable agriculture, biodiversity conservation and locally based food security, demands adoption of an agricultural system that causes minimum disturbances to the soil and the environment, at the same time having the potential to meet the escalating food demands. Moreover, due to the growing concern on the side effects of agrochemicals, the folk has diverted their interest towards organic agricultural products. The most viable strategy to address the above requirements is the exploitation of the potentials of microorganisms. Mycorrhizas which represent three-way interactions between plant, soil and fungi are the most suitable candidates to address such a situation. Among the mycorrhizas, the arbuscular mycorrhizal fungi (AM fungi) which associate symbiotically with the roots of over 95% of the land plants is especially significant for productive low-input agriculture as they offer diverse benefits to the host plants like greater water/nutrient uptake, resistance to pathogens and abiotic stresses etc. To exploit their potentialities, the primary need is to compile inventories of the indigenous AM fungal species associated with the crops.

Canna edulis Ker. (Queensland arrowroot or edible canna) is a heavy yielding, herbaceous, perennial root crop of the Canna family, adapted to grow in a wide range of soil types and environmental regimes. Its fleshy rootstocks form the source of the high quality 'canna starch' which has been identified as a possible substitute for the present day commercial starches. Advantageous characteristics like heavy yield potential, resistance to environmental stresses, non-reliance on fertilizers and other inputs, greater nutrient/water use efficiency, lack of replant problems etc. make them very promising candidates for more extensive cultivation especially, in the present context of rapidly dwindling agricultural lands and expanding food requirements. The plant has been reported to be highly mycorrhizal [1]. The present study was undertaken to evaluate the arbuscular mycorrhizal status of Queensland arrowroot (*Canna edulis* Ker-Gawler) in a few ultisols of Kerala and to collect AM fungal spores for identification of indigenous species colonizing its rhizosphere.

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MATERIALS AND METHODS

A field survey was carried out in the ultisols in different parts of Thiruvananthapuram district in Kerala. Rhizosphere soil samples (500g from each plant) and root samples (2g fresh weight) were collected from different cultivated sites and locations.

Rhizosphere Soil Analysis: Fifty percent of each soil sample was used for estimating spore density. The remaining part was air dried and sieved through a 2mm mesh nonferrous sieve and the subsamples were used for the analysis of physicochemical characteristics.

Variables like soil pH, soil moisture, available soil phosphorus (soil P) and soil organic carbon (SOC) content were estimated. Soil pH was determined by agitating soil samples in double distilled water (1:4). pH of the supernatant was read in a digital pH meter. Moisture content in the soil rhizosphere was determined by drying 100g air dried samples in a hot air oven at 110°C till weights became constant. Percentage of soil moisture was then calculated. 5g of sieved soil subsamples were used for the spectrophotometric estimation of soil P [2]. SOC was determined according to Walkley and Black [3].

100g of each soil sample was used to determine fungal spore density by wet sieving and decanting method [4] using a soil sieve assembly, comprising standard test sieves of 250, 105 and 45µm mesh size positioned in ascending order. Filtered mass from the lowest sieve was examined microscopically to count the spores. Spore density as number of spores/100g soil was calculated. Material from the second sieve was observed under high magnification of microscope to identify AM fungal spore types based on their morphology [5, 6]. Frequency of occurrence of different AM fungal taxa expressed as the percentage of soil samples containing the particular species was calculated.

Root Analysis: The collected root samples were cleaned and cut into 1cm long bits for preservation in 10% KOH. A random lot consisting of 50 bits was processed by the root clearing and staining method of Phillips and Hayman [7]. The stained root bits were examined microscopically for the presence of fungal hyphae, vesicles, arbuscules and other structures characteristic of AM fungi. Percent root colonization was then calculated as the number of root bits showing AM fungal structures.

RESULTS AND DISCUSSION

Physicochemical parameters like pH, moisture content, SOC and soil P varied in the different sampling sites. Analysis of soil samples indicated significant levels of AM fungal infection in the rhizosphere of the plant. Spore density showed variations between sampled sites (Table 1). A range from 286 to 370 spores was recorded per 100g soil in the present survey.

Assessment of the AM fungal infection pattern in the roots revealed the high susceptibility of the crop to mycorrhizal colonization. All the collected plants showed presence of AM fungal structures like hyphae, vesicles, arbuscules etc. indicating the high mycorrhizal dependency of the plant. Highest percentage of root colonization was observed in S_1 (67.14%) and the lowest in S_4 (46.7%). The occurrence of vesicles with varied morphology in the mycorrhizal roots indicated infection of the plant by different AM fungal species. Observation of spores belonging to different AM fungal taxa in the rhizosphere soils confirmed their biodiversity.

Morphological characterization of spores in the soil rhizosphere revealed four AM fungal taxa belonging to three genera viz., *Glomus, Acaulospora* and *Scutellospora* in the vicinity of *C. edulis* roots. The genus *Glomus* was found to dominate the rhizospheres in all sites (frequency of occurrence 62.5%). Two species viz., *Glomus aggregatum* and *G. constrictum* were characterized and identified. One species of *Acaulospora* (*A. laevis*) also was identified. Spores with characteristics of *Scutellospora* could not be identified up to species on the basis of morphological features. *G. aggregatum* was found to be the most frequent species in this type of soil.

Table 1: Physicochemical characteristics of rhizosphere soil and AM fungal colonization in *C.edulis* in the ultisols under field conditions

Code	Locations	pH	Moisture %	Soil P (µg L^{-1})	Organic C %	Root Infection %	Spore density (No./100g soil)
S_1	Vettinad 1	5.2	5.88	12.32	0.32	67.14	286
S_2	Vettinad 2	5.3	6.95	8.08	0.61	46.90	319
S_3	Vattappara 1	5.4	7.72	8.21	0.60	48.60	321
S_4	Vattappara 1	5.0	8.34	6.88	0.65	46.70	370
S_5	Vembayam	5.2	10.01	5.36	0.42	50.00	290
S_6	Velavoor	5.9	5.63	9.51	0.88	49.30	300
S_7	Pothencode	5.9	6.84	7.90	0.55	55.45	287
S_8	Chempazhanthi	5.3	6.95	8.08	0.61	49.90	319
	Mean	5.4	7.29	8.29	0.58	51.75	312

Analysis of the rhizosphere soil and the roots indicated Queensland arrowroot to be highly susceptible to invasion by AM fungi. The distribution of mycorrhizal roots throughout the sampled sites revealed that the AM association is naturally established in the crop. The spore density per 100g rhizosphere soil in the crop varied greatly in different soils and sampling sites. Plant roots from different cultivation sites also showed heavy AM colonization, further confirming high mycorrhizal dependency of the plant.

The variability observed in root infection and AM spore density between different sites may be reflecting the influence of edaphic factors like pH, moisture content, SOC and available soil P on mycorrhizal colonization [8-10]. Further, the variability in rhizosphere spore load may also be due differences in soil fertility that stimulate differential sporulation by AM fungal species in the field [11, 12]. The microclimate, physicochemical and microbiological properties of the soil [12], the sampling season and age of the plant also be contributing to the variability in spore density between samples [13].

The heterogeneity of species distribution observed in the present study reflects the ability of individual plants to associate with many species of fungi. Since, these plants are not cultivated solely in an area but along with other crops, the fungal diversity may be influenced by the root systems of the cohabiting species. Even a short period of growth of different plant species has been shown to alter AM fungal biodiversity in the rhizosphere [14]. The biodiversity of AM fungi observed in the vicinity of *C.edulis* roots reflects apparent lack of host specificity among these fungi. But, the dominance of *Glomus* in the rhizosphere of *C. edulis* adds to the growing body of evidences as to the preferential association of AM fungal species to their plant partners [15-17].

Among the different species of *Glomus*, spores of *G. aggregatum* were recovered from almost all sampled sites. This reflects the increased adaptation of this species to *C. edulis* rhizosphere. It has been suggested that in long-term cropping systems, certain species become dominating as the prevailing conditions of the habitat and the host favour them. The occurrence of different AM fungal structures like hyphae, vesicles and arbuscules also varied greatly both within and between different habitats. This may be due to a no. of factors like the influence of soil nutrient status, seasonal changes and/or root age [13].

It is concluded from the present study that *Canna edulis* Ker-Gawler is highly dependent on AM fungal colonization and that it shows symbiotic association with more than one species of the fungi in the ultisols of Thiruvananthapuram. Further, it is seen that the crop shows a preferential association with species of *Glomus*.

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