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Influence of Arbuscular Mycorrhizae (AM) Fungi in some selected contaminated soils of Visakhapatnam

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Abstract

Mycorrhizae are a type of fungi which form a mutialistic relationship with the roots of most plant species. Such symbiosis was first evolved ~400 million years ago, possibly helping the earliest terrestrial plants to take up nutrients in the absence of complex vascular root system. The driving force behind AM interactions is an exchange of nutrients between fungus and plant. The fungus provides nutritional benefits to the plant by delivering minerals, including the biologically essential nutrients like Phosphorous (P) and Nitrogen (N). Phosphate acquisition via the mycorrhizal pathway begins with the uptake of free phosphate from soil by fungal extra-radical hyphae. These fungal hyphae extend beyond the host root system, allowing a greater soil volume to be exploited for phosphate uptake. The occurrence Glomus species was more in soil samples ranging from 23% to 88% (SS4-SS5) whereas Acaulospora species was more in soil samples ranging from 11% to 77% (SS4-SS5) along with Scutellospora species measured in soil samples ranged from 9% to 77% (SS1-SS6).

Keywords: AM fungi, symbiosis, nutrients

INTRODUCTION

The Agricultural revolution in the 18th century and the Green revolution of 20th century have shown amazing results of high yielding crops to selection of a beneficiary crop which show benefits in presence of high amounts of fertilizers. These revolutions hand in hand have also increased industrialization vastly. This has shown results of abiotic stress on plant community. Colonization of plant roots by AMF have not only plant nutrition but also has many beneficial effects even under stress conditions.

India is one of the most populated countries of the world. At this point, the crop production has to increase for the burgeoning population to meet the food demand of the increasing population. An article was published on the status of mycorrhizal research in Bangladesh at First Asian Conference on Mycorrhiza with emphasis on the need of research [1]. A large number of plant species including agriculture crops and sand dunes have been studied for their mycorrhizal associations [2].

As explained [3] that most soils in India are generally of low fertility status, to maintain high crop yield, agrochemicals, i.e. fertilizers, pesticides and agricultural wastes, are applied at annual rates [4]. Generally most of the cultivated soils are deficient in organic matter, nitrogen and phosphate. Industrialization, deforestation and indiscriminate use of agrochemicals have become sources of metal toxicity in soils and water because of run-off into rivers, resulting in depleted soil fertility and decreased plant growth and yield [5]. Microbial land remediation practices and the use of microorganisms as bio-control agents in the place of chemical pesticides have gained considerable momentum for a sustainable agriculture [5]. Arbuscular mycorrhizal (AM) associations are integral, functioning parts of the plant roots and are widely recognized as enhancing plant growth on several disturbed sites, including those contaminated with heavy metals and salinity [6].

AM fungi can significantly increase both the water and nutrient uptake of plants and their ability to tolerate stress conditions [7]. Because AM efficacy is highly

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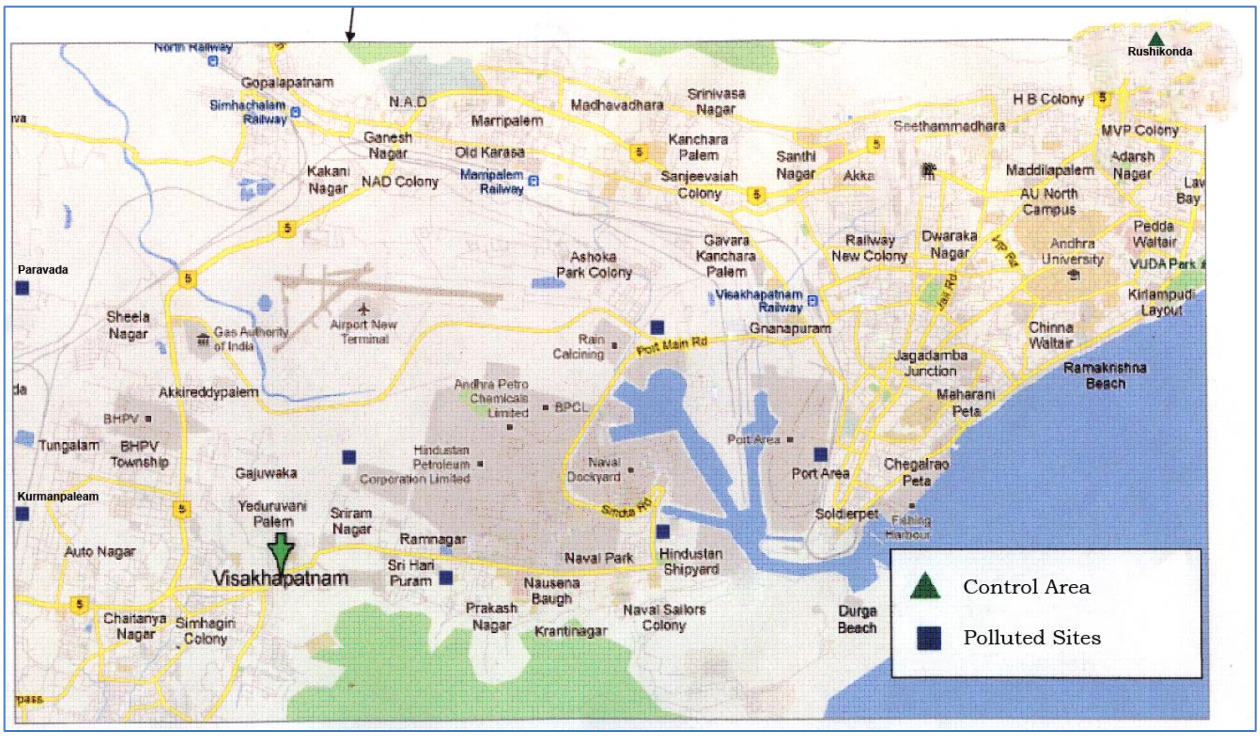
dependent on the symbiotic partners and environmental conditions, it is desirable to inoculate plants with appropriate AM fungi in order to improve the phytoremediation capabilities of plants.

Mycorrhizal symbiosis usually increases plant biomass and the rate of photosynthesis [8].Growth and development of fungal mass and reproductive structures directly influence the increased rate of plant photosynthesis. Varieties of studies suggest that water extraction by plant roots can be enhanced when mycorrhizae infect them.Mycorrhizal fungi might indirectly increase water uptake by improving root conductance to water flow.

MATERIALS AND METHODS

Figure 1: Map shows the soil collection sites of Visakhapatnam.



Literature reveals that AM fungi shows excess amount of sporulation during the summer period and winter seasons whereas the percentage of sporulation is less during the monsoon. Therefore, sampling was during the summer season in a few polluted areas of Visakhapatnam, Andhra Pradesh, India. Numerous soil samples of the polluted areas were collected (Fig.1) out of which only a few showed the existence AM fungi.

The soil samples were collected and were analyzed for different physico-chemical and biological parameters following standard procedures [10]. Phosphates were also measured using spectroscopy method.

The spores were isolated by using a stereolight microscope through wet sieving and decanting techniques [9].The isolated spores were then mounted on PVLG-Melzer reagent for identification and were then observed under compound microscope [11].

RESULTS AND DISCUSSION

All the collected soil samples were analyzed for physico-chemical parameters and the results are shown in Table-1.The soil pH and moisture content ranged from 6.4 to

8.24 and 0.13% to 1.92% respectively (Table 1). The conductivity and Organic Carbon of all sampling sites (polluted soils) ranged from 0.25 mmho to 4.75 mmho and 3.7% to 9.2% (Table 1).The Sulphate and Phosphate measured in all the soil samples were 2.6 mg / gm to 9.2 mg/gm and 0.8 mg/Kg to 5.2 mg/Kg.

Table 1: Physicochemical parameters of some selected polluted soil samples

S.NO	SAMPLE CODE	SOIL MOISTURE (%)	pH	CONDUCTIVITY (MMHO)	ORGANIC CARBON (%)	SULPHATES (MG /GM)	PHOSPHATES (MG / KG)
1	SS1	1.66± 0.57	6.83 ± 1.41	4.75 ± 1.15	3.9 ± 1.08	5.8 ± 1.37	1.3 ± 0.57
2	SS2	0.13 ± 0.43	7.52 ± 1.52	0.31 ± 0.43	5.2 ± 1.37	5 ± 1.27	1.16 ± 0.57
3	SS3	1.26 ± 0.57	6.34 ± 1.41	2.25 ± 0.79	4.7 ± 1.24	2.6 ± 1.10	1.9 ± 0.79
4	SS4	1.56 ± 0.72	8.24 ± 1.62	0.25 ± 0.43	4 ± 1.23	4 ± 1.23	2 ± 0.92
5	SS5	0.64 ± 0.54	7.61 ± 1.52	1.65 ±0.57	3.7 ± 1.24	9.2 ± 1.72	0.8 ± 0.54
6	SS6	1.92 ± 0.72	7.84 ± 1.52	0.33 ± 0.43	4 ± 1.23	4.2 ± 1.23	1.12 ± 0.57
7	SS7	1.72 ± 0.79	7.42 ± 1.52	0.34 ± 0.43	3.7 ± 1.23	5 ± 1.27	1.20 ± 0.57
8	CS8	22.6 ± 2.68	7.22 ± 1.58	0.40± 0.43	17.6 ± 2.35	50.9 ± 5.01	1.34 ± 0.72

Table 2: Distributions and Identification of AM Fungi

S.No	Am Fungal Spores		Polluted Sampling Sites							
	Spores	Colour	SS1	SS2	SS3	SS4	SS5	SS6	SS7	CS8
1	***AcaulosporaBireticulata***	Light Brown	2	2	-	5	1	3	-	4
2	***AcaulosporaDelicata***	Hyaline to pale yellow	-	-	-	-	-	-	-	3
3	***AcaulosporaElegans***	Dark Brown	-	-	-	5	-	-	4	4
4	***AcaulosporaFoveta***	Yellowish Brown to Reddish Brown	-	-	-	-	-	2	-	-
5	***GlomusAlbidum***	Yellowish with subtending Hyphae	1	3	-	3	2	-	2	-
6	***GlomusCaledonium***	Dull Yellow to Brown	3	-	-	-	-	-	-	3
7	***GlomusGeosporum***	Light to Dark Brown	-	-	-	-	-	-		5
8	***GlomusIntraradices***	Brown	4	-	-	-	3	6	2	8
9	***GlomusMacrocarpum***	Reddish Brown	-	4	4	-	1	1	3	-
10	***GlomusMosseas***	Yellow to Brown	-	3	4	-	2	2	-	3
11	***GlomusPachycaulis***	Yellow to Yellow Brown	-	-	-	-	-	-	-	2
12	***ScutellosporaCalospora***	Hyaline to Pale Greenish Yellow	1	6	5	-	-	4	4	-
13	***ScutellosporaNigra***	Dark Brown to Black	-	-	5	-	-	3	2	1

Organic Carbon in the soil is an indirect measure of vital status of the soil. It also retains nutrients and supports microbial life whereas the moisture content has the capacity to hold the nutrients in soils. The presence of phosphate in the soil focuses on less usage of chemical fertilizers and pesticides as AM fungal spores make the nutrients available to the plants. In the present study Arbuscular Mycorrhizae spores, grouped into 13 morphological types belonging to Glomus, Scutellospora and Acaulospora species were extracted from the indigenous soil.

The occurrence Glomus species was more in soil samples ranging from 23% to 88%. The spore count of Glomus species was more with 88% (SS5) and least with 23% (SS4). The incidence Acaulospora species was more in soil samples ranging from 11% to 77%. The spore count of Acaulospora species was more with 77% (SS4) and least with 11% (SS5) whereas the Scutellospora species measured from 9% to 77%. The spore count was more with 77% (SS6) and least with 9% (SS1) (Table 2 and 3).

Table 3: Occurrence of AM Fungi in various soil samples

S.No	Sample Code	No. of AM spores	Spore Number (per 50g)					
			Acaulospora Species	%	***Glomus Species***	%	***Scutellospora Species***	%
1	SS1	11	2	18	8	72	1	9
2	SS2	18	2	11	10	55	6	33
3	SS3	18	-	-	8	44	10	55
4	SS4	13	10	77	3	23	-	-
5	SS5	9	1	11	8	88	-	-
6	SS6	21	5	23	9	42	7	77
7	SS7	17	4	23	7	41	6	35
8	CS8	33	11	33	21	63	1	3

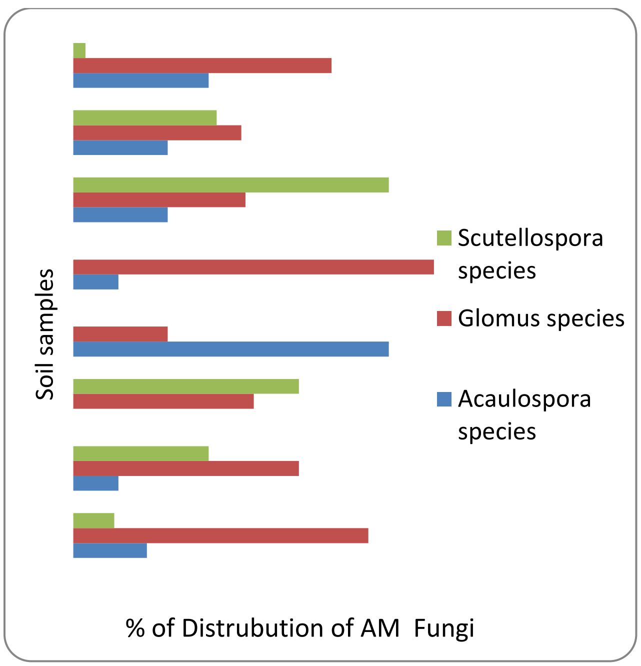


Figure 2: Graphical representation of distribution of AM fungi in some polluted soils of Visakhapatnam

Among all the species, the percentage Glomus species were found more in the polluted soil samples as compared to that of other species (Fig 2).

CONCLUSION

AM (Arbuscular Mycorrhizae) fungi is present in 90% of vascular plants. It acts as barrier against the transfer of pollutants to plant shoot. Mycorrhizal association increase the absorptive surface area of the plant due to extrametrical fungal hyphae exploring rhizosphere beyond root-hair, which in turn increases water and mineral uptake. In some cases, composted municipal solid waste addition and mycorrhizal inoculation has proved a effective tool in re-vegetation programs. Manipulation of agricultural programs with AM fungi has proved effective or positive for afforestration programs.

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