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Studies on Tomato (*Lycopersicon esculentum* Mill.) with reference to AM fungi

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ABSTRACT

The survey of Arbuscular Mycorrhizal fungi from rhizosphere and non-rhizosphere soil of tomato (Lycopersicon esculentum Mill.) from eight different localities of Yeola taluka, Nashik district of Maharashtra was carried out. The maximum number of AM propagules (1580 per 100 g of soil) and highest root infection (95 %) was reported from Bharam locality and minimum number of AM propagules (174 per 100 g of soil) and lowest root infection (50 %) was reported from Panjarwadi locality. The two other localities Saigaon (1278 per 100 g of soil) and Mukhed (1124 per 100 g of soil) with root infection 92% and 93% respectively also shows maximum number of AM propagules The other localities, Dongargaon, Nagade, Kusur, and Gawandgaon showed intermediate results. Three genera with forty one species were isolated from rhizosphere and non-rhizosphere soil of tomato. The genus Glomus was dominant with twenty two species. The other genera reported were Acaulospora with seven species and Scutellospora with twelve species. The number of AM propagules was more in the rhizosphere soil than non-rhizosphere soil.

KEY WORDS: *Arbuscular Mycorrhizal fungi; diversity; Lycopersicon esculentum Mill.; rhizosphere; non-rhizosphere; Tomato*

INTRODUCTION

Mycorrhizae have been associated with vascular plants since the Paleozoic era [1]. Arbuscular mycorrhizae (AM), the most prevalent plant-fungus association, comprise about 150 species, belonging to the order Glomales of Zygomycotina [2-6]. The arbuscular mycorrhizal (AM) symbiosis is an association between most terrestrial plants and a class of fungi (Glomeromycota) which occurs in the roots of host plants [7]. The fungus receives carbohydrates (sugars) and growth factors from the plant, which in turn receives many benefits, including increased nutrient absorption. They are found in all kinds of soil but more where chemical fertilizers are not used. They have the ability to improve fertility of soil. Colonization of roots by AM fungi has been shown to improve productivity of numerous crop plants in soils under drought stress [8-11]. Ultimately AM fungi improve soil structure by binding soil particles together.

Tomato (*Lycopersicon esculentum* Mill.) belongs to family Solanaceae. It was originated in western South America. Tomato is an herbaceous perennial, but is usually grown as an annual crop in temperate regions. The fruit is a berry with 2 to 12 locules containing many seeds. Most tomato varieties have red fruits, due to the red carotenoid lycopene. Tomato is highly esteemed as a source of vitamin C, vitamin A and protein. Tomato juice contains 19 amino acids, principally glutamic acid. There are many reports on arbuscular mycorrhizas, microbial communities, nutrient availability, and soil aggregates in organic tomato production [12]. Phosphorus uptake by a community of arbuscular mycorrhizal fungi was studied by [13]. Nagy [14] studied the characterization of novel mycorrhiza-specific phosphate transporters from *Lycopersicon esculentum* and *Solanum tuberosum* uncovering functional redundancy in symbiotic phosphate transport in solanaceous species.

Tomato is cultivated in Maharashtra as a chief commercial crop, survey of literature do not show any report on association of AM Fungi with tomato in this area. The study of this association will definitely be useful to all tomato growers to increase yield and to improve fertility of soil. The present work is done with respect to qualitative and

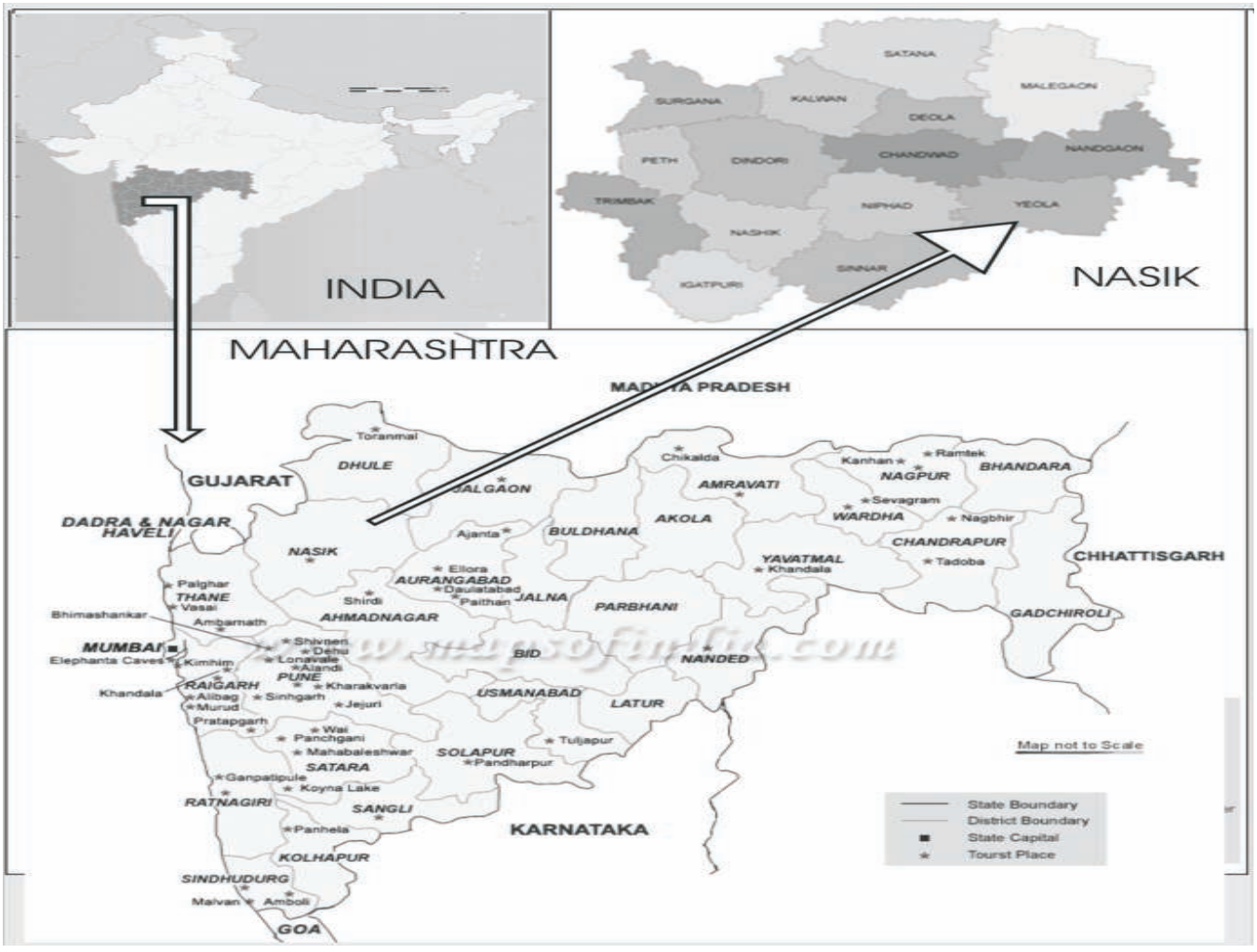
quantitative assessment along with some physico-chemical properties of rhizosphere and non- rhizosphere soil of tomato like pH, EC, OC (%), P2O5 (Kg / ac), K_2O (Kg / ac), Zn (ppm), Cu (ppm), Fe (ppm), Mn (ppm).

MATERIALS AND METHODS

In 2008 and 2009, we collected rhizosphere and non- rhizosphere soil samples of tomato from Yeola taluka, Nasik district. The latitude and longitude of Yeola, India is 20° 02' 0" N / 74° 30' 0" E. We sampled from eight different localities at an interval of 30 days for two months. These localities selected were Panjarwadi, Dongargaon, Saigaon and Nagade during the year 2008 and Kusur, Gawandgaon, Saigaon, Mukhed and Bharam during 2009. From each site, 4- 8 samples were collected.

Fresh soil samples were brought to the laboratory. Fine roots were fixed in solution of formalin acetic acid alcohol (90:5:5) after thorough washing for determination of root infection. Soil samples were air dried in the shade for further spore counting at laboratory temperature. Roots were autoclaved for 15 to 20 minutes in KOH solution (10%), cleared in distilled water and neutralized with HCl (2%) and stained in trypan blue (0.05%) in lactophenol. The percentage root infection was measured by [15] method.

100 g of air dried soil mixture was placed into beaker with 1000 ml of tap water. The root soil mixture was vigorously mixed with glass rod for 30 seconds. After settling the soil particles and organic debris, the remaining soil- root-hyphae- spore suspension was slowly poured through a set of 240, 170, 150,100 and 72 µm sieves. The extracts were washed away from sieves to what man filter paper. Using trinocular research microscope, spores, aggregates and sporocarps were picked by means of needle [16]. 5- 10 spores were added to each drop of PVLG. The mountant was allowed to set for 3 – 5 minutes before adding a cover slip. Identification of isolated spores has been done with the help of key proposed by [17]. Physical and chemical characteristic of soil sample was carried out according to procedure of Jackson [18].



RESULTS AND DISCUSSION

The data obtained were mainly from the active growth stage and flowering period of the plants. The rhizosphere soil from Bharam had the maximum number of AM propagules (1580 per 100 g of soil) and that of Panjarwadi showed the minimum 174 spores per 100 g of soil. Same range occurred in the non-rhizosphere soil with 1122 and 123 spores per 100 g of soil from Bharam and Panjarwadi respectively. The two other localities Saigaon (1278 per 100 g of soil) and Mukhed (1124 per 100 g of soil) also shows maximum number of AM propagules in rhizosphere soil. The other localities, Dongargaon, Nagade, Kusur, and Gawandgaon showed intermediate results. A similar gradation was observed in the percentage of root infection with 95 % infection in plants from Bharam, 50% from Panjarwadi and with lesser differences in plants from other six localities. There was also increase in the number of Am propagules percentage infection with age of the plants there by indicating the rhizosphere effect (Table 1).

Table 1 Number of Propagules per 100g of soil and Percentage Root Infection

Year	Locality	Sample	No. of Spores /100 g		% Root Infection	
			I	II	I	II
2008	L1	R	174	228	50	62
		NR	123	186		
	L2	R	424	446	70	82
		NR	374	382		
	L3	R	340	376	65	72
		NR	302	325		
	L4	R	274	296	61	70
		NR	266	284		
2009	L1	R	348	442	61	82
		NR	92	238		
	L2	R	322	786	48	72
		NR	304	446		
	L3	R	802	1278	78	92
		NR	562	856		
	L4	R	986	1124	74	93
		NR	748	1022		
	L5	R	690	1580	73	95
		NR	468	1222		
Year: 2008		L1: Panjarwadi		L2: Dongargaon		L3: Saigaon
		L4: Nagade				
Year: 2009		L1: Kusur		L2: Gawandgaon		L3: Saigaon
		L4: Mukhed		L5: Bharam		

Three genera, *Glomus, Acaulospora* and *Scutellospora* were found associated with the roots of tomato plants. As a characteristic of tropical soil the genus *Glomus* was dominant with twenty two species, that of *Scutellospora* with twelve species and *Acaulospora* with seven species. *Glomus fecundisporum*, *Scutellospora calospora*,*Scutellospora minuta*, and *Scutellospora pellucida* were found in all the localities under study. Similar is the case with *Glomus convolutum, Glomus fistulosum, Glomus fragilistratum, Scutellospora auriglobosa, Scutellospora gregaria* were

found only in two localities (Table 2).

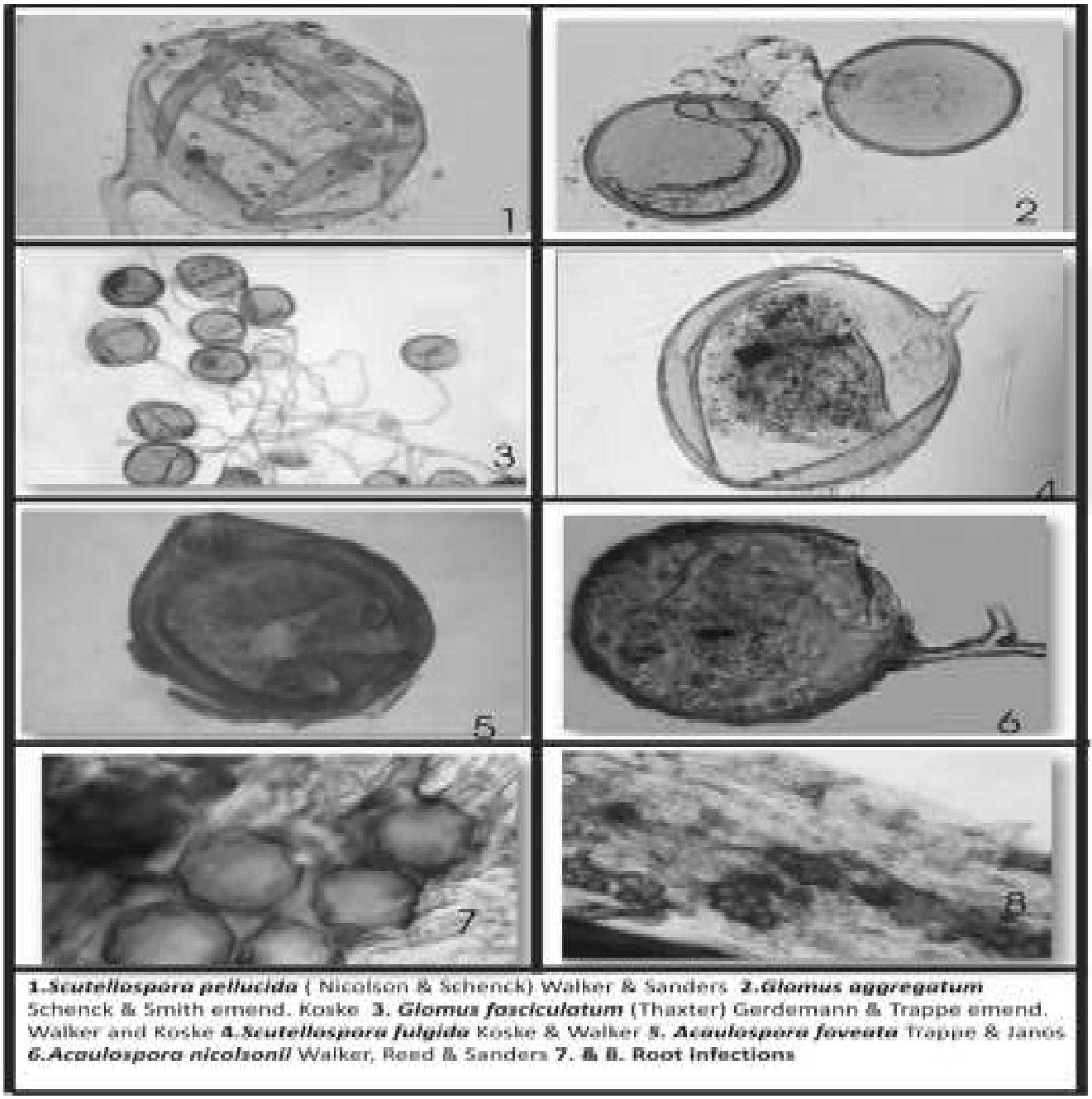
Table 2 Arbuscular Mycorrhizal fungi reported from rhizosphere soil of Tomato

Sr. No.	Year	2008				2009				
	Name of Genus and species	L-1	L-2	L-3	L-4	L-1	L-2	L-3	L-4	L-5
1	*Acaulospora appendiculata* Spain, Sieverding & Schenck	+	-	+	+	-	-	+	-	+
2	*Acaulospora delicata* Walker, Pfeiffer & Bloss	+	-	+	-	-	-	+	-	+
3	*Acaulospora denticulata* Sieverding & Toro	-	-	+	-	-	-	+	+	-
4	*Acaulospora foveata* Trappe & Janos	+	-	-	+	-	+	-	+	+
5	*Acaulospora laevis* Gerdemann & Trape	+	-	+	-	+	-	+	-	+
6	*Acaulospora nicolsonii* Walker, Reed & Sanders	-	+	-	-	+	-	-	+	-
7	*Acaulospora polonica* Blaszkowski	-	+	+	-	-	+	+	-	-
8	*Glomus albidium* Walker & Rhodes	-	+	+	-	-	+	+	+	+
9	*Glomus aggregatum* Schenck & Smith emend. Koske	-	-	-	+	-	-	-	+	+
10	*Glomus boreale* (Thaxter) trappe & Gerdemann	+	-	-	-	+	-	-	+	+
11	*Glomus callosum* Sieverding	-	-	-	+	-	+	-	-	+
12	*Glomus constrictum* Trappe	+	+	+	+	+		+	+	-
13	*Glomus convolutum* Gerdemann & Trappe	-	+	-	-	-	-	-	+	-
14	*Glomus dimorphicum* Boyetchko & Tewari	+	-	+	-	-	+	+	-	+
15	*Glomus etunicatum* Becker & Gerdemann	-	+	-	+	-	-	+	+	+
16	*Glomus fasciculatum* (Thaxter) Gerdemann & Trappe emend. Walker and Koske	+	+	+	+	-	-	+	+	+
17	*Glomus fecundisporum* Schenck & Smith	+	+	+	+	+	+	+	+	+
18	*Glomus fistulosum* Skou & Jakobsen	-	-	+	-	-	-	+	-	-

19	*Glomus formosanum* Wu & Chen	+	-	+	-	-	-	+	-	+
20	*Glomus fragilistratum* Skou & Jakobsen	-	-	-	+	-	-	-	+	+
21	*Glomus globiferum* Koske & Walker	+	+	+	+	-	-	+	-	+
22	*Glomus heterosporum* Smith & Schenck	+	-	-	+	+	-	-	+	-
23	*Glomus invermayanum* Hall	+	+	-	-	-	-	-	+	+
24	*Glomus leptotichum* Schenck & Smith	-	+	-	-	+	+	-	+	-
25	*Glomus monosporum* Gerdemann & Trappe	+	-	+	+	-	-	+	-	-
26	*Glomus mosseae* (Nicolson & Gerdemann) Gerdemann & Trappe	-	+	-	+	+	-	-	+	-
27	*Glomus pansihalos* Berch & Koske	+	-	+	+	+	+	+	+	+
28	*Glomus tenebrosum* (thaxter) Berch	+	+	+	+	+	-	+	+	-
29	*Glomus trimurales* Koske & Halvorson	+	+	+	-	+	-	+	+	-
30	*Scutellospora arenicola* Koske & Halvorson	-	-	+	+	-	+	-	-	+
31	*Scutellospora auriglobosa* (Hall) Walker & Sanders	-	-	-	-	+	-	-	+	-
32	*Scutellospora calospora* (Nicolson & Gerdemann) Walker & Sanders	+	+	+	+	+	+	+	+	+
33	*Scutellospora dipapillosa* (Walker & Koske) Walker & Sanders	+	-	-	-	+	-	+	-	+
34	*Scutellospora dipurpurascens* Morton & Koske	-	+	+	-	-	-	+	-	+
35	*Scutellospora fulgida* Koske & Walker	-	+	+	-	-	+	+	-	+
36	*Scutellispora gregaria* (Schenck & Nicolson) Walker & Sanders	+	-	-	-	-	-	-	+	-
37	*Scutellispora heterogama* (Nicolson & Gerdemann) Walker & Sanders	+	+	+	+	-	-	+	-	+
38	*Scutellospora minuta* (Ferrer & Herrera) Walker & Sanders	+	+	+	+	+	+	+	+	+

39	*Scutellospora pellucida* (Nicolson & Schenck) Walker & Sanders	+	+	+	+	+	+	+	+	+
40	*Scutellispora persica* (Koske & Walker) Walker & Sanders	+	-	+	+	-	-	+	-	-
41	*Scutellospora weresubiae* Koske & Walker	+	-	+	-	+	-	+	-	+

+ Present; - Absent Year: 2008 L1- Panjarwadi; L2- Dongargaon; L3- Saigaon; L4- Nagade
Year: 2009 L1- Kusur; L2- Gawandgaon; L3- Saigaon; L4- Mukhed; L5- Bharam



1.*Scutellospora pellucida* (Nicolson & Schenck) Walker & Sanders **2.*Glomus aggregatum*** Schenck & Smith emend. Koske **3. *Glomus fasciculatum*** (Thaxter) Gerdemann & Trappe emend. Walker and Koske **4.*Scutellospora fulgida*** Koske & Walker **5. *Acaulospora foveata*** Trappe & Janos **6.*Acaulospora nicolsonii*** Walker, Reed & Sanders **7. & 8. Root Infections**

The rhizosphere and non-rhizosphere soil analysis of all localities were done (Table-3). AM fungi were found to improve plant mineral nutrition in particular phosphorus (P). Same results were obtained by [19]. Though P uptake usually dominates consideration of the AM association, it was observed that AMF plays important role in the uptake of other nutrients by the host plant. Zinc (Zn) nutrition is most commonly observed to be influenced by the AM association. Uptake of copper (Cu), iron (Fe), nitrogen (N), potassium (K) had been reported as being enhanced [19, 20]. The pH and electrical conductivity (EC) of the rhizosphere and non-rhizosphere soil almost remained constant. AM are present in most soils and are generally not considered to be host specific. However, population sizes and species composition are highly variable and influenced by plant characteristics and a number of environmental factors such as temperature, soil pH, soil moisture, P and N levels, heavy metal concentration [21], the presence of other microorganisms, application of fertilizers and soil salinity [22, 23]. The role of AM fungi in agricultural crop plants was becomes a subject of growing interest since last few decades. It was concluded that AM fungi adapted to the crop plants and environment managing the indigenous fungal populations in agricultural practices, so as to enhance population of efficient native fungi.

Table- 3 Soil analysis of various sample

Year	Locality	Sample		pH	EC	OC%	P2O5 Kg/ac	K2O Kg/ac	Zn ppm	Cu ppm	Fe ppm	Mn ppm
2008	L1	R	I	8.81	0.22	0.16	18	158	0.17	0.38	6.49	8.58
			II	8.16	0.33	0.13	12	148	0.38	0.33	4.71	9.49
		NR	I	7.37	0.28	0.13	20	200	0.73	0.54	4.92	12.86
			II	8.29	0.49	0.16	15	211	0.73	0.39	3.87	13.35
	L2	R	I	7.38	0.18	0.26	15	200	0.76	0.69	5.17	12.83
			II	7.91	0.32	0.10	12	200	0.24	0.68	3.98	14.49
		NR	I	7.41	0.67	0.36	17	167	0.92	0.80	7.31	13.04
			II	7.88	0.41	0.26	15	165	0.62	0.84	5.73	16.02
	L3	R	I	8.61	0.25	0.33	14	207	0.52	0.87	5.08	14.56
			II	8.13	0.17	0.10	15	173	0.49	0.65	4.57	20.29
		NR	I	7.78	0.29	0.76	17	200	1.06	1.10	5.20	18.21
			II	7.02	0.58	0.10	18	157	0.66	0.76	4.62	24.28
	L4	R	I	7.99	0.38	0.33	18	200	0.81	1.93	5.67	13.07
			II	7.59	0.46	0.29	12	210	0.44	1.29	4.99	20.86
		NR	I	7.67	0.48	0.36	20	205	1.09	3.63	5.03	29.55
			II	7.56	0.29	0.33	14	198	0.82	2.43	6.89	21.67

The rhizosphere and non-rhizosphere soil analysis of all localities were done (Table-3). AM fungi were found to improve plant mineral nutrition in particular phosphorus (P). Same results were obtained by [19]. Though P uptake usually dominates consideration of the AM association, it was observed that AMF plays important role in the uptake of other nutrients by the host plant. Zinc (Zn) nutrition is most commonly observed to be influenced by the AM association. Uptake of copper (Cu), iron (Fe), nitrogen (N), potassium (K) had been reported as being enhanced [19, 20]. The pH and electrical conductivity (EC) of the rhizosphere and non-rhizosphere soil almost remained constant. AM are present in most soils and are generally not considered to be host specific. However, population sizes and species composition are highly variable and influenced by plant characteristics and a number of environmental factors such as temperature, soil pH, soil moisture, P and N levels, heavy metal concentration [21], the presence of other microorganisms, application of fertilizers and soil salinity [22, 23]. The role of AM fungi in agricultural crop plants was becomes a subject of growing interest since last few decades. It was concluded that AM fungi adapted to the crop plants and environment managing the indigenous fungal populations in agricultural practices, so as to enhance population of efficient native fungi.

2009	L1	R	I	7.70	1.76	0.79	12	162	0.47	8.00	2.10	17.50
			II	8.00	0.79	0.53	6	150	0.48	5.00	1.60	24.20
		NR	I	8.10	0.66	0.75	8	184	0.41	10.00	2.20	22.10
			II	7.90	0.76	0.13	8	186	0.63	6.00	1.90	28.30
	L2	R	I	8.40	0.51	0.18	4	154	0.81	3.00	1.10	16.30
			II	8.30	0.49	0.09	3	138	0.21	3.00	0.70	15.40
		NR	I	8.40	0.37	0.09	3	160	0.22	4.00	1.20	16.40
			II	8.20	0.70	0.40	4	136	0.33	4.00	0.70	17.60
	L3	R	I	8.40	0.28	0.31	3	260	1.25	1.25	2.30	28.60
			II	8.10	0.64	0.17	3	224	0.31	0.31	1.90	26.80
		NR	I	8.60	0.12	0.22	3	270	0.34	0.34	2.30	30.10
			II	8.40	0.67	0.18	3	274	0.46	0.46	1.90	25.90
	L4	R	I	8.40	0.23	0.44	4	230	0.42	4.00	2.30	24.00
			II	8.30	0.72	0.24	3	213	0.34	3.59	2.45	22.50
		NR	I	8.10	0.13	0.44	3	324	0.47	9.00	3.60	34.00
			II	7.96	0.69	0.23	3	335	0.45	7.65	3.76	32.30
	L5	R	I	7.80	1.44	0.22	5	388	0.46	3.00	3.00	17.90
			II	8.00	0.17	0.04	4	362	0.26	3.65	1.90	28.70
		NR	I	7.80	2.20	0.18	8	720	0.30	4.00	1.80	14.90
			II	7.60	0.32	0.08	8	715	0.32	3.86	1.70	13.30

Year: 2008 L1- Panjarwadi; L2- Dongargaon; L3- Saigaon; L4- Nagade
Year: 2009 L1- Kusur; L2- Gawandgaon; L3- Saigaon; L4- Mukhed; L5- Bharam
NR- Non rhizosphere soil R- Rhizosphere soil
I - Collection of Soil sample after 30 days
II- Collection of Soil sample after 60 days

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