Int J Pharm Bio Sci 2012 July; 3(3): (B) 1007 - 1017

Research Article **Microbiology**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

EFFECT OF ARBUSCULAR MYCORRHIZAL FUNGI FOR THEIR SYMBIOTIC EFFICIENCY ON TWO VARIETIES OF *SOLANUM LYCOPERSICUM* L.

PUSHPA. K.KAVATAGI[1] AND H.C.LAKSHMAN [*2]

[1]Microbiology laboratory, Post graduate Department of studies in Botany, Karnatak University Dharwad- 580 003, India

ABSTRACT

Earthen pot experiments were conducted in a randomized block design with three replications to evaluate the effects of Tomato (*Solanum lycopersicum* L.) varieties, PMK-1 and Vaibhav. The indigenous species; *Glomus fasciculatum* (Thaxter) Gerdmann and Trappe emend. Walker & Koske, *Gigaspora margarita* Becker & Koske, *Sclerocystis dussii* (Patouillard) von Hohnel, and *Acaulospora laevis* Gerd & Trappe., were used in the study species Sorghum was used as a trap host. All species had the ability to colonize tomato root with different colonization levels. Significantly higher root were colonized by *Glomus fasciculatum* compared to *Acaulospora laevis.* A *Glomus fasciculatum* significantly increased shoot length, root length, dry and fresh weight of shoot and root, number of fruits and flowers. Higher spores were counted in *Glomus fasciculatum* inoculated plant compared to *Gigaspora margarita, Sclerocystis dussii* and *Acaulospora laevis* plants. The relationship between mycorrhiza and plant is very widely spread among terrestrial vascular plants. Inoculation with arbuscular mycorrhizal fungi (AMF) were significantly enhanced tomato shoots and root biomass. The endogenous species, *Glomus fasciculatum* was the best species among four species tested.

KEYWORDS: ***Glomus fasciculatum,*** **Tomato, Colonization, Vascular plant**

H.C.LAKSHMAN

Microbiology laboratory,Post graduate studies in department of Botany,Karnatak University Dharwad- 580 003, India

Corresponding author

INTRODUCTION

Arbuscular mycorrhizal fungi are a major component of the agricultural natural resource. AMF are obligate symbionts that require a plant host to complete their cycle and produce spores (Smith and Read, 1997).The responses properties such as, soil PH (Clark, 1997), soil phosphorus level, plant species as well as inoculum levels (Schroeder and Janos, 2005). The lack of demonstrated benefit may be due to the use of inappropriate strains of fungi, relatively high available P in the soil, inappropriate inoculation of mycorrhizal fungi, in ability of introduced AM fungi to establish in the soil and large variation in rates of plant growth (Jasper, 1994; Lakshman, 1996).

The Effect of mycorrhiza on root morphology has attributed to improvement of P uptake by AMF, but AMF effect on hormone production may be responsible (Berta *et al.,* 1993). Arbuscular mycorrhizal fungi (AMF) represent a key component of the rhizosphere, they are considered to play a fundamental role in natural as well as agricultural ecosystems together with other soil micro-organisms, opening new employment perspectives in the frame of a low-input agriculture. The extent of root colonization varies with several soil and climatic factors apart from the host involved. However, these fungi show a preferential colonization to hosts and there by the extent to which a host is benefited depends on the fungal species involved in relation to their phosphorus requirement and the ability of the host to translocate the native soil phosphorus further determines the efficacy of these fungi (Koide, 1991).

MATERIALS AND METHODS

1 Soil and selection of plant material

The soil physical and chemical characteristic used for pot experiments were estimated as per Jackson (1973) and is shown (Table 1). The soil: sand (3:1 v/v) mixture was filled into 17.5 cm diameter pots containing 3 kg of soil. The seeds of NS 524 and NS 585 varieties of *Solanum lycopersicum* L., were collected from Namdhari seed company Bangalore, India. Seeds were surface sterilized by treating with 1% sodium hypochlorite for 2-3 min before sowing and after germination uniform seedlings were made one per pot.

2 Inoculation of AM fungi

The four AM fungal species were collected from Agricultural Microbiology Laboratory, University of agricultural sciences, Dharwad: *Glomus fasciculatum* (Thaxter) Gerdmann and Trappe emend. Walker & Koske ,*Sclerocystis dussiii* (Patouillard) von Hohnel, *Acaulospora laevis* Gerd & Trappe and Gigaspora *margarita* Becker & Koske., were mass multiplied in 32 cm diameter containing 8.5 kg using sterilized sand : soil (1:1 v/v) mixture as the substrate and (*Sorghum vulgare* L.) Jawar as the host is shown (Figure 2). After 60 days of growth, shoots of Jawar were chopped and the inoculum containing spores root bits was air dried. 10 g of the mycorrhizal inoculum was applied to the planting area a depth of about 4 cm to the pots (except non-inoculated control) before sowing seeds.

3 Treatments and experimental design

The experiment was completely randomized with three replication of each treatment and noninoculated control without inoculum was maintained. The treatments were as follows.

A. Noninoculated control
B. *Glomus fasciculatum* (Thaxter) Gerdmann and Trappe emend. Walker & Koske
C. *Gigaspora margarita* Becker & Koske
D. *Sclerocystis dussii* (Patouillard) von Hohnel
E. *Acaulospora laevis* Gerd & Trappe

The pots were treated with 10 ml of Hoagland solution without P at an interval of 15 days. The plants were exposed to sunlight and were kept free of weeds and irrigated properly. The plants were harvested after 30, 60 and 90 days. The percentage of mycorrhizal infection was evaluated

microscopically followed by clearing of roots in 10 % KOH, neutralized in 2% HCL and stained with 0.05% tryphan blue in lactophenol according to method described by (Phillips and Hayman , 1970) and calculated as mentioned below.

$$\text{Percent of root colonization (\%)} = \frac{\text{No of root bits colonization}}{\text{Total number of root bits observed}} \times 100$$

The growth parameters like Shoot length, fresh weight of shoot, dry weight of root, dry weight of root, number of leaves, number of flowers and number of fruits, shoot and dry weight were determined after drying the plant samples at 600 C to a constant weight in a hot air oven. The AM fungal spores were counted in 50 g of soil by wet sieving and decanting (Gerdemann and Nicolson, 1963).

RESULTS

1 NS 524

The table (1) reveals, that after 30 days of the plants growth, *Gigaspora margarita* had significant effect on the (130.42g) fresh weight of shoot, (31.66) number of leaves, (26.00%) root colonization, (32.00) spore number in 50 g of soil and stem diameter (1.51cm). the plant inoculated with *Glomus fasciculatum* which showed significant increase in (16.09cm) shoot length, (35.15g) fresh weight and (3.28g) dry weight of shoot, (4.09cm) root length (3.32g) fresh and (0.65g) dry weight of root. The root colonization, (51.66%) and spore number (45.00), number of leaves (42.33) was recorded. There was no record of flowers and fruits. After 60 days, there was a significant effect of *Glomus fasciculatum* on (38.09cm) shoot length, (94.53g) fresh and (14.03g) dry weight of shoot, (9.11cm) root length, (21.44g) fresh and (6.15g) dry weight of root, number of flowers and fruits were highest with inoculated *Glomus fasciculatum* compared with *Gigaspora margarita, Sclerocystis dussii* and *Acaulospora laevis*. The mycorrhizal (41.33%) root colonization, (58.00) spore number in 50 g of soil. After 90 days of plant growth, the inoculation of *Glomus fasciculatum* was significant on (12.62g) fresh and (16.13g) dry weight of shoot, (13.81cm) root length, (22.32g) fresh and (3.14g) dry weight of root. The plant inoculated with (3.00) *Glomus fasciculatum* and (3.00) *Gigaspora margarita* produced same number of flowers and fruits. The root colonization (91%) and (81.00) spore number in 50 g of soil was highest inoculated with *Glomus fasciculatum* compared to *Sclerocystis dussii* and Acaulospora *laevis* (Table 1).

2 NS 585

The table (2) reveals that after 30 days that response of *Glomus fasciculatum* showed significant result on (17.26cm) shoot length, (32.35g) fresh and (3.73g) dry weight of shoot, (5.34cm) root length, (3.89g) fresh and (0.16g) dry weight of root. There were no records of flowers and fruits. The root colonization and spore number in 50 g of soil were not significantly recorded by *Glomus fasciculatum* responded significantly on (38.39cm) shoot length, (71.43g) fresh and (9.43g) dry weight of shoot, (9.25cm) root length, (14.34g) fresh and (4.20g) dry weight of root, (6.33) number of flowers, (2.66) number of fruits (3.12cm) stem diameter. There were no significant records of root colonization. The (54.00) spore number in 50g soil, the number of (73.66) leaves significant in the inoculated *Glomus fasciculatum* compared to *Gigaspora margarita, Sclerocystis dussii* and Acaulospora *laevis.* The response of *Glomus fasciculatum* continued to show significance after 90 days. The highest response were recorded in the inoculated *Glomus fasciculatum* on (43.20cm) shoot length, (15.39g) fresh and (13.68g) dry weight of shoot, (13.71cm) root length, (19.18g) fresh

and (2.88g) dry weight of root, (81.66) number of leaves, (3.39cm) stem diameter, (87.66%) root colonization, (83.33) spore number in 50g soil (Table 2).

Figure 1

The symbiotic response of Glomus fasciculatum, Gigaspora margarita, Sclerocystis dussii and Acaulospora laevis on plant growth of Solanum lycopersicum L., varieties NS 524 and NS 585.

1. NS 524 variety

A. Non inoculated control
B. Glomus fasciculatum (Thaxter) Gerdmann and Trappe emend. Walker & Koske
C. Gigaspora margarita Becker & Koske
D. Sclerocystis dussiii (Patouillard) von Hohnel
E. Acaulospora laevis Gerd & Trappe

2. NS 585 variety

A. Non inoculated control
B. *Glomus fasciculatum* (Thaxter) Gerdmann and Trappe emend. Walker & Koske
C. *Gigaspora margarita* Becker & Koske
D. *Sclerocystis dussiii* (Patouillard) von Hohnel
E. *Acaulospora laevis* Gerd & Trappe

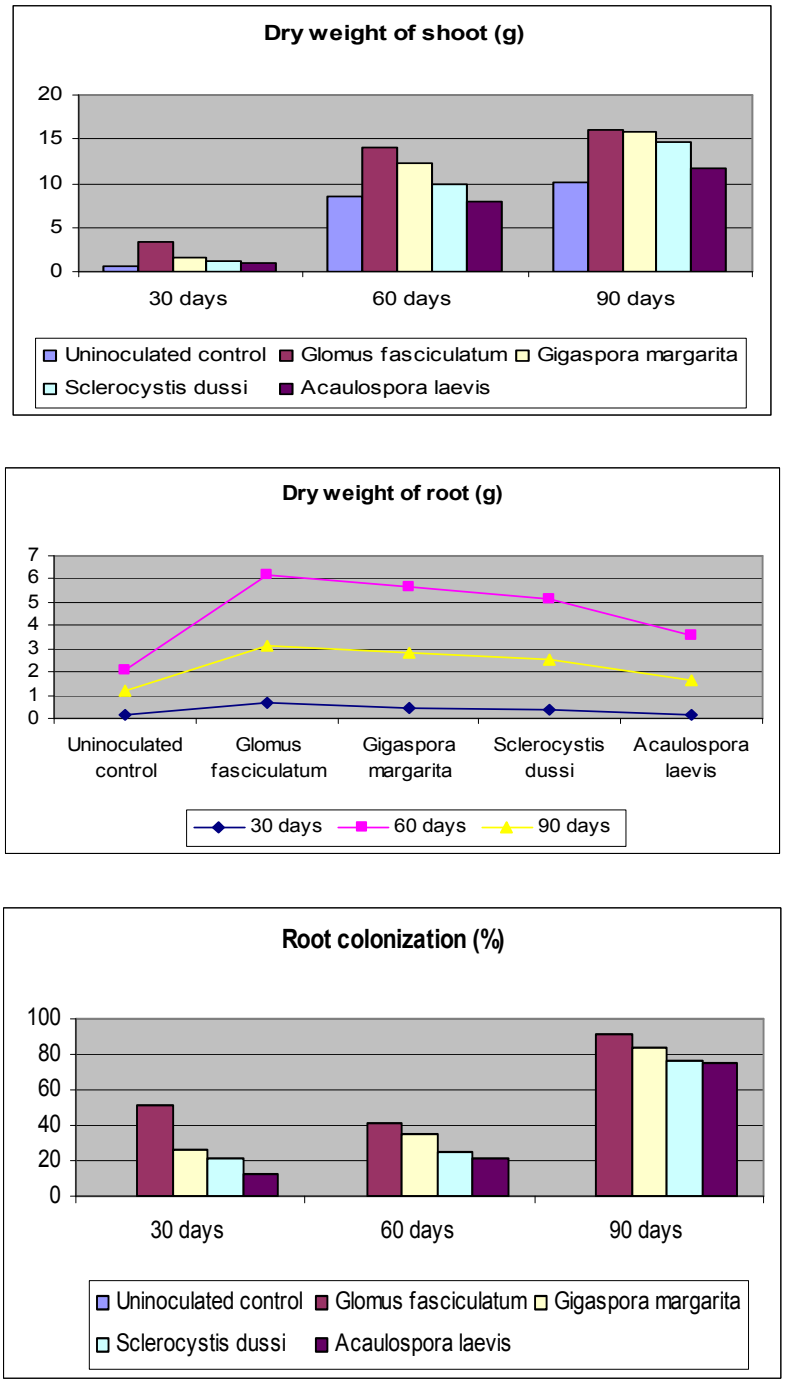
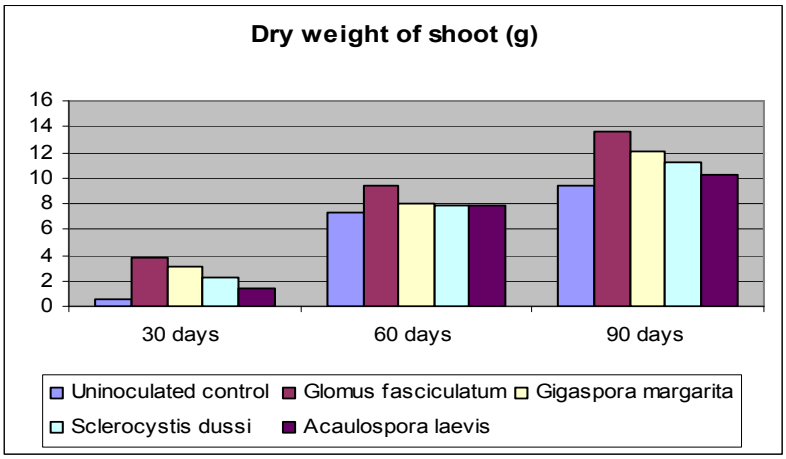
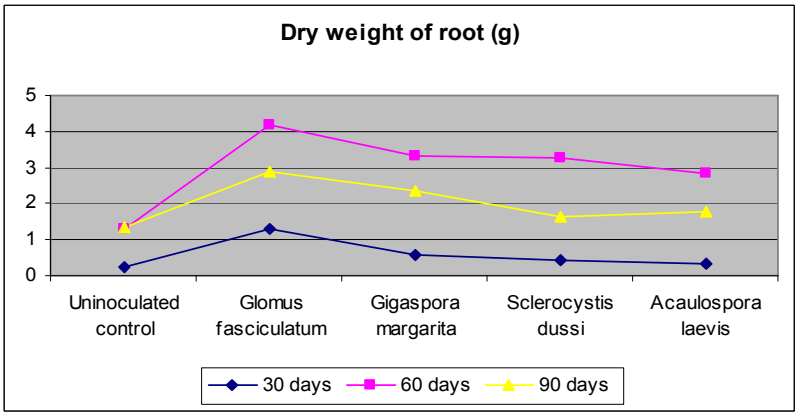


Figure 2

The effect of different AMF species on dry weight of shoot and root, and percent of root colonization in Solanum lycopersicum L., varieties NS 524





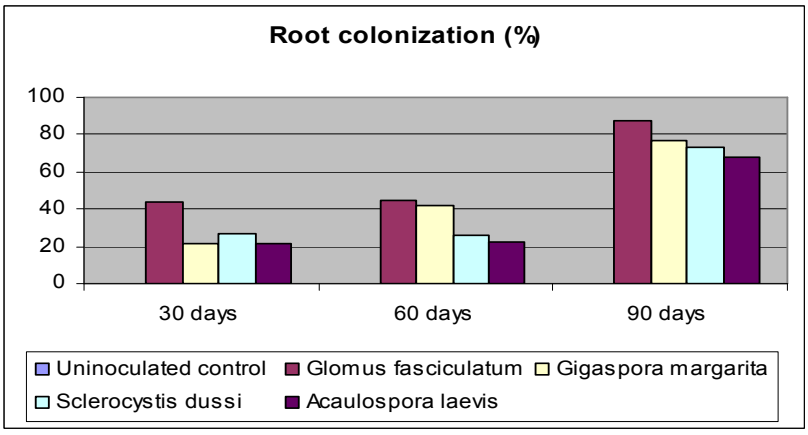


Figure 3

The effect of different AMF species on dry weight of shoot and root, and percent of root colonization in Solanum lycopersicum L., varieties NS 585.

Table 1

The effect of Glomus fasciculatum, Gigaspora margarita, Sclerocystis dussii and Acaulospora laevis on growth characteristics, root colonization, spore number of Solanum lycopersicum L. var. NS 524 for 30, 60, and 90 days.

Treatments	SL (cm)	FWS (g)	DWS (g)	RL (cm)	FWR (g)	DWR (g)	NL	NF_w	NF_r	PC (%)	SN	SD (cm)
30 Days												
Noninoculated control	9.08± 0.04e	9.15± 0.01e	0.65± 0.03e	1.22± 0.01d	0.95± 0.01e	0.12± 0.02d	14.33 ±0.33 e	0.00± 0.00	0.00± 0.00	0.00± 0.00e	0.00± 0.00e	1.11± 0.05c
Glomus fasciculatum	16.09 ±0.04 a	35.15 ±0.02 a	3.28± 0.02a	4.09± 0.04a	3.32± 0.01a	0.65± 0.02b	42.33 ±0.33 a	0.00± 0.00	0.00± 0.00	51.66 ±0.08 a	45.00 ±0.57 a	2.11± 0.05a
Gigaspora margarita	14.5± 0.08b	13.42 ±0.08 b	1.63± 0.02b	2.51± 0.05b	1.93± 0.08b	0.43± 0.08b	31.66 ±0.33 b	0.00± 0.00	0.00± 0.00	26.00 ±0.05	33.66 ±1.52 b	1.50± 0.05b
Sclerocystis dussii	10.09 ±0.04 c	11.89 ±0.02 c	1.10± 0.02c	1.51± 0.08b	1.55± 0.08c	0.36± 0.08c	23.33 ±0.33 c	0.00± 0.00	0.00± 0.00	21.66 ±0.88 c	28.00 ±0.57 d	1.52± 0.08b
Acaulospora laevis	12.09 ±0.04 d	10.60 ±0.02 d	0.94± 0.01d	2.51± 0.01c	1.73± 0.02d	0.12± 0.01d	20.33 ±0.33 d	0.00± 0.00	0.00± 0.00	13.00 ±0.57 d	31.00 ±0.57 c	1.51± 0.08b
60 Days												
Noninoculated control	20.11 ±0.05 e	61.08 ±0.02	8.51± 0.03d	6.09± 0.04e	10.12 ±0.03 e	2.05± 0.04e	51.33 ±0.33 e	3.66± 0.33c	1.33± 0.33c	0.00± 0.00e	0.00± 0.00d	1.50± 0.08d
Glomus fasciculatum	38.09 ±0.04 a	94.53 ±0.04	14.03 ±0.01 a	9.11± 0.05a	21.44 ±0.01 a	6.15± 0.01a	78.33 ±0.33 a	7.33± 0.33a	7.33± 0.33a	41.33 ±1.52 a	5.00± 0.57a	2.51± 0.08a
Gigaspora margarita	28.10 ±0.05 b	85.35 ±0.02 b	12.20 ±0.08 b	7.51± 0.08b	17.11 ±0.05 b	5.64± 0.02b	64.33 ±0.33 b	4.66± 0.33b	3.33± 0.33b c	35.00 ±0.57 b	48.00 ±0.57 b	2.11± 0.05b
Sclerocystis dussii	25.11 ±0.05 c	72.52 ±0.02 c	9.82± 0.01c	7.10± 0.05c	16.58 ±0.29 c	5.12± 0.04c	60.66 ±0.88 c	4.33± 0.33b	2.00± 0.57c d	25.00 ±0.57 c	44.00 ±0.01 c	1.71± 0.08c
Acaulospora laevis	24.10 ±0.05 d	71.55 ±0.01 d	7.98± 0.68d	6.82± 0.01d	12.34 ±0.02 d	3.55± 0.01d	57.66 ±0.33 d	3.66± 0.33b	2.66± 0.33b	21.66 ±0.88 d	11.66 ±0.88 c	1.52± 0.01d
90 Days												
Noninoculated control	29.07 ±0.37 e	83.73 ±0.01 e	10.09 ±0.02 e	7.51± 0.08e	12.93 ±0.02 e	1.16± 0.08e	60.33 ±0.33 cd	2.333 ±0.33 cd	2.66± 0.33d	0.00± 0.00d	0.00± 0.00e	1.51± 0.05d
Glomus fasciculatum	40.09 ±0.04 a	120.6 ±0.01 a	16.13 ±0.05 a	13.81 ±0.08 a	22.32 ±0.01 a	3.14± 0.03a	88.66 ±0.33 a	3.33± 0.33a	4.33± 1.20a	91.00 ±0.57 a	81.00 ±0.57 a	2.82± 0.01a
Gigaspora margarita	33.11 ±0.05 b	115.7 ±0.02 b	15.85 ±0.01 b	8.82± 0.01b	17.7± 0.05b	2.82± 0.01b	48.24± 23.75a b	3.00± 0.00a b	4.33± 0.33a b	83.66 ±0.88 b	77.66 ±0.88 b	2.52± 0.01b
Sclerocystis dussii	31.12 ±0.06 c	100.5 5±0.0 1c	14.62 ±0.01 c	8.52± 0.01c	15.45 ±0.02 c	2.53± 0.05c	67.00 ±1.00 ab	2.33± 0.33b	3.68± 0.33c	76.66 ±1.20 c	75.00 ±0.57 c	2.12± 0.06c
Acaulospora laevis	30.11 ±0.05 d	98.44 ±0.02 d	11.75 ±0.01 d	8.11± 0.05d	13.13 ±0.02 d	1.65± 0.01d	61.33 ±0.88 bc	2.66± 0.33c	3.33± 0.33c d	74.66 ±0.33 c	72.00 ±0.57 d	2.07± 0.03

Table 2

The effect of Glomus fasciculatum, Gigaspora margarita, Sclerocystis dussii and Acaulospora laevis on growth characteristics, root colonization, spore number of Solanum lycopersicum L. var. NS 585 for 30, 60, and 90 days.

Treatments	SL (cm)	FWS (g)	DWS (g)	RL (cm)	FWR (g)	DWR (g)	NL	NF_w	NF_r	PC (%)	SN	SD (cm)
30 Days												
Noninoculated control	8.16 ±0.08e	21.37 ±0.13e	0.55± 0.02e	2.53± 0.05d	2.09± 0.04e	0.25 ±0.02d	20.33 ±0.33d	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	1.16± 0.08c
Glomus fasciculatum	17.2 ±0.14a	32.35 ±0.15a	3.73± 0.07a	5.34± 0.19a	3.89± 0.01a	1.32 ±0.05a	37.66 ±0.33a	0.00± 0.00	0.00± 0.00	43.66 ±1.85a	35.00 ±0.57a	2.39± 0.08a
Gigaspora margarita	12.08±0.04b	33.43 ±0.06b	3.13± 0.02b	4.63± 0.11b	3.14± 0.01b	0.59 ±0.02	31.00 ±0.57b	0.00± 0.00	0.00± 0.00	21.66 ±0.05b	31.66 ±0.33b	1.47± 0.11b
Sclerocystis dussiii	13.57±0.03c	27.12 ±0.01c	2.28± 0.16c	3.40± 0.28c	2.89± 0.04c	0.41 ±0.08c	26.00 ±0.57c	0.00± 0.00	0.00± 0.00	27.00 ±0.57b	31.33 ±0.88b	1.64± 0.06b
Acaulospora laevis	11.17±0.17d	25.26 ±0.07d	1.42± 0.01d	2.62± 0.15d	2.49± 0.03d	0.35 ±0.01d	24.66 ±0.33c	0.00± .0.00	0.00± .0.00	21.00 ±0.57b	20.66 ±0.88	1.55± 0.03b
60 Days												
Noninoculated control	19.37±0.19e	50.35 ±0.05e	7.35± 0.06d	5.51± 0.05e	9.83± 0.06e	1.29 ±0.04c	55.33 ±1.20d	3.33± 0.33c	1.33± 0.33d	0.00± 0.00	0.00± 0.00	1.41± 0.09c
Glomus fasciculatum	38.39±0.19a	71.43 ±0.23a	9.43± 0.07a	9.25± 0.13a	14.34 ±0.07a	4.20 ±0.15a	73.66 ±0.33a	6.33± 0.33a	2.66± 0.33a	44.33 ±2.08a	54.00 ±0.57a	3.12± 0.06a
Gigaspora margarita	27.03±0.02b	58.73 ±0.06b	8.07± 0.02b	7.56± 0.03b	12.07 ±0.03b	3.33 ±0.03ab	65.66 ±0.33b	4.33± 0.33b	1.76± 0.33b	41.66 ±0.88b	46.00 ±0.88b	2.28± 0.14b
Sclerocystis dussii	23.08±0.04c	53.21 ±0.09c	7.80± 0.08c	6.54± 0.06c	11.73 ±0.09c	3.27 ±0.05bc	60.33 ±0.33c	5.00± 0.57b	1.33± 0.33c	26.00 ±0.57c	44.00 ±0.57c	1.57± 0.03c
Acaulospora laevis	23.08±0.04d	52.36 ±0.36d	7.88± 0.02c	6.08± 0.04d	10.74 ±0.02d	2.83 ±1.00bc	58.66 ±0.33c	5.00± 0.57b	1.00± 0.00c	22.00 ±0.57d	41.66 ±0.88d	1.51± 0.03c
90 Days												
Noninoculated control	25.13±0.09e	90.83 ±0.08e	9.35± 0.06e	7.48± 0.13e	11.06 ±0.07e	1.33 ±0.05d	65.33 ±0.33d	3.66± 0.33c	3.33± 0.33c	0.00± 0.00e	0.00± 0.00e	1.37± 0.08c
Glomus fasciculatum	43.20±0.07a	150.39±0.34a	13.68 ±0.11a	13.71 ±0.12a	19.18 ±0.18a	2.88 ±0.02a	81.66 ±0.33a	5.66± 0.33a	5.33± 0.33a	87.66 ±0.88a	83.33 ±0.88	3.39± 0.19a
Gigaspora margarita	37.3 ±0.19b	141.09±0.02b	12.13 ±0.04b	10.35 ±0.07b	13.62 ±0.12b	2.36 ±0.15b	75.33 ±0.33b	2.66± 0.33ab	3.66± 0.33b	77.00 ±0.57b	80.00 ±0.57b	2.30± 0.11b
Sclerocystis dussii	36.28±0.38c	116.24±0.04c	11.26 ±0.05c	9.70± 0.09c	12.67 ±0.06c	1.63 ±0.06c	71.66 ±0.33c	2.66± 0.33ab	2.33± 0.33bc	73.33 ±0.88c	75.00 ±0.57c	1.45± 0.04bc
Acaulospora laevis	31.22±0.51d	110.00±0.13d	10.22 ±0.05d	9.28± 0.18d	12.27 ±0.13d	1.76 ±0.07c	70.66 ±0.66c	2.33± 0.33c	3.33± 0.33bc	68.00 ±0.57d	72.33 ±0.33d	1.50± 0.08bc

DISCUSSION

The current investigation showed that AMF *Glomus fasciculatum* was able to significantly increase the shoot length, root length, fresh and dry weight of shoot and root, stem diameter, number of flowers, leaves and fruits , percent of root colonization and spore number of *Solanum lycopersicum* L varieties, NS 524 and NS 585. The present results in the same line with the results obtained by many researchers (Davies *et al.,* 1992; Clark, 1997), they reported that the main benefits of AMF are enhance plant acquisition of mineral nutrients and increase the ability of plants to with stand or reduced acquisition of toxic elements to growth. Host preference among AM fungi has been reported by earlier workers (Mc Graw and Schenck, 1981; Vasanthakrishna *et al*., 1995). Hence the need for inoculating different mycotrophic plants has been stressed (Jeffries, 1987; Bagyaraj and Varma, 1995). The present study with an objective of screening for an efficient AM fungus for tomato seedlings has also resulted plant growth responses to different AM fungi.

The varieties of tomato plants grown in the presence of arbuscular mycorrhiza showed a general increase in plant growth parameters like plant height, root length, fresh and dry weight of shoot and root, number of leaves, flowers and fruits, as against those grown in uninoculated control (Table 1 and 2). *Glomus fasciculatum* significantly enhanced the plant height as compared to all other treatments except for *Gigaspora margarita. Sclerocystis dussii* and Acaulospora *laevis* showed a lowest number of spores and colonization of the roots compared to *Glomus fasciculatum* and *Gigaspora margarita.* Mycorrhizal fungi are also implicated in improving the soil structure by increasing the soil aggregation by their hyphae (Miller and Jastrow, 1992). Soil aggregation is a measure of the amount of extrametrical hyphae, which is in turn related to the efficiency of the fungus (Reena and Bagyaraj, 1990) The positive effects of root colonization on increasing spore number were found in NS 524 and NS 585 varieties, Thus *Glomus fasciculatum, Gigaspora margarita* can be considered as to be the most promising symbiont for inoculating *Solanum lycopersicum* L., varieties.

Inoculation with Arbuscular mycorrhizal fungi was significantly enhanced increased four varieties of tomato shoots and root growth. The endogenous species, *Glomus fasciculatum* was the best species among three species tested. Hence it can be concluded that tomato seedlings show varied response to different AM fungi and *Glomus fasciculatum* confirm maximum growth benefits compared to all other fungi used in this study. The majority of research on the stresses has focused on mycorrhizal formation and nutrient acquisition under extreme changes in water amounts, temperature, PH and inorganic nutrient availability.

CONCLUSION

Inoculation with Arbuscular mycorrhizal fungi was significantly enhanced increased four varieties of tomato shoots and root growth. The endogenous species, *Glomus fasciculatum* was the best species among three species tested. Hence it can be concluded that tomato seedlings show varied response to different AM fungi and *Glomus fasciculatum* confirm maximum growth benefits compared to all other fungi used in this study. The majority of research on the stresses has focused on mycorrhizal formation and nutrient acquisition under extreme changes in water amounts, temperature, PH and inorganic nutrient availability.

ACKNOWLEDGMENT

First author is indebted to category cell for financial support under University Research fellowship. Second Author wish to thank UGC-SAP DPS-III phase New Delhi, for their financial support.

REFERENCES

1. Bakshi B K, Thaper, H S, Mycorrhiza in *Taxus baccata* and *Pinus wallichiana.* Indian Forester, 86, pp 16-17, (1960).
2. Bagyaraj D J, Varma, A, Interactions between arbuscular mycorrhizal fungi and plants: their importance in sustainable agriculture in arid and semiarid tropics. Advance in Microbiology and Ecology, 14, pp 119-142, (1995).
3. Clark,R D, Arbuscular mycorrhizal adaptation, spore germination, root colonization and host plant growth and mineral acquisition at low PH. Plant soil, 192, pp 15-22, (1997).
4. Declerck S, Cevos, B, Delvaux, B and Plenchette, C, Growth response of micropropagated banana plants to VAM inoculations, Fruits 49, pp 103–109, (1994).
5. Ek, M. Ljungquist PO, Stenstrom, E, Indole acitic acid production by mycorrhizal fungi determined by gas chromatography mass spectrometry. New Phytol, 94, pp 401-407, (1983).
6. Gavito M E and Varela, L, Response of criollo maize to single and mixed species inocula of arbuscular mycorrhizal fungi. Plant and Soil, 176, pp 101–105, (1995).
7. Gerdemann J W, Nicolson, T H, Spores of mycorrhizal endogene species extracted from the soil by wet sieving and decanting. Trans. Br. Mycology . Society, 46, pp 235-244, (1963).
8. Gera Hol W H and Cook, R, An overview of arbuscular mycorrhizal fungi nematodes interventions. Basic and Journal of Applied. Ecology, 6, pp 489–503, (2005).
9. Hamel C, Dalpe, Y and Furlan, V, Indigenous populations of arbuscular mycorrhizal fungi and soil aggregate stability are major determinants of leek (*Allium porrum* L) response to inoculation with *Glomus intraradices* Schenck & Smith *or Glomus versiforme* (Karsten) Berch. Mycorrhiza, 7, pp 187–196, (1997).
10. Hildebrandt U, Kaldorf, M and Bothe, H, The zinc violet and its colonization by arbuscular mycorrhizal fungi. Journal of Plant Physiol, 154, pp 709–717, (1999).
11. Jaizme-Vega, M.C, Galán, V and Carbrera, J, Preliminary results of VAM effects of banana under field conditions, Fruits 46, pp 19–22, (1991).
12. Jeffries P, Use of mycorrhizae in agriculture. Crit. Review. Biotechnology, 5, pp 319-357, (1987).
13. Khan A G, Mycorrhizal association in gymnosperm of Pakistan. Pakistan Journal of Botany, 2, pp 9-18, (1971).
14. Lambert DH, Cole H Jr, Baker DE, Adaptation of vesicular–arbuscular mycorrhizal to edaphic factors. New Phytol, 85, pp 513–520, (1980).
15. Lakshman H.C, VA-mycorrhizal studies in some economically important tree species, Ph.D. thesis Karnatak University Dharwad, India, (1996).
16. Msiska Z, Arbuscular Mycorrhizal Fungi of Uganda banana plantation soils. M.Sc. Thesis. University of Pretoria, Pretoria, (2001).
17. Miller R M, Jarstfer A G, and Pillai, J.K, Biomass allocationin an Agropyron smithi-Glomus symbiosis. American Journal of Botany,74, pp 114-122, (1987).
18. McGraw and Schenck N C, Effects of two species of vesiculararbuscular mycorrhizal fungi on the development of Fusarium wilt of tomato. Phytopathology, 7, pp 894-897, (1981).
19. Mosse B, Fructifications of an Endogone species causing endotrophic mycorrhiza

in fruit plants. Ann Botany, 20, pp 349-362, (1956).
20. Phillips J M, and Hayman, DS, Improved procedure for clearing roots and vesicular arbuscular mycorrhizal fungi for apid assessment of infection. Trans British Mycorrhizal Society, 55, pp 158-161, (1970).
21. Smith S E, Read D J, Mycorrhizal symbiosis, second edition, USA; Academic Press. San Diego, CA,USA, (1997).
22. Vasanthakrishna M, Bagyaraj D J, and Nirmalnath J P, Selection of efficient VA mycorrhizal fungi for *Casuarina equisetifolia* second screening. New phytol, 9, pp 157-162, (1995).