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Full Length Article

Screening of efficient AM fungus to improve plant growth yield and biomass production of Tomato (*Solanum lycopersicum* L)

Pushpa K Kavatagi and H C Lakshman
Microbiology laboratory,
Post graduate studies in department of Botany, Karnatak University Dharwad- 580 003, India
pushpak.k2@gmail.com

ABSTRACT

The different arbuscular mycorrhizal (AM) fungi were evaluated for their symbiotic response with *Solanum lycopersicum* L (Var.Vaibhav) under greenhouse conditions. Four AM fungi were used *Rhizophagus fasciculatus* (Thaxt.) C.Walker&A.Schußle, *Gigaspora margarita* Becker & Koske*, Sclerocystis dussi* (Patouillard) von Hohnel and *Acaulospora laevies* Gerd & Trappe. All the inoculated seedlings showed significant results over control after 30, 60 and 90 days of inoculation. *Solanum lycopersicum* L (Var.Vaibhav) seedlings raised in the presence of AM fungi showed higher Shoot length, fresh weight of shoot, dry weight of root, dry weight of root, number of leaves, number of flowers and number of fruits, compared to non-inoculated control plants. The possible second influenced AM fungus was *Gigaspora margarita, Sclerocystis dussi and Acaulospora laevies,* the third and fourth respectively. *Rhizophagus fasciculatus* appeared to be the most promising AM fungus for inoculating for overall growth and biomass production of Tomato. Considering the various plant growth parameters and nutritional status of the plants, it was observed that *Rhizophagus fasciculatus* the best AM symbiont for tomato plants compared to the others used under this experiment.

Key words: Plant growth, Tomato, biomass, greenhouse, *Acaulospora laevies,* spore number.

INTRODUCTION

Arbuscular mycorrhizas are the mutualistic symbiosis between fungi in the phylum glomeromycota and most terrestrial plant roots (Smith and Read, 2008). Vegetable crops that require a nursery stage can benefit from AMF inoculation, thus its use has been incorporated into horticultural practices (Evans, 1997). Mycorrhizal symbiotic association increases the supply of mineral nutrients to the plant, particularly those whose ionic forms have a poor mobility rate or those which are present in low concentration in the soil and thus promote plant growth (Erco-lin and Reinhardt, 2011). Mycorrhizas involve plant exchange of photosynthates in return for fungal exchange of mineral nutrients. The convergence of so many unrelated forms of mycorrhizas is a testament for the mutual benefits of these trading partnerships. It is known mycorrhizal colonization effect plant growth and development owing to plant nutrition elements that are provided by mycorrhizaes in a lot of plant types. (Cavagnara *et al.,* 2006; Singh et *al.,* 2008; Lakshman, 2009, 2012). Thus, mycorrhizal symbioses physically and chemically structure the rhizosphere, and they impact communities and ecosystems (Cardon and Whitbeck, 2007). Arbuscular mycorrhizal fungi are obligate symbionts that colonize the roots of most cultivated plant species.

Mycorrhizal symbiosis can be found in nearly all types of ecological situations and most plant species are able to form this symbiosis naturally (Smith and Read, 1997;Lakshman and Kadam,2011).The purpose of the present research was screening for *S.lycopersicum* L., (Var.Vaibhav)that showed higher biomass and shoot and root growth on arbuscular mycorrhizal fungi. Presently, the use of AMF application as a biofertilizer has been recommended with the aim of increasing productivity and reducing fertilizer use.

MATERIALS AND METHODS

Procurement of seeds

The soil physical and chemical characteristic used for pot experiments were estimated as per Jackson (1973). The soil: sand (3:1 v/v) mixture was filled into 17.5 cm diameter pots containing 4 kg of soil. The seeds of *Solanum lycopersicum* L., (Var. Vaibhav) 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.

Inoculation of AM fungi

The four AM fungal species were collected from Agricultural Microbiology Laboratory, University of agricultural sciences, Dharwad, India. *Rhizophagus fasciculatus* (Thaxt.) C.Walker&A.Schußler*, Gigaspora margarita* Becker & Koske*, Sclerocystis dussi* (Patouillard) von Hohnel and *Acaulospora laevies* Gerd & Trappe., were mass multiplied in 32 cm diameter containing 8 kg using sterilized sand : soil (1:1 v/v) mixture as the substrate and (*Sorghum vulgare* L.) Jowar as the host. After 30 days of growth, shoots of Jowar were chopped and the inoculum containing spores root bits was air dried. 10 g mixed inoculums of the mycorrhiza was applied to the planting area a depth of about 2 cm to the pots except non-inoculated control before sowing seeds.

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. Non-inoculated control
B. *Rhizophagus fasciculatus* (Thaxt.) C. Walker & A. Schußler
C. *Gigaspora margarita* Becker & Koske
D. *Sclerocystis dussi* (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% trypan blue in lactophenol according to method described by (Phillips and Hatman , 1970) and percent root colonization was calculated as mentioned below (Giovanneti and Mosse, 1980).

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

The AM fungal spores were counted in 50 g of soil by wet sieving and decanting (Gerdemann and Nicolson, 1963). 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 in a hot air oven at 70^0 C for 1 hr.

RESULTS AND DISCUSSION

The selection of AM fungal species such as *Rhizophagus fasciculatus, Gagaspora margarita Sclerocystis dussi* and *Acaulospora laevis,* have clearly proved an increased shoot length, fresh and dry weight of shoot, root length, fresh and dry weight of root, number of leaves, number of flowers, number of fruits, root colonization, spore number and stem diameter the results of vaibhav variety (Table, 1). The symbiotic response of *Rhizophagus fasciculatus, Gagaspora margarita, Sclerocystis dussi* and *Acaulospora laevis* on plant growth of *Solanum lycopersicum* L. (Var. Vaibhav). The table 1 depicts that after 30 days the plants inoculated with *Rhizophagus fasciculatus* showed significant growth than all other treatments like *Gigaspora margarita, Sclerocystis dussi, Acaulospora laevis* and non-inoculated control (Figure, 1).

Figure 1: Showing symbiotic response of *Rhizophagus fasciculatus, Gagaspora margarita, Sclerocystis dussi* and *Acaulospora laevis* on plant growth of *Solanum lycopersicum* L., (Var. Vaibhav).

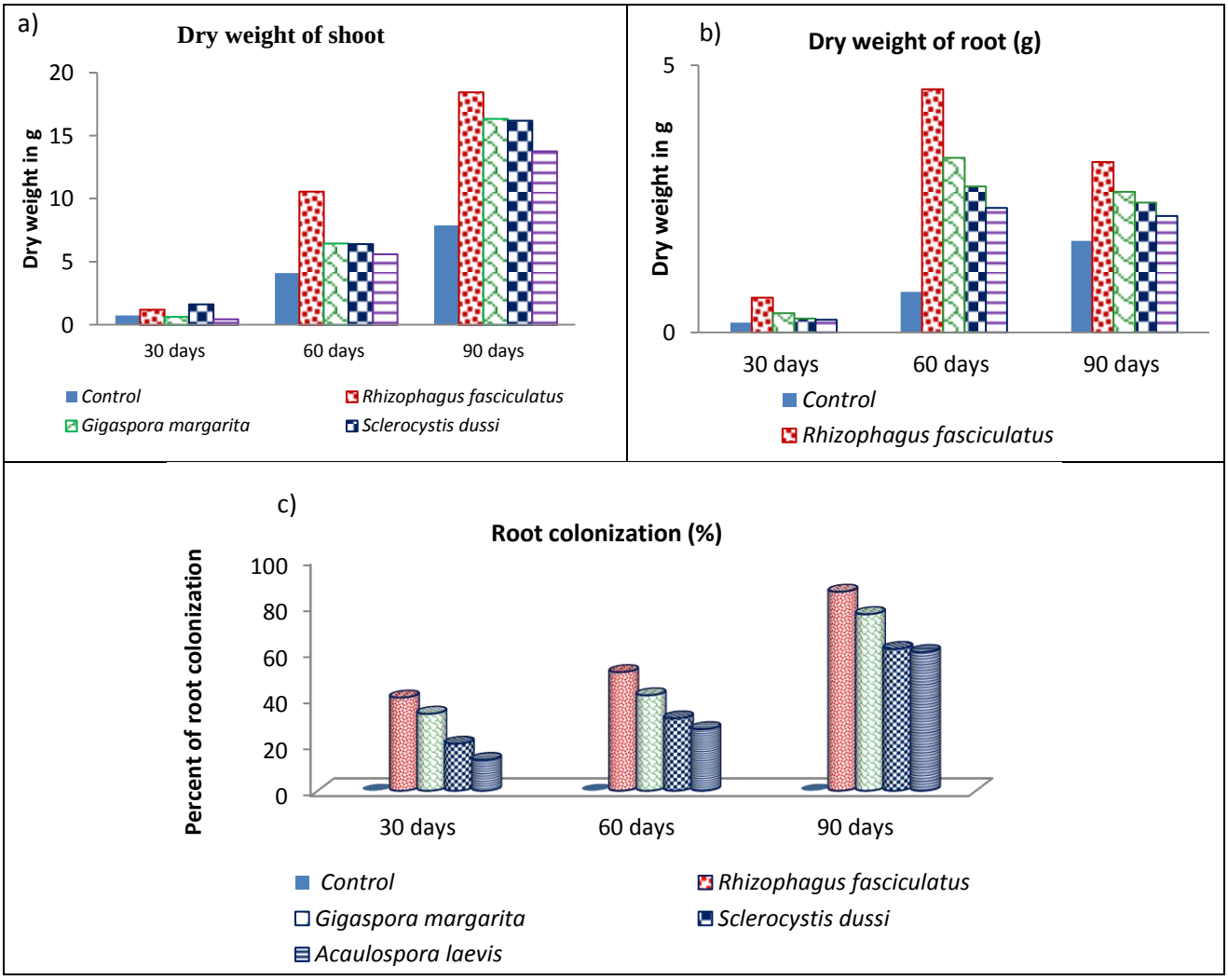

Figure 2: Showing effect of different AMF species on *Solanum lycopersicum* L., (Var.Vaibhav).
(a) .Dry weight of shoot (b).Dry weight of root, and (c). Percent of root colonization

Table 1: Showing effect of *Rhizophagus fasciculatus, Gigaspora margarita, Sclerocystis dussii* and *Acaulospora laevis* on growth characteristics, of *Solanum lycopersicum* L. (Var. Vaibhav) for 30, 60, and 90 days. SL-shoot length ,FWS-fresh weight of shoot,DWS-Dry weight of shoot,RL-Root length, FWR-Fresh weight of root,DWR-Dry weight of root, NL-Number of leaves,NF_w-Number of flowers, NF_r- Number of fruits ,PC-percent of root colonization ,SN-Spore number, SD-Stem diameter.

Treatments	SL	FWS	DWS	RL	FWR	DWR	NL	NF_w	NF_r	PC	SN	SD
30 Days												
Control	8.11±0.05e	11.52±0.01e	0.74±0.01d	0.20±0.01c	2.50±0.08d	0.18±0.08d	15.33±0.33	0.00±0.00	0.00±0.00	0.00±0.00e	0.00±0.00e	1.08±0.04d
Rhizophagus fasciculatus	16.11±0.05a	21.28±0.08a	1.21±0.03a	5.09±0.04a	3.74±0.01a	0.65±0.01a	31.00±0.57a	0.00±0.00	0.00±0.00	40.33±0.33a	51.66±0.88a	2.22±0.01a
Gagaspora margarita	7.08±0.04b	20.23±0.01b	0.64±0.08b	4.51±0.08ab	1.54±0.03b	0.36±0.08b	25.66±1.33b	0.00±0.00	0.00±0.00	33.33±0.33b	41.00±0.57b	1.51±0.08b
Sclerocystis dussi	10.09±0.099c	18.52±0.02c	1.63±0.02b	4.09±0.09ab	2.47±0.05c	0.26±0.02c	23.33±0.33b	0.00±0.00	0.00±0.00	20.33±0.33c	41.33±0.88c	1.52±0.02b
Acaulospora laevis	12.10±0.05d	15.53±0.01d	0.45±1.73c	3.52±0.01b	2.82±0.01c	0.24±0.02c	23.33±0.33b	0.00±.0.00	0.00±.0.00	13.33±00.33d	26.00±0.50d	1.22±0.01c
60 Days												
Control	18.50±0.01e	52.59±0.10e	4.09±0.02d	2.51±0.03e	6.55±0.01d	0.76±0.07e	24.669±0.33e	0.00±0.00e	0.00±0.00e	0.00±0.00e	0.00±0.00e	1.52±0.01d
Rhizophagus fasciculatus	45.46±0.02a	95.39±0.02a	10.57±0.05a	8.48±0.05a	16.90±0.01a	4.55±0.07a	70.33±0.33a	8.33±0.33ab	54.33±0.33a	51.33±0.33a	67.00±0.57a	2.50±0.05a
Gagaspora margarita	37.03±0.06b	69.41±0.02b	6.47±0.05b	7.09±0.05b	12.23±0.07b	3.27±0.05b	62.66±0.33b	4.33±0.33ab	3.33±0.33b	41.33±0.33b	50.33±0.88b	2.09±0.04b
Sclerocystis dussi	29.21±0.14c	66.65±0.01c	6.41±0.02b	6.51±0.08c	12.08±0.04b	2.73±0.05c	62.33±0.33c	11.00±7.00ab	1.33±0.33c	31.33±0.88c	47.33±1.20c	1.35±0.02c
Acaulospora laevis	25.07±0.03d	62.24±0.05d	5.62±0.02c	6.12±0.06d	10.38±0.20c	2.33±0.05d	52.33±0.66d	4.00±0.57ab	1.23±0.33d	26.66±0.33d	41.00±0.57	1.50±0.05c
90 Days												
Control	30.13±0.07e	70.61±0.01e	7.88±0.03d	5.12±0.12e	9.51±0.02e	1.71±0.03d	37.66±0.33d	1.66±0.66d	2.66±0.33c	0.00±0.00e	0.00±.0.00e	1.48±0.03c
Rhizophagus fasciculatus	52.26±0.20a	198.20±0.07a	18.45±0.09a	11.52±0.01a	21.27±0.03a	3.19±0.11a	82.33±0.33a	8.33±0.33a	5.66±0.33a	86.00±0.57a	75.33±0.33a	3.15±0.04a
Gagaspora margarita	41.32±0.17b	120.34±0.14b	16.34±0.04b	10.15±0.09b	16.54±0.04b	2.63±0.04b	72.33±0.67b	5.00±0.57b	4.33±0.33a	76.33±0.88b	71.00±0.57b	2.52±0.01b
Sclerocystis dussi	38.21±0.13c	119.63±0.05c	16.21±0.11b	7.80±0.05c	14.25±0.05c	2.43±0.05b	71.00±0.57b	3.33±0.33c	6.00±0.57b	61.33±0.88c	66.66±0.88c	2.18±0.12c
Acaulospora laevis	32.11±0.05d	100.49±0.18d	13.77±0.03c	7.46±0.13d	11.38±0.02d	2.18±0.07c	66.00±2.51c	3.33±0.33c	2.56±0.57c	60.00±0.57d	67.00±0.57d	2.0±0.05c

Data represents means ± SE of 3 replicates; each experiment was repeated thrice. Mean separation within column by Duncan's multiple range test at $P < 0$.

Plants inoculated with *Rhizophagus fasciculatus* promoted greater shoot length(16.11cm), fresh (21.29g) and dry weight of shoot(1.21g), fresh (3.74g) and dry weight of root(0.65g), whereas (5.09cm) of root length was effective (Figure, 2). The numbers of leaves (31.00) were significant, inoculated with *Rhizophagus fasciculatus*. The number of flowers and fruits were not recorded. The highest root colonization (40.33%), spore number (51.66) in 50g soil was recorded in *Rhizophagus fasciculatus.*

After 60 days, the shoot length (45.46cm) was highest inoculated with *Rhizophagus fasciculatus.* The effect of *Rhizophagus fasciculatus* was significant in fresh weight of shoot (95.39g), dry weight of shoot(10.57g), root length(8.48cm), fresh (16.90g)and dry weight of root(4.55g). The numbers of leaves (70.33) were more in plants inoculated with *Rhizophagus fasciculatus.* The number of flowers, (8.33) fruits, (4.33) were significant inoculated with *Rhizophagus fasciculatus* showed higher number compared to *Gigaspora margarita* and *Sclerocystis dussi.* The plants inoculated with *Rhizophagus fasciculatus* (2.50cm) and *Gigaspora margarita* (2.09cm) was significant. The root colonization (51.33%), spore number (67.00) in 50 g of soil was recorded significant in plants inoculated with *Rhizophagus fasciculatus.* After 90 days, *Rhizophagus fasciculatus* which showed significant increase in fresh (198.20g) and dry weight of shoot(18.45g), root length(11.52cm), fresh (21.27g) and dry weight of root(3.19g) . The significance with *Rhizophagus fasciculatus* continued to show even in flowers (8.33), number of leaves (82.38), stem diameter (3.15cm) and spore number (75.33) in 50 g of soil.

Tomato is recognized as a mycotrophic plant (Kubota *et al.,* 2005) and the usefulness of AMF inoculation in improving the fitness and vitality of tomato host has been described under stress conditions (Karagiannidis *et al.,* 2002).Species and strains of AM fungi have differed to the extent by which they increase nutrient uptake and plant growth (McGraw and Schenck, 1981, Gracy Sailo and Bagyaraj, 2005). In the present study, mycorrhizal parameters, such as percent root colonization and extrametrical spores, were considerably higher in all the inoculated treatments compared to the uninoculated control treatment. The existence of host preference by AM Fungi has been investigated by several researchers which provide support for the argument that different AM Fungi produce markedly different levels of root colonization, growth rates and nutritional responses in some plant species compared to others (Helgason *et al.,* 2002; Vandenkoornhuyse *et al.,* 2003). The extent of colonization and the spore count varied with different AM fungi. However, (Declerck *et al*., 1995), working with several banana cultivars and arbuscular mycorrhizal fungi, observed different growth promotional effects depending on the banana cultivar and the *Glomus* strain the quality of inoculum also is important. From besides some fungi have different colonization patterns and different effects on host plant growth consistent with early works contribution of (Ortas *et al.,* 2002a,b; Ortas, 2008, 2009; Ortas and Varma, 2007;Lakshman, 2008), it is clear that different mycorrhizal species have different root colonization capacity and also have different influence on plant growth. Hence it can be concluded that tomato seedlings show varied responses to different AM fungi and *Rhizophagus fasciculatus* confers maximum growth benefits compared to all other fungi used in this study. Therefore, it can be concluded that *Solanum lycopersicum* L., (Var.Vaibhav) plants biomass and its yield can be improved by inoculating efficient strain Am fungus *R. fasciculatus* at nursery stage.

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