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Field Response of Capsicum Annuum Dually Inoculated with AM Fungi and PGPR in Western Rajasthan

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Abstract: *The interactive effects of one of the vesicular- arbuscular mycorrhizal (VAM) fungi (Glomus deserticola) and PGPR (Azospirillum) on biomass production, nutrient uptake and productivity on Capsicum annuum. It is one of the most important spice crops of the world and is widely cultivated throughout the warm, temperate, tropical and subtropical countries. It is an indispensable spice essentially used in every Indian cuisine due to its pungency, spice, taste, appealing odor and flavor. Its fruits are rich source of Vitamin C, A and E. Capsicum is famous for its pleasant aromatic flavor, pungency and high coloring substance. It is used widely in culinary, pharmaceutical and beverage industries. Hence, Capsicum finds diverse utility as a spice, condiment, culinary supplement, medicine and vegetable, besides it is an important commercial crop. The beneficial microbes are the most important components of the sustainable agriculture. The experiments were conducted in soil of nutrient deficient, with a high indigenous AM fungal population or exotic AM fungal species and other beneficial microorganisms. Such conditions usually promote positive responses in the experimental plant. Significantly increased growth was observed in plants with dual inoculation of G. deserticola and Azospirillum over uninoculated control plant. The present experimental results demonstrate that the synergistic effect of AM fungi and other beneficial microorganisms on the Capsicum annuum plant were discussed. The four treatments were: a. non-inoculated plants (Control); b. plants inoculated with G. deserticola (VAM); c. plants inoculated with Azospirillum; d. plants inoculated with both G. deserticola + Azospirillum. The best respoinse of capsicum plant were shown by the dual inoculation of G. deserticola + Azospirillum over singly inoculate plant with G. deserticola and Azospirillum and uninoculated plant.*

Keywords: *Capsicum cultivar, G. deserticola and Azospirillum*

1. INTRODUCTION

Biofertilizers are commonly called as microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes. For the last one-decade, biofertilizers are used extensively as an eco-friendly approach to minimize the use of chemical fertilizers, improve soil fertility status and for enhancement of crop production by their biological activity in the rhizosphere. Interactions of growth-promoting microbial populations in the rhizosphere of VAmycorrhizal plants have been studied, Baas 1990. Subba Rao *et al.* (1985) reported that the synergistic interactions of VAM and *Azospirillum brasilense* significantly increased dry matter production and grain yield of barley. Response of plants to colonization by mycorrhizas depends on many biotic and environmental factors. This trial aimed to study the interactions of VAM fungus with *Azospirillum* in rhizosphere soils of capsicum plant and their effect, on plant growth, nutrient concentration, and biomass production. Extensive research was carried out on the use of bacteria Azospirillum and VAM fungi G. deserticola as biofertilizers to supplement nitrogen and phosphorus and observed considerable improvement in the growth of several crop plants. Dual inoculation of VAM and Bacterial biofertilizer proved more effective in increasing the growth of different crop plants (Sreeramulu et al., 2000 and Sumana and Bagyaraj, 2002).

2. MATERIAL AND METHODS

The experiments were conducted in Jai Narain Vyas University dept of Botany, Jodhpur.

*Soil preparation***:** The soil used for conducting the pot culture experiment properties: pH 7.1 and total N, P, K, respectively. *Capsicum annuum* (mathania cultivar) collected from mathania area, Jodhpur region from field. Well decomposed farm yard manure, nitrogen through urea, phosphorus through single super phosphate in correct proportion were used in all the pot culture experiments.

A stock culture of *Glomus deserticola* was used as VAM inoculum, in pot culture using sorghum bicolor for mass multiplication grown in loam: sand (1:1) ratio for 6 months. Inocula consisted of a mixture of the soil medium, extraradical hyphae and spores and colonized root segments (2 mm in length).

Fresh cultures of *Azospirillum brasilense* was isolated from soil with specific media were used as bacterial inocula. VAM inoculum soil, containing spores along with hyphae and infected root fragments. Pellets were prepare of Azospirillum with clay soil for innoculum of microorganism and these pellets were placed about 2 cm below the soil surface in the pots .The control pot received autoclaved inocula. The treatments used were: (i) AM-free (control), (ii) *Azospirillum*, (iii) VAM, (iv) VAM + *Azospirillum*, seeds of capsicum mathania cultiver were sown in all the pots. The pots were kept in a greenhouse, watered regularly .Each treatment was replicated four times. The plants were harvested and assessment of growth parameters such as biomass production, productivity, tissue nutrient (N, P) concentrations was performed.

3. AM FUNGI COLONIZATION ASSESSMENT

Per cent root colonization of AM fungi was done after 3 months of planting as per the growing season of capsicum annuum and determined after staining the roots with tryphan blue as described by Phillips and Hayman (1970) , koske, R.E. and Gemma 1989 with slight modifications. For clearing and viewing under sterio microscope at 45x magnification on gridline plate Giovanetti,M. and B. Mosse,1980.

4. BIOMASS PRODUCTION

Harveted capsicum plants were seperated into leaves, stem and roots. Dry weight of leaves and stems were determined after oven drying at 70^{o}C. fruits per plant were determined at harvest. Tuber yield mycorrhizal dependency were expressed as the difference between fresh tuber yield of innoculated plant to non inoculated plant.

5. POST HARVESTING

After harvesting soil sample were collected from the pots and analysis of soil samples were done for N,P by Rayment, G.E. and Lyons, D.J. 2011

6. RESULTS

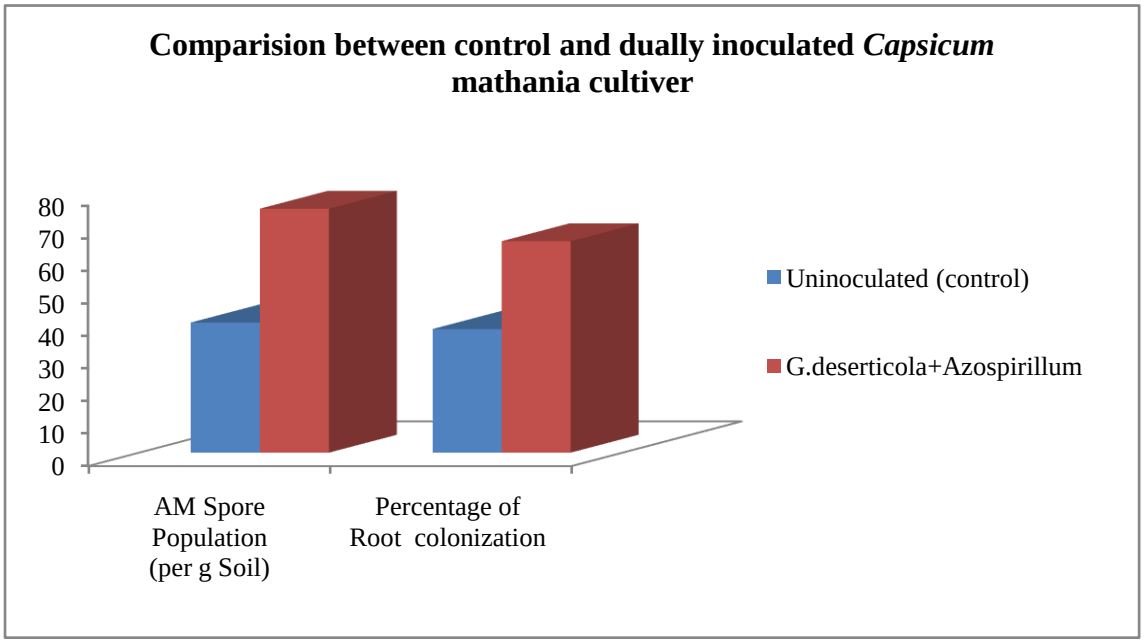
6.1. Plant Growth Effects

In capsicum, *Azospirillum* and AM co-inoculated plants recorded significantly increased plant height and dry weight than *Azospirillum* or AM fungi singly inoculated ones. (Table 1)

Sl.No.	Treatment	Plant height (in cm)	Total mg/g dry wt.
1	Control	60	0.2
2	*Glomus deserticola*	70	0.58
3	*Azospirillum*	66.4	0.38
4	*G.deserticola + Azospirillum*	74.1	0.64

6.2. Fungal Spore Population and Percent Root Colonization

The effect of combination biofertilizers on spore population and percent root colonization in capsicum mathania cultivar are shown Figure 1.



Compared to the uninoculated plant, the AM fungi inoculated capsicum mathania cultivar demonstrated better spore population and per cent root colonization. However, maximum fungal population is about nearly 80% and root colonization is 60-70% respectively was observed in co-inoculated in mathania cultiver.

7. Plant Phosphorus and Nitrogen Content

Significant elevation of plant phosphorus content in *capsicum* mathania cultiver was observed upon dual inoculation rather than single inoculation (Table 2).

Table 2. *Influence of dual inoculation (AM + PGPR) on Phosphorus and Nitrogen of Mathania cultivar.*

Sl.No.	Treatment	Total P mg/g dry wt.	Total N mg/g dry wt.
1	Control	0.2	2.02
2	*Glomus deserticola*	0.58	4.46
3	*Azospirillum*	0.38	3.15
4	*G.deserticola +Azospirillum*	0.64	6.01

The effect of bio-inoculants on plant nitrogen content (percent) of capsicum revealed that inoculation of AM or *Azospirillum* singly or in combination increased plant nitrogen content of capsicum crop to about thrice times over un-inoculated control. Moreover, when the single inoculums were compared, the AM fungal inoculums brought about substantial increase in nitrogen than *Azospirillum*.

8. Fruit Dry Weight

Weight of fruits per plant significantly increased with single inoculation of either AM fungi or Azospirillum than the un-inoculated plants. However the maximum number of fruits dry weight20.2/g was observed in co-inoculated plants while it was 18.9 /g fruits for Azospirillum and 17.5/g for AM inoculations. The bio-inoculums were also observed to improve the yield of fruits in plants significantly than the un-inoculated plants. (Table 3).

Table3. *Influence of dual inoculation (AM+PGPR) on Fruit dry weight (per 10 fruits/g) of Mathania cultivar.*

Sl.No.	Treatment	Fruit dry weight (per 10 fruits/g)
1	Control	16.2
2	*Glomus deserticola*	17.5
3	*Azospirillum*	18.9
4	*G.deserticola + Azospirillum*	20.2

9. DISCUSSION

Arbuscular mycorrhizae are well known to be of ubiquitous occurrence. Its distribution (Mathur and Vyas, 1995, Mathur et al. 2006.) and their diversity associated with rhizosphere of *capsicum annuum* (M.vyas and A.vyas 2012) in Indian Thar Desert. There has been a phenomenal increase of interest on AM fungi in recent years leading to numerous surveys for enumerating and accessing AM fungal species and their colonization of host plants in different regions of this country (Muthukumar and Udaiyan, 2000).

Certain beneficial bacterial flora such as *Azospirillum* are considered a type of biofertilizer that directly help to endow the host plants with nutrients, or indirectly influence positively root growth and morphology, or helps by other beneficial symbiotic relationships (Johansson JF et al.,2004,Guru et al 2011). Among these beneficial activities, facultative root interactions at the rhizospheric level have great implications in ecological and sustainable resource management in agriculture, which include interactions aiding in nutrient exchange, mobilization of exudates/enzymes and modification of root structure (Vessey, 2003, Bohme L and Bohme F, 2006).

Since AM fungi compensate to nutrient deficiency of the host plant, its potentiality to colonize the root is likely to be decrease with increase in nutrient status of both the rhizosphere soil and the host plant (Mathur and Vyas, 2000).

Capsicum Mathania cultivars, were inoculated with Glomus deserticola, different PGPR & dual inoculation of PGPR+ Mycorrhiza for the further studies. In this phase of experiment efforts were made to exploit the potentiality of different arbuscular mycorrhizae & PGPR on productivity and nutrient uptake in the plant *Capsicum* Mathania cultivar. Observations revealed that different arbuscular mycorrhizal species varied in their efficacy to improve productivity and nutrient uptake. *Glomus deserticola* was found to be most efficient in increasing productivity and nutrient uptake of *Capsicum* Mathania cultivar.

When the plant *Capsicum* Mathania cultivar infected by *Azospirillum*, which increases nutrient uptake and productivity of plant found to be most efficient. Increase in nutrient uptake & productivity may be due to this association, which affects plant by two ways. Indirect stimulation of plant proliferation includes preventing phytopathogens from inhibiting plant growth and development direct stimulation provides plants with compounds such as phosphorus from the soil and production of ethylene synthesis inhibitor, ACC-deaminase that can modulate the level of phytohormone, ethylene (Wang et al. 2000; Glick and Penrose 2003).

When capsicum mathania cultiver were inoculated with dual inoculation of AM fungi and PGPR the results were better than single inoculation. Dual inoculations with AM fungi and rhizobacteria have resulted in increased mycorrhizal colonization, possibly due to increased spore germination However dual inoculation of *Glomus deserticola* and *Azospirillum* proved to be more significant. Individually these microorganisms increase in nutrient uptake, productivity & biomass production of the plant but synergistic effect shows more significance. This is due to their interrelationship where these microorganisms produce the beneficial products for each other, which increases growth of these microbes. The bacterial growth also increased in presence of AM fungi.

Our present study clearly demonstrated that inoculation with glomus derticola and *Azospirillum* singly or in combination increased plant growth, and yield significantly in capsicum over un-

inoculated control. Earlier studies had reported increase in yield parameters of capsicum due to inoculation with AM fungi in hydroponics sand culture conditioned (Ojala JC et al., 1980; Mohandas S et al., 1987). In the present study the presence of AM fungi alone brings about substantial increase in growth and yield parameters

From the above discussion it is clear that dual inoculation of PGPR and arbuscular mycorrhizal fungi vary in their efficacy to improve productivity and nutrient uptake of the host plant. However, the important factors that determine the potential benefits of a particular mycorrhizal species to a host plant are the nutritional level of the host plant, availability of nutrient in the rhizosphere soil of the particular plant, the root system of the plant and efficiency of the particular mycorrhizal species & PGPR to compensate the nutritional requirement of the host plant.

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