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Beneficial Effect of PSB and AM Fungus Inoculation on Growth and Nutrient (N, P, K) Uptake in *Glycine max* var. LSb1

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Abstract:
The influence of a phosphate solubilizing bacterium (Pseudomonas striata) and Arbuscular mycorrhizal (AM) fungus (Glomus mosseae) on the growth of Glycine max var. LSb1. revealed that G. mosseae and P. striata inoculated plants in sterilized soil produced significantly higher growth, dry matter, increase in nodule number, N, P and K uptake in shoot. A moderate or lower growth response was observed among the plants growth in unsterilized soil and either PSB or AM inoculation. On the contrary un-inoculated plants in sterilized garden soil do not showed better growth and total N, P and K uptake. Therefore, synergistic effect was recorded with increased plant dry matter, nodule number, N, P and K uptake in the plants treated with both the inoculants in sterilized soil.

Keywords: *Glycine max, Glomus mosseae, Pseudomonas striata, sterile, unsterile soil*

1. Introduction

Modern agriculture, which is characterized by intensive cultivation methods, is totally dependent on regular input of numerous types of inorganic fertilizers. The long term effects of such massive fertilization lead to affect on the environment and, it is in now a matter of serious concern. In recent days, researches on plant nutrition through PSB and AM fungi have amply demonstrated that these organisms play an important role in uptake of nutrient from the marginal soils. Research in the last three decades has established that dual inoculation of phosphate solubilizing bacteria and AM fungi stimulates plant growth (Subba rao, 1988). Phosphate solubiliizing bacteria solubilize insoluable P and help plants to absorb and translocate more soluble phosphate (Azcon-Aguliar *et al.*, 1986). It has been estimated that in some soil up to 75 per cent applied phosphatic fertilizers may be lost to the plant because of mineral phase precipitation (Kaulpunik and Douds, 2000). Many free living bacteria and fungi are being employed to enhance P use efficiency (Patel, 2002). *Glycine max* LSb1 grown in most of north Karnataka. It is an indigenous variety produced by University of agricultural sciences Dharwad-58003. Most of these varieties are being grown in nutrient deficient soils. AM fungi are inoculated on crop plants to study the possibility of saving phosphatic fertilizers and improving plant growth and yield (Jeffries, 1987). Phosphorus is usually considered to be the major problem when AM infection and responses are poor. Fertilization is often very important in such practical situations. High phosphorus levels in soil or P additions are known to reduce AM colonization of roots and sporulation. Several earlier studies indicated that addition of an excess of readily available P eliminates the beneficial mycorrhizal effect (Sreenivasa *et al.*, 1993). At the same time, use of insoluble form of P had little or no effect when inoculated with AM fungi. The dual inoculation of Rhizobium and and PSB showed that the increased grain yield either with or without chemical fertilizers (Dhange and Kachhave, 2008). Airsang and Lakshman (2009) have observed that the significant increased yield when treated with *Glomus fasciculatum* and *Rhizobium* on *Glycine max* Merr.(var DH-125). Hence, in the present investigation, possible synergistic interactions between AM fungus, *Glomus mosseae* and a phosphate-solubilizing bacterium, *Pseudomonas striata*, at different proportions of available and unavailable form of P were studied in a vertisol. No research work was directed on *Glycine max* LSbl so far. Hence, the present study was carried out to evaluate the efficiency of phosphate solubilizing bacteria and Arbuscular-mycorrhizal fungus on the growth N, P and K uptake in soybean LSb1.

2. Materials and methods

The Green house experiments were undertaken in the Post graduate Department of Botany, Karnatak University, Dharwad-580003 India. *Pseudomonas striata* , a phosphate solubilizing bacterium, was procured from the Department of Agricultural Microbiology Department, U.A.S. Dharwad-580005. The AM fungus *Glomus mosseae* was multiplied with Sudan grass (*Sorghum* *vulgare* var. *sudaneese*) as a host plant and maintained in a polyhouse, Department of Botany, Karnatak University, Dharwad-580003 India. Soil based AM inoculum was established and maintained in pot culture.

Seedlings were raised in earthen pots each pot measuring 15x20 (breadth length) filled with 3 Kg of sterilized and unsterilized garden soil. The used soil to the experiment was a sandy loam with a pH 6.8, EC 0.14 µmhos/cm^2, organic carbon 0.38%, available N; 199 kg/ha, available K; 204 kg/ha and available P 4.6 kg/ha. Before sowing the seeds into experimental pots surface of Soybean seeds were sterilized in 2% Sodium hypochlorate, washed 1-2 times in sterile water. Seeds were pasted with peat based inoculum (0.10 mg/100g seeds) around the root system. Mycorrhiza colonized chopped root bits (5 g) and 5 g soil of the host plants which consisted of spores (approximately 158 / 250 g soil) and external hyphae was 10 g. dry inoculum singly or in combination was placed 3 cm below the soil of each experimental pots, before sowing the seeds. There were altogether 20 treatments including uninoculated control with 4 replications. Plants were watered on alternate days and harvested once 30 days. But here, 90 days harvest was given. The inoculation treatments were as follows.

- Un-inoculated control
- Pseudomonas striata alone
- Glomus mosseae alone
- P.striata + G. mosseae

Plants growth parameters: Plant height, dry weight of shoot and nodule number were recorded N, P and K uptake in shoots were determined. The per cent of AM fungal colonization of *Glycine max* LSb1 roots were estimated according to (Philips and Hayman, 1970). The extra metrical chalamydospores were isolated by adopting wet sieving and decanting technique outlined by (Gerdemann and Nicolson, 1963). Phosphorus content of shoots was estimated by vanadomolybdate phosphoric yellow colour method outlined by Jackson (1973). Nitrogen was determined Microkjeldahl method and potassium by the Flame photometer.

3. Results And Discussion

The data on growth, nodules number, biomass yield and N, P and K content in shoot and roots of both type experiments in both unsterilized and sterilized garden soil was given in (Table 1-2). Soybean plants inoculated with PSB phosphate solubilizing bacteria i.e *Pseudomonas striata* influenced greatly than AM fungus i.e. *Glomus mosseae* inoculation and no such improvement was observed non inoculated (control) plants. The two fold increase of plants height, tenfold increase of biomass yield, seven fold increase of nodule number and significantly increased N, P and K in shoot and roots was significant, when the soybean plants inoculated with the two micro organisms i.e PSB and AM fungus in unsterilized soil (Table 1). Experimental results clearly brought optimum growth biomass yield higher number nodules and per cent colonization under sterilized garden soil. Phosphate solubilizing bacteria is more influenced compared to AM fungus over the control plants. PSB plus AM fungus *Pseudomonas striata* with *Glomus mosseae* influenced very significantly increased fourfold growth, biomass yield, nodule number and nitrogen and phosphorous uptake and per cent root colonization (Table 2). Similarly, improvement of shoot dry weight and nitrogen content in sterilized and unsterilized soil are given (Fig 1). Specific rhizosphere micro organisms are important. That can play important role in promoting root growth and mycorrhizal development (Linderman *et al*., 1990; Lakshman, 1996). Soybean *Glycine max* LSb1 showed a positive response to combined inoculation of PSB plus AM fungus over the non inoculated control plants. These results are consistent with early workers contribution (Bagyaraj and Menge, 1978; Barea *et al.,* 1983; Dileepkumar *et al.,* 2001; Mohammad and Zaidi, 2007; Sabannavar and Lakshman, 2008). IAA and GA or cytokinins produced by bioinoculants have good impact on plant growth and useful for increasing vegetative growth and yield (Nirmalnath and Srinivas, 1992; Muthuraju *et al*., 2002; Eranna *et al.,* 2002; Suman *et al.,* 2003). It was at 90 days dual inoculation of PSB and AM fungus *Pseudomonas striata* plus *Glomus mosseae* has brought higher growth than that of single inoculation and over the non inoculated plants. Similar findings were also reported on Soybean and Lentil by (Azcon-Aguilar *et al.,* 1986; Sattar and Gaur, 1989; Lakshman, 2010). The present investigation clearly demonstrated PSB *Pseudomonas striata* and *Glomus mosseae* AM fungus inoculation to *Glycine* max LSb1 in sterilized in more suitable in improving plants biomass yield, N, P and K uptake and nodule number and nitrogen fixation in roots. This indicates that the plants might need of AM fungal community associated with rhizobacteria. Synergistic positive interactions have more beneficial to leguminous plants. In conclusion, this study clearly brings out that the combined inoculation of *G. mosseae* and *Psedomonas striata* to Soybean LSb1 is better and obtain higher biomass yield.

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Treatments	Plant height (cm)	Shoot dry weight (g/pl.)	% AMF Root colonization	Spore count/ 50g soil	Nodule number/ plant	Root Dry weight (g/plant)	P uptake in shoot (ppm)	N uptake in root (ppm)	K uptake in shoot (ppm)
Un-inoculated (control)	12.6a	2.3a	14.6b	14.2a	0.4a	0.62b	23	33b	49a
PSB	26.8b	7.2b	31.3b	29.2b	3.4b	0.78c	51c	67c	132b
AMF	21.3d	6.4a	42.2d	186.7c	3.1c	1.99b	73b	98d	141d
PSB+AMF	32.5c	9.7c	51.6e	201.4d	8.4e	2.84d	89a	124b	148c

Table 1: Effect of PSB and AM fungus inoculation of growth, dry matter, nodule number and P uptake of 90 days old Glycine max LSb1. in unsterilized garden soil.

- Mean values followed by the same letter within a column do not differ significantly at p=0.05 by one way ANOVA

Treatments	Plant height (cm)	Shoot dry weight (g/pl.)	% AMF Root colonization	Spore count/ 50g soil	Nodule number/ plant	Root Dry weight (g/plant)	P uptake in shoot (ppm)	N uptake in root (ppm)	K uptake in shoot (ppm)
Un-inoculated (control)	19.7a	3.4a	11.2	11.0b	0.51d	0.89c	34b	43a	51a
PSB	38.2c	12.5c	27.9a	33.23b	4.3b	1.92b	96a	102c	133d
AMF	35.8d	10.4d	54.3d	52.57a	2.9b	2.11e	98e	123b	142c
PSB+AMF	49.1b	14.8e	74.8d	128.5d	11.3c	3.75d	109b	134d	157b

Table 2: Effect of PSB and AM fungus inoculation of growth, dry matter, and nodule number and P uptake of 90 days old Glycine max LSb1. in sterilized garden soil.

- Mean values followed by the same letter within a column do not differ significantly at p = 0.05 by one way ANOVA.

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