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ORIGINAL ARTICLE

EFFECT OF DUAL INOCULATION WITH GLOMUS FASCICULATUM AND RHIZOBACTERIA ON THE GROWTH AND YIELD OF CHILLI

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Abstract:

The present study focused on the combining effect of Glomus fasciculatum with Rizobacteria (Azospirillum brasilense and Pseudomonas fluorescens) on the growth and yield of chilli variety PLR-1. All the treatments were applied as single, dual and combined inoculants, under pot conditions, in a Completely Randomised Block Design (CRPD).The biofertilizers were applied to the roots by coating or dipping, with the inoculants in a solid or liquid support, respectively. The population of AMF and rhizobacteria were enumerated at 30, 90, 120 days after inoculation, the highest population of AMF was 75.1 % at 90 days after inoculation. The populations of P. fluorescens was ranged from 3.55 × 106 to 11.7 × 106 cfu g-1 of soil and A. brasilense was ranged from 2.99 × 106 to 14.0 ×106 cfu g-1 of soil were detected in the rizosphere soil of chilli. The highest population of P. fluorescens was recorded 11.7 × 106 cfu g-1 of soil and A. brasilense was recorded 14.0 × 106 cfu g-1 of soil at 90 days after inoculation.

In the pot condition the combined inoculation showed highest results and slightly difference were occurred on growth parameter and chlorophyll content. Single and dual inoculation also promotes the growth of leaves, chlorophyll content, plant height and root weight. Overall obviously excellent results were observed in combined inoculation. The maximum yields (158.33) were recorded on T12 - Pseudomonas fluorescens + Azospirillum brasilense + Glomus fasciculatum (combined inoculation) and minimum yield recorded on T3 - P. fluorescens (single inoculant) (104.33), these observations were significantly greater than control.

KEYWORDS-

Chilli, biofertilizer, AMF, Rizobacteria, root coating, root dipping, growth parameters, chlorophyll content.

INTRODUCTION-

Chilli is one of the most important vegetable and spice crop in India. India produces a tune of 9.21 lakh tonnes of chilli per annum, grown in an area of 8.92 lakh ha-1 with a productivity of 1.00 tonne per hectare (Jain, 2002) contributing to nearly one fourth world's production. Among the microorganisms that have been used as biofertilizers there is a group of bacteria known as plant growth promoting rhizobacteria (PGPR) and arbuscular mycorrhizal fungi (AMF), that have been recognized for their potential use in agriculture and horticulture (Azcon, 2000; Lucy et al., 2004).

Wu (2005) reveled that plant growth promoting rhizobacteria (PGPR) are a group of bacteria that actively colonize plant roots and increase plant growth and yield. The beneficial plant-microbe interactions

in the rhizosphere are the primary determinants of plant health and soil fertility (Jeffries et al., 2003). Various Pseudomonas species have been shown to be effective in controlling pathogenic fungi and stimulating plant growth by a variety of mechanisms, including production of siderophores, synthesis of antibiotics, production of phytohormones, enhancement of phosphate uptake by the plant, nitrogen (N) fixation, and synthesis of enzymes that regulate plant ethylene levels (Abdul Jaleel et al., 2007). Synergistic positive interactions have been reported between AM fungi and plant-growth promoting bacteria (PGPB) such as N fixers, fluorescent pseudomonads, and sporulating bacilli (Hameeda et al., 2007). The mechanisms by which PGPR promote plant growth are diverse, and often the beneficial effect is due to a combination of mechanisms (Bashan et al., 2004).

Nitrogen fixation, the solubilisation of phosphorous in the rhizosphere and the production of phytohormones, enhance plant growth directly. In mycorrhizal associations, plants supply carbohydrates to fungi, while fungi improve plant nutrition by increasing the absorption and translocation of nutrients, principally P, as well as N, K, Cu, Zn and Mg (Linderman, 1992). Arbuscular mycorrhizal (AM) fungi as well as microbial-free inoculants used as phytostimulators (Azospirillum) or as biological control agents of fungi (Pseudomonas and Trichoderma) have shown beneficial effects on plant growth and health (Mar Vazquez, 2000). Arbuscular mycorrhizal (AM) fungi improve plant growth profoundly through increased of phosphrous nitrogen and other nutrients. The use of AM fungi enhancing plant growth and yield of many crops has gained momentum in recent years because of the higher cost and hazardous effects of heavy doses of chemical fertilizer (Sarwade et al., 2011).

Co-inoculation studies with PGPR and Bradyrhizobium japonicum have also demonstrated increased soybean plant root and shoot weight, seed yield, plant vigour, nodulation and nitrogen fixation (Yahalom et al., 1987).

In the present study the effect of dual inoculation with Glomus fasciculatum and rhizobacteria in the growth and yield of chilli (Var. PLR – 1).

MATERIALS AND METHODS

All experiments were conducted in the Department of Microbiology, Annamalai University, Tamil Nadu, India. All the chemicals were used as AR grade unless or otherwise stated as the double distilled water was used throughout the study. The PLR-1 variety chilli was obtained from Vegetable Research Station, Palur, Cuddalore. Pure strains of Azospirillum brasilense, Pseudomonas fluorescens and Glomus fasciculatum were used in the experiments. These were obtained from the Department of Agricultural Microbiology, Faculty of Agriculture, Annamalai University, India. Glomus fasciculatum was multiplied on Rhodes grass (Chloris gayana Kunth) following the open pot culture method (Gilmore, 1968).

Analysis of soil

The soil used for the present experiment was collected from the agricultural field at Annamalai University, Tamil Nadu, India. The physicochemical characteristics of the soil used for the pot experiments were tested in soil testing laboratory at Soil Science Department, Annamalai University.

Preparation of biofertilizer

In the case of liquid biofertilizers, Azospirillum brasilense was grown in a NFB. Pseudomonas fluorescens was grown in a Kings B broth, were incubated at 300C with orbital agitation (150 rpm) for 48 hours in the case of Azospirillum brasilense and Pseudomonas fluorescens, to obtain a concentration of 1×109 colony forming units (cfu) ml-1. The solid biofertilizers (Azospirillum brasilense, Pseudomonas fluorescens and Glomus fasciculatum) were prepared from the liquid biofertilizers using a substrate of dry sugarcane press mud with a particle diameter of 1.5 mm, sterilized at 1.2 atm for 1½ hours. Every kilogram of substrate was inoculated with 500 ml of the liquid inoculants. The incubated solid substrates were incubated at 300C for 12 days. The concentration of Azospirillum brasilense, and Pseudomonas fluorescens in solid supports was 1×1010 cfu g-1 which was verified by the dilution plate count method.

Experimental design in the pot culture study

In this experiment we evaluated the effect of the different application methods (dipping and root coating in single, dual and combined form) on Rhizobacteria populations and Glomus fasciculatum colonization as well as plant growth and chlorophyll content. A completely randomized experiment was designed with thirteen treatments and 3 replications (Table-1). When plants had grown to the desired size they were individually inoculated with the treatments explained in Table - 1. Instantaneously after inoculation seedlings were separately transplanted to thirteen-cm-diameter pots amended with 3 kg of air-dried sterilized soil-sand-manure (seived at 3 mm and sterilized at 1.5 atm for 30 min.) mix (3:2:1).

Application of Biofertilizers

The single coating treatments (T2 – GfS, T4 – PfS, T6 – AbS) involved a 1:10 mixture of 10 g of biofertilizers and 90 ml of adherent (2 % w/v starch), where as in the dual and combined treatments (T8 – AbS+ GfS , T10 – PfS+ GfS, and T12 – PfS + AbS +GfS) the mixture contained 10 g per inoculants and 190 ml of adherent. The root balls of seedlings were coated with the mixture of the different treatments and allowed to dry in the shade for 10 min. In the single treatments where non-combined liquid biofertilizers were applied by dipping (T1 – GfL, T3 – PfL, T5 – AbL), the roots were submerged in their corresponding bacterial or G.fasciculatum inoculants for five minutes. A 1:1 (v/v) mixture, each of the inoculants was previously prepared for the dual and combined treatments applied by dipping roots (T7 – AbL+GfL, T9 – PfL+GfL and T11 – PfL + AbL +GfL). Afterwards, the complete root ball of the seedling was submerged for 5 minutes in the inoculants preparation and allowed to dry in the shade for 10 min. The seedlings were irrigated daily with to maintain the moisture at approximately 30 % water holding capacity of the soil.

Enumeration of population dynamics of rhizobacteria and AM fungi

Samples of 10 g of rhizospheric soil per plant were collected 30, 60 and 120 days after inoculation to determine the rhizobacterial and AM fungi population. Soil samples were suspended in 90 ml sterile distilled water and shaken for 30 min at 150 rpm. Immediately after shaking, each suspension was serially diluted by pipetting 1 ml aliquots into 9 ml sterile water, to obtain a final dilution of 106 fold. A 1 ml volume of each dilution of the series was plated with NFB medium for A. brasilense treatment, whereas Kings B medium was used for P. fluorescens treatments. Three replicate dishes were prepared for each dilution. Agar plates were incubated at 30°C for 48-72 hours. After incubation, the number of colony forming units (cfu) g- 1 of soil was determined by the spread plate method. Rhizobacteria were identified considering cellular, colony morphology and Gram staining (Holt, 2000, Bergey's Manual).

Root samples were washed well with 10% KOH solution and stained with 0.1% Trypan blue before estimation of mycorrhizal colonization. Arbuscular mycorrhizal colonization was estimated using a modified line intersect method MeGonigle et al. (1990) where a minimum of 100 line intersections per root sample, replicated three times, were scored for the presence of AM structures. These observations were made using the light microscopy to rate the degree of root infection by AMF in one plant per replicate (three plants per treatment). The percentage of AM infection was calculated from the following equation:

$$\text{Percentage of AM infection} = \frac{\text{Root length infected}}{\text{Root length observed}} \times 100$$

Estimation of chlorophyll

0.5 mg of fresh leaf was ground in a mortar and pestle with 20 ml of 80 per cent acetone. The homogenate was centrifuged at 3000 rpm for 15 min. The supernatant was collected. The pellet was restricted with 5 ml of 80 per cent acetone each time, until it become colourless. All the supernatants were pooled and utilized for chlorophyll determination. Absorbance was measured at 645 and 663 nm in spectrophotometer. The chlorophyll content was determined by using the following formula.

Chlorophyll 'a' (mg/g fr. wt.) = (0.0127) × (OD663) - (0.00269) × (OD645)
Chlorophyll 'b' (mg/g fr. wt.) = (0.229) × (OD645) - (0.00488) × (OD663)
Total chlorophyll (mg/g fr. wt.) = (0.0202) × (OD645) - (0.00802) × (Od663).

Statistical Analysis

Results were then subjected to a one way ANOVA and means were compared by Duncan's Multiple Range Test ($p<0.05$) (DMRT). All analyses were performed using STATISTIC version 17.0 Software.

RESULT AND DISCUSSION

Characterization of the soil and Seedling the plant material

The results are as follows: The soil was clay loam in texture with pH 7.3, total organic carbon (C), 1.51 % ; available N, 0.7 g kg-1 available phosphorous (P), 28.2 g kg-1 and available potassium (K), 45.1 g kg-1. Seeds were germinated in pots. After (40 days) germination, uniform seedlings were transplanted to pot.

Rhizobacteria and AM fungi colonization

The population of rhizobacteria and mycorrhial colonization (after 30, 90, 120 days) were mentioned in Table 1, 2, 3. The both population were increased in 30 and 90 days but decrease at 120 days. While compared to the liquid biofertilizer to solid biofertilizer produced great result, in case of combined inoculation were affect the population of both due to in short supply of nutrient. According to Constantino et al., (2008), the root coating and dipping, either single or combined inoculation did not significantly affect the population of either rhizobacteria species. The after 30 days inoculation highest number of colony forming units (Cfu's) for P. fluorescens was found in the rhizosphere of chilli plant ranged from 2.0×106 to 8.6×106 and was significantly less than that determined for A. brasilense ranged from 2.2×106 to 12.1×106 (Table - 2). Soil microorganisms influence AM fungal development and the establishment of symbiosis but no clear pattern of response has been found. Negative impacts upon the AM fungi include a reduction in spore germination and hyphal length in the extrametrical stage, decreased root colonization and a decline in the metabolic activity of the internal mycelium (Wyss et al., 1992). According to our results, the highest occurrence of T2 - AM fungi (G. fasciculatum) colonization (62.7 %) was recorded and involving single biofertilization by root coating. These results were noticed in Constantino et al., (2008), the highest incidence of mycorrhizal colonisation was observed in the treatment AMFS involving single biofertilisation by root coating.

After 90 days inoculation the populations of rhizobacteria were increased (Table - 3), the highest results were noticed in the treatments of single (T4 - P. fluorescens - 11.7×106, T6 - A. brasilense - 14.0×106) and dual inoculants (T8 - A. brasilense - 13.8×106 and T10 - P. fluorescens - 11.3×106) inoculation by root coating. Simultaneously Glomus fasciculatum colonization was increased in single (T2 – 75.1 %) and dual inoculation with P. fluorescens. Even as compared to 30 and 90 days inoculation, the populations were decreased at 120 days in both (Rhizobacteria and AM fungi). According to Sarwade et al., (2011) the high root colonizations were recorded in dual inoculation (Glomus fasciculatum + Trichiderma viride). In the present study, the combined inoculation of rhizobacteria and AMF showed in a low colonization with treatments of single and dual inoculants. These results vary from persons of Fitter and Garbaye (1994) who reported that rhizobacteria increased the capacity of AMF to colonies the roots of plants.

Effect of microbial inoculants on the growth and Chlorophyll content of chilli in pot conditions.

Reaction to Glomus fasciculatum, P. fluorescens, A. brasilense on Chilli (Var PLR -1) had a beneficial effect on the growth parameter and Chlorophyll content. In a single inoculation of rhizobacteria and AMF was not much more effective than dual inoculation Glomus fasciculatum with P. fluorescens or A. brasilense, whereas the combined inoculation with P. fluorescens, A. brasilense and Glomus fasciculatum. The growth parameter and chlorophyll content were mentioned in Fig.1 (A, B) after 30 days inoculation of biofertilizer. With regards to number of primary branches, numbers of leaves, whole plant fresh weight, dry weight, Fresh root weight, dry root weight were recorded in dual inoculation excluding plant height because the plant height was increased in Single inoculation of Glomus fasciculatum. The combination of P. fluorescens, A. brasilense and Glomus fasciculatum were produced the greatest growth parameters than the other treatments and significantly greater than control. Additionally the present study showed the good results on plant growth parameter and chlorophyll content in inoculation of biofertilizer by root coating method. Similar results were recorded in Sesamum Indicum L. by Shweta et al., (2011). The highest chlorophyll content was observed in the combined (T11, T12) treatment and this was significantly differing from single, dual treatment and control Fig 1 (B).

Several studies have reported increases in growth and development for crops such as tomato, coriander, pepper and lettuce after inoculation with Azotobacter and Azospirillum (Terry et al., 2002; Bashan et al., 2004). Sakthivel et al., (2009) reported that the effect of seed inoculation of PGPR (Pesudomonas fluorescens) and the growth, increasing the yield of tomato. Vanith et al., (2005) reported significant increase in plant height, number of leaves and number of branches, fresh weight and dry weight in Ocimum kilimandscharicum on inoculation with Glomus fasciculatum compared to nonmycorrhizal plants. Hemavathi et al., (2006) reported increase in plant height, number of branches, fresh weight and P updake in Ocimum basllicum on inoculation with Glomus fasciculatum + Pesudomonas fluorescens + Bacillus megaterium. An earlier study conducted by Raghu et al., (2005) supports these findings where the highest plant biomass (Shoot and root) was observed in Dalbergia sissoo an inoculation with Glomus

fasciculatum + Azotobacter chroococcum + Bacillus coagulans + Trichoderma harzianum. Muthuraj and Jayashella, (2005) recorded the highest shoot and root dry weight in Capsicum annum on treatment with Pseudomonas fluorescents + Glomus mosseae + Azospirillum brasilense compared to other treatments. Zaidi and Khan, (2006) found increased dry matter yield in green gram plants on treatment with triple inoculation of Glomus fasciculatum, Bradyrhizobium and Bacillus subtillis.

After 90 days inoculation the plant growth parameter viz., plant height, number of primary branches, whole plant fresh weight, dry weight and chlorophyll content were significantly increased in the combined inoculation (T12 - P. fluorescens + A. brasilense + Glomus fasciculatum) by root coating methods, while comparing to other treatments (single and dual) the liquid methods also produced good results. The number of leaves (single inoculation of T1 - Glomus fasciculatum) and root fresh and dry weight (dual-T10 - PfS+ GfS) were increased, increasing root fresh and dry weight in our study may be due to synergistic or additive effects of dual inoculation, resulting in a favorable plant AMF- microbial interaction Fig 2 (A). The chlorophyll content was highly increased in combined inoculant (T12 - PfS + AbS + GfS) when compare with single, dual and control Fig - 2 (B).

After 120 days slightly variation was occurred in the plant growth parameters and chlorophyll content Fig - 3 (A, B). Highest results were recorded in combined (T11 - PfL+ AbL+GfL , T12 - PfS+ AbS +GfS) inoculation number of primary branches, plant fresh weight and dry weight, root fresh and dry weight. Simultaneously inoculation of Glomus fasciculatum and dual inoculation of T7 - AbL+GfL, T8 - AbS+GfS were showed good results for number of leaves, plant height, chlorophyll content, similarly chlorophyll 'a' content was observed in the combined inoculation by root coating methods. These results showed significantly greater than control.

Effect of microbial inoculants on the yield of chilli plant (PLR-1)

The application of bifertilizers had a positive effect on the yield of chilli fruits with compared to control. The maximum chilli yields, fruit length, girth, number of seeds, fruit weight were highly recorded in the combined inoculation (T12 - PfS+ AbS +GfS) when compared with single and dual inoculant Table - 5. Our results were differ from Constantino et al., (2008) who has reported treatments that used combinations of biofertilizers resulted in significantly lower yields than those that were applied as single. Triple inoculation of AMF + Pseudomonas fluorescens + Rhizoctonia solani in plants recorded higher yield as compared to AMF + Rhizoctonia solani (Neeraj and Singh, 2009). The effect of AMF on Capsicum annuum L. plants has been studied, in some detail with records of positive effects on growth, development, yield and some parameters of fruit quality such as size, colour and pigment content (Mena-Violante et al., 2006). Almas Zaidi and Mohammad Saghir Khan (2006) revealed that the increased in chlorophyll content following the application of 3 organisms together, i.e. Bradyrhizobium + G. fasciculatum + B. subtilis and A. awamori + B. subtilis + G. fasciculatum ranged between 52% and 86%, respectively, in comparison with the control.

CONCLUSION

Now a days the hazardous effects of heavy doses of chemicals affect the soil fertility, hence the beneficial microbes are influenced by this chemicals. In conclusion, the results of the present study suggest that the combined inoculation of AMF and rhizobacteria improved the plant growth, consequently signifying a synergistic effect on the chilli and that it can supply the substitute to chemical fertilizers. The results in the present experiment showed that greatest values were recorded in root coating method, its significantly greater than root dipping method. Moreover, in this method suitable for applying chilli crops to get the good yield in Agricultures.

Table 1: Details of experimental treatments

S.No	Treatments	Description	Support	Application Method
1.	T_1 - Gf_L	*Glomus fasciculatum*	Liquid	Root dipping
2.	T_2 - Gf_S	*Glomus fasciculatum*	Solid	Root coating
3.	T_3 - Pf_L	*Pseudomonas fluorescens*	Liquid	Root dipping
4.	T_4 - Pf_S	*Pseudomonas fluorescens*	Solid	Root coating
5.	T_5 - Ab_L	*Azospirillum brasilense*	Liquid	Root dipping
6.	T_6 - Ab_S	*Azospirillum brasilense*	Solid	Root coating
7.	T_7 - Ab_{L+} Gf_L	*A. brasilense*+ *G. fasciculatum*	Liquid	Root dipping
8.	T_8 - Ab_{S+} Gf_S	*A. brasilense*+ *G. fasciculatum*	Solid	Root coating
9.	T_9 - Pf_L+ Gf_L	*P. fluorescens*+*G. fasciculatum*	Liquid	Root dipping
10.	T_{10} - Pf_{S+} Gf_S	*P. fluorescens*+*G. fasciculatum*	Solid	Root coating
11.	T_{11} - Pf_L + Ab_L +Gf_L	*P. fluorescens*+ *A. brasilense* +*G. fasciculatum*	Liquid	Root dipping
12.	T_{12} - Pf_S + Ab_S +Gf_S	*P. fluorescens*+ *A. brasilense* +*G. fasciculatum*	Solid	Root coating
13.	T_{13} - Control	-	-	-

Table 2: Population dynamics of Rhizobacteria and *G. fasciculatum* colonisation in chilli (PLR-1) 30 days after inoculation in the different treatments under pot conditions.

S.No	Treatments	Mycorrhizal colonization (%)	Rizobacterial population (cfu g soil^{-1})	
		G. fasciculatum	*P. fluorescens*	*A. brasilense*
1.	T_1 - Gf_L	48.2 ^{c}	-	-
2.	T_2 - Gf_S	62.7 ^{e}	-	-
3.	T_3 - Pf_L	-	$7.8\times10^{6\ c}$	-
4.	T_4 - Pf_S	-	$8.6\times10^{6\ d}$	-
5.	T_5 - Ab_L	-	-	$10.5\times10^{6\ cd}$
6.	T_6 - Ab_S	-	-	$11.2\times10^{6\ d}$
7.	T_7 - Ab_{L+} Gf_L	33.6 ^{b}	-	$11.3\times10^{6\ d}$
8.	T_8 - Ab_{S+} Gf_S	29.9 ^{bc}	-	$12.1\times10^{6\ f}$
9.	T_9 - Pf_L+ Gf_L	39.2 ^{bc}	$7.5\times10^{6\ c}$	-
10.	T_{10} - Pf_{S+} Gf_S	44.5 ^{d}	$7.9\times10^{6\ cd}$	-
11.	T_{11} - Pf_L + Ab_L +Gf_L	29.6 ^{b}	$6.1\times10^{6\ bc}$	$9.6\times10^{6\ c}$
12.	T_{12} - Pf_S + Ab_S +Gf_S	35.7 ^{c}	$5.9\times10^{6\ b}$	$7.9\times10^{6\ b}$
13.	T_{13} - Control	9.1 ^{a}	$2.0\times10^{6\ a}$	$2.2\times10^{6\ a}$

Means values followed by the same letter are not significantly different based on Duncan's multiple range test ($p<0.05$), a>b>c. cfu colony forming units. Treatment codes are given in Table 1.

Table 3: Population dynamics of Rhizobacteria and *G. fasciculatum* colonisation in chilli (PLR-1) 90 days after inoculation in the different treatments under pot conditions.

S.No.	Treatments	Mycorrhizal colonization (%)	Rizobacterial population (cfu g soil^{-1})	
		G. fasciculatum	*P. fluorescens*	*A. brasilense*
1.	T_1 - Gf_L	65.2 ^{d}	-	-
2.	T_2 - Gf_S	75.1 ^{f}	-	-
3.	T_3 - Pf_L	-	$10.2\times10^{6\ b}$	-
4.	T_4 - Pf_S	-	$11.7\times10^{6\ c}$	-
5.	T_5 - Ab_L	-	-	$12.9\times10^{6\ cd}$
6.	T_6 - Ab_S	-	-	$14.0\times10^{6\ f}$
7.	T_7 - Ab_{L+} Gf_L	39.2 ^{a}	-	$13.5\times10^{6\ d}$
8.	T_8 - Ab_{S+} Gf_S	46.4 ^{b}	-	$13.8\times10^{6\ df}$
9.	T_9 - Pf_L+ Gf_L	55.7 ^{c}	$10.0\times10^{6\ b}$	-
10.	T_{10} - Pf_{S+} Gf_S	58.0 ^{c}	$11.3\times10^{6\ bc}$	-
11.	T_{11} - Pf_L + Ab_L +Gf_L	47.1 ^{b}	$7.5\times10^{6\ a}$	$10.7\times10^{6\ ab}$
12.	T_{12} - Pf_S + Ab_S +Gf_S	47.6 ^{b}	$7.9\times10^{6\ a}$	$11.2\times10^{6\ b}$
13.	T_{13} - Control	10.3 ^{a}	$3.55\times10^{6\ a}$	$2.99\times10^{6\ a}$

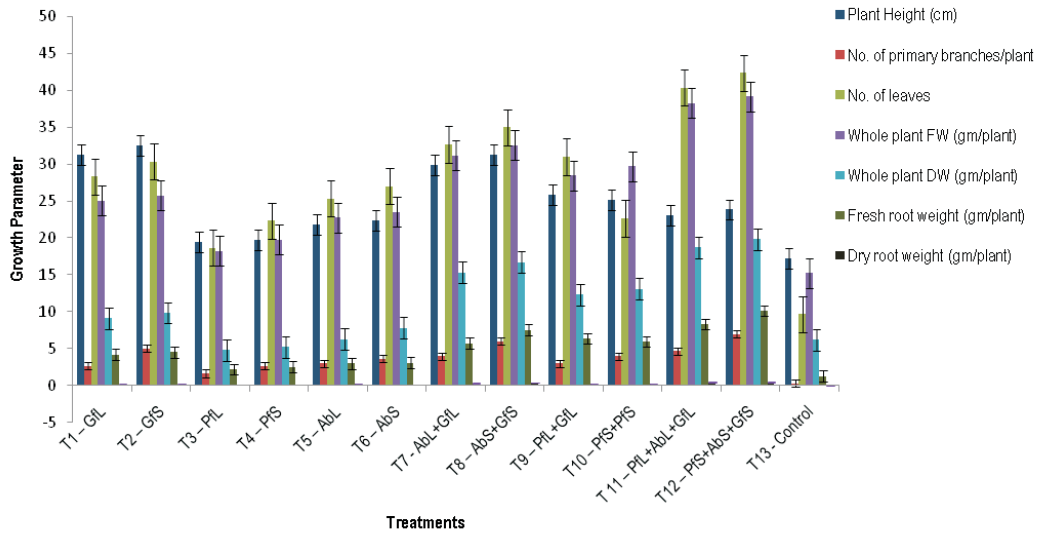
Means values followed by the same letter are not significantly different based on Duncan's multiple range test ($p<0.05$), a>b>c. cfu colony forming units. Treatment codes are given in Table 1.

Table 4: Population of Rhizobacteria and *G. fasciculatum* colonisation in chilli (PLR-1) 120 days after inoculation in the different treatments under pot conditions.

S.No	Treatments	Mycorrhizal colonization (%)	Rizobacterial population (cfu g soil^{-1})	
		G. fasciculatum	*P. fluorescens*	*A. brasilense*
1.	T_1 - Gf_L	37.3 ^{c}	-	-
2.	T_2 - Gf_S	58.4 ^{d}	-	-
3.	T_3 - Pf_L	-	$4.3\times10^{6\ ab}$	-
4.	T_4 - Pf_S	-	$5.1\times10^{6\ c}$	-
5.	T_5 - Ab_L	-	-	$8.6\times10^{6\ c}$
6.	T_6 - Ab_S	-	-	$8.9\times10^{6\ d}$
7.	T_7 - Ab_{L+} Gf_L	29.2 ^{a}	-	$9.2\times10^{6\ d}$
8.	T_8 - Ab_{S+} Gf_S	24.1 ^{a}	-	$9.7\times10^{6\ df}$
9.	T_9 - Pf_L+ Gf_L	34.3 ^{c}	$5.6\times10^{6\ c}$	-
10.	T_{10} - Pf_{S+} Gf_S	39.0 ^{c}	$6.2\times10^{6\ cd}$	-
11.	T_{11} - Pf_L + Ab_L +Gf_L	25.6 ^{a}	$4.1\times10^{6\ ab}$	$7.6\times10^{6\ b}$
12.	T_{12} - Pf_S + Ab_S +Gf_S	30.4 ^{ab}	$3.4\times10^{6\ a}$	$6.2\times10^{6\ a}$
13.	T_{13} - Control	11.5 ^{a}	$0.45\times10^{6\ a}$	$1.00\times10^{6\ a}$

Means values followed by the same letter are not significantly different based on Duncan's multiple range test ($p<0.05$), a>b>c. cfu colony forming units. Treatment codes are given in Table 1.

(A)



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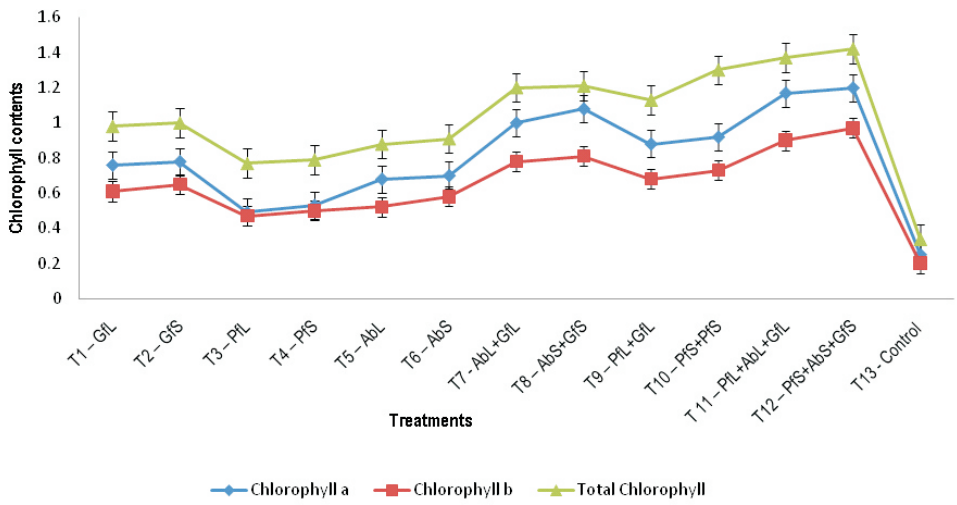
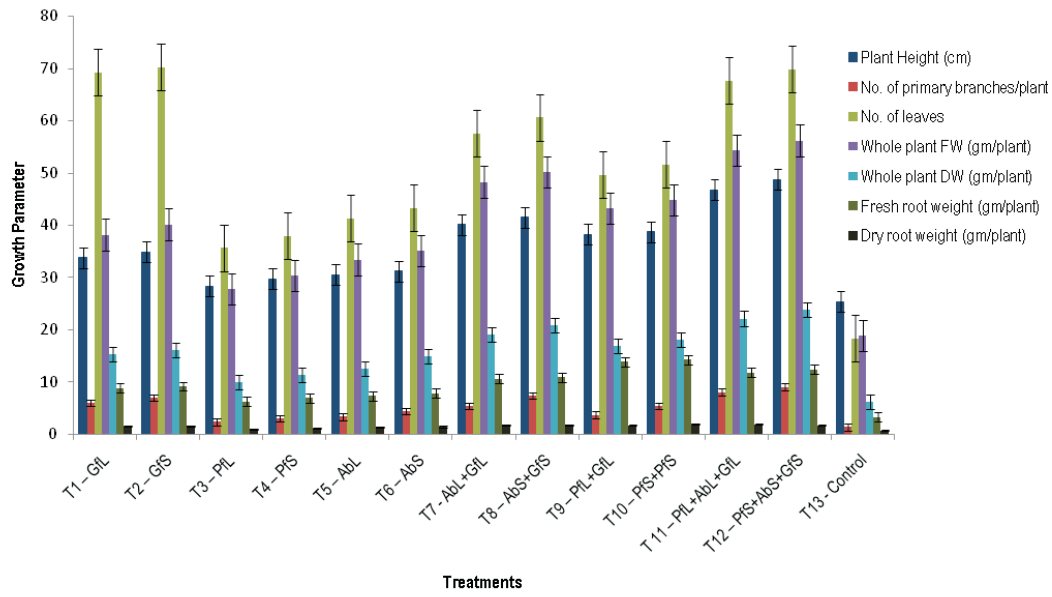


Fig 1 (A, B): Showing Effect of the different treatments on growth parameter and chlorophyll content in chilli (PLR-1) plant at 30 days post inoculation in pot conditions. Bars represent standard errors of the means (n=3).

(A)



(B)

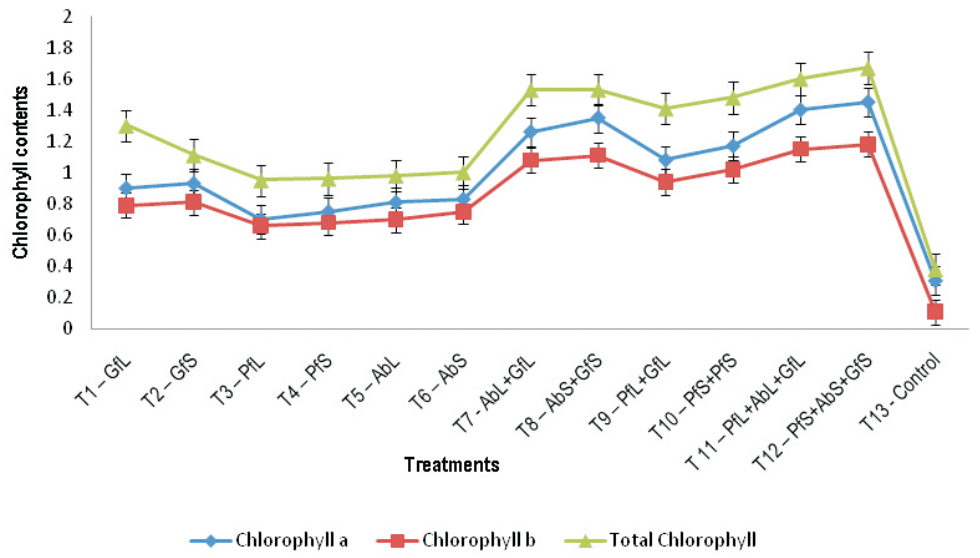
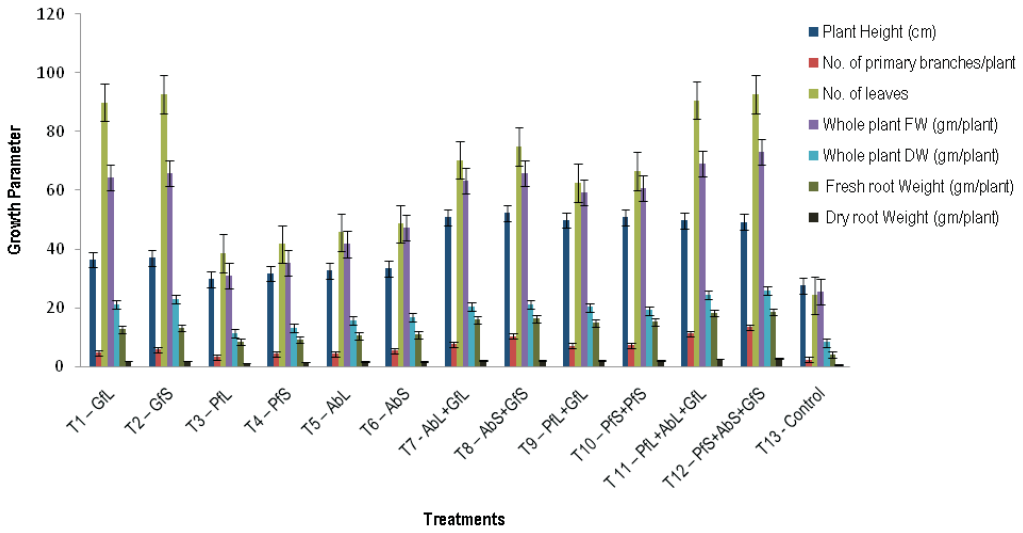


Fig 2 (A, B): Showing Effect of the different treatments on growth parameter and chlorophyll content in chilli (PLR-1) plant at 90 days post inoculation in pot conditions. Bars represent standard errors of the means (n=3).

(A)



(B)

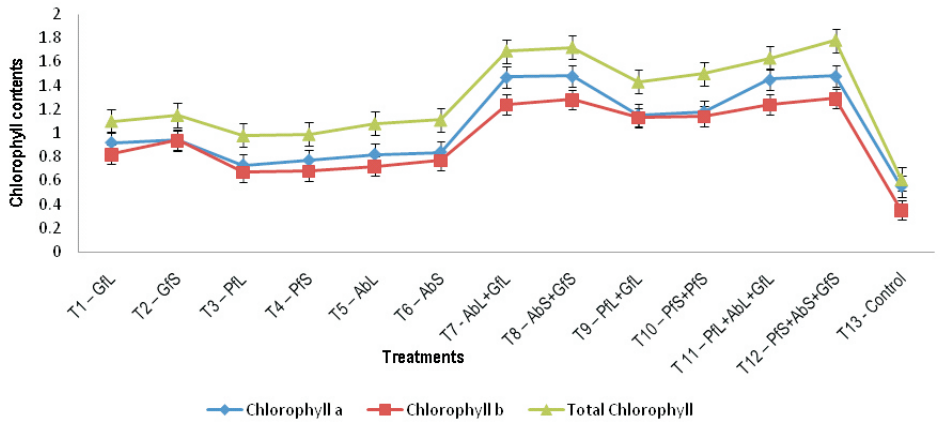


Fig 3 (A, B): Showing Effect of the different treatments on growth parameter and chlorophyll content in chilli (PLR-1) plant at 120 days post inoculation in pot conditions. Bars represent standard errors of the means (n=3).

Table 8: Effect of the microbial inoculants on the yield parameters of chilli (PLR-1) under pot conditions.

S.No.	Treatments	Total no. of fruits/plants	Fruit length (cm)	Fruit girth (cm)	Fruit weight (gm)	No. of seeds/ fruit
1.	T_1 - Gf_L	117.66^{c}	5.39^{c}	4.70^{c}	2.60^{b}	38.00^{c}
2.	T_2 - Gf_S	122.33^{d}	5.45^{c}	4.75^{c}	2.96^{c}	41.00^{d}
3.	T_3 - Pf_L	104.33^{b}	4.86^{b}	4.55^{b}	2.40^{b}	26.33^{b}
4.	T_4 - Pf_S	106.00^{b}	4.91^{b}	4.57^{b}	2.42^{b}	29.33^{b}
5.	T_5 - Ab_L	112.66^{c}	5.07^{cd}	4.70^{b}	2.45^{b}	32.33^{c}
6.	T_6 - Ab_S	114.00^{c}	5.12^{c}	4.92^{bc}	2.48^{b}	33.66^{c}
7.	T_7 - Ab_{L+} Gf_L	138.00^{e}	6.08^{df}	5.02^{df}	3.82^{c}	48.66^{d}
8.	T_8 - Ab_{S+} Gf_S	139.33^{e}	6.12^{f}	5.08^{df}	3.96^{cd}	52.00^{e}
9.	T_9 - Pf_L + Gf_L	129.66^{d}	5.87^{c}	4.91^{d}	3.68^{c}	44.66^{d}
10.	T_{10} - Pf_{S+} Gf_S	134.33^{e}	5.92^{d}	4.98^{d}	3.71^{c}	46.33^{d}
11.	T_{11} - Pf_L + Ab_L +Gf_L	150.33^{f}	6.67^{f}	5.28^{f}	4.31^{d}	62.00^{f}
12.	T_{12} - Pf_S + Ab_S +Gf_S	158.33^{f}	6.72^{f}	5.36^{f}	4.37^{d}	68.33^{f}
13.	T_{13} - Control	71.00^{a}	2.81^{a}	1.97^{a}	1.87^{a}	14.33a

Means values followed by the same letter are not significantly different based on Duncan's multiple range test ($p<0.05$), a>b>c. Treatment codes are given in Table 1.

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