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Effect of Arbuscular Mycorrhizal Symbiosis and plant growth promoting microbes in tea plantation of North East India

R. PHUKAN, S. R. SARMAH, P. DUTTA, I. PHUKAN, R. BEGUM, A. J. TANTI, S. DEBNATH AND B. K. BARTHAKUR*

Tocklai experimental station, Tea Research Association, Jorhat 785008, Assam, India

Per cent root colonization of Arbuscular Mycorrhizal (AM) fungi in tea (*Camellia sinensis* (L) O. Kuntze) is well documented. Recently a survey was conducted in tea growing areas of North-East India to assess the occurrence of AM fungi in tea plantation. Being an obligate symbiont, infection of AM fungi in dominant weed flora was also considered. Per cent association of AM infection in feeder roots of tea and dominant weed species of tea plantation ranged within 25-60 % and 40-90 % respectively. The experiments conducted showed encouraging response of AM fungi in young tea in terms of leaf harvest irrespective of addition of P_2O_5. Application of phosphate can be reduced or minimized by inoculating AM fungi in tea plantation. Nutrient parameters analysed showed suitability of the samples for microbial as well as AM population. Moreover, the analysis of rhizosphere soil revealed dominant presence of fungi and bacteria than other groups of specific organisms i.e. *Azospirillum, Azotobacter, Rhizobium,* Actinomycetes, PSB etc.

The experiment conducted in the green house with the native PGPR microbes both in case of tea and other test plants had proved the benefits in terms of biomass increase.

Key words : Arbuscular Mycorrhiza, symbiosis, tea, plant growth promoting microbes

INTRODUCTION

The Arbuscular Mycorrhizal (AM) fungi are known to enhance plant growth and phosphate uptake by the plant, particularly in P-deficient soil (Smith *et al*, 1988). Rhizosphere microbes and AM fungi are the most important constituents of tea ecosystem. Now a day it is well known that most of these microbes are beneficial in nature. One group of microorganisms, which are beneficial to crops, is bacteria that colonize roots or rhizosphere soil. These bacteria are referred to a group of plant growth promoting rhizobacteria (PGPR) (Kloepper, 1993). Tunstall (1925, 1930) has first reported the association of AM fungi in tea. In the recent years various workers (Barthakur *et al.,* 1992, 1994 ; Hazarika *et al.,* 2001 ; Dutta *et al.,* 2004 ; Chakraborty *et al.,* 2004 ; Phukan *et al.,* 2005) have studied the possible beneficial aspects of AM fungi and rhizosphere microflora in tea plantations in respect to nutrient uptake, disease protection, PGP activity etc. AM fungi are specially known for their phosphate uptake by the roots (Gerdeman, 1968 ; Schultz *et al.,* 1981; Papilane and Bandrs, 1985). Trials are conducted both *in vitro* and *in vivo* to assess the beneficial effect of AM fungi and PGP microbes. AM and rhizosphere microorganisms can mutually influence each other and this can result in synergistic interaction.

In the present investigation an attempt has been made to observe the occurrence of AM fungi in North East India (Barthakur *et al.,* 2005) and to evaluate the effect of certain beneficial PGP microbes in tea plantation as an integrated plant nutrient management. Tea rhizosphere harbours beneficial microbes, which in turn influence the growth and vigour of the plant. However, the establishment of inoculated plant growth promoting rhizosphere microbes (PGP) in the developing root system is a pre-condition for beneficial plant growth promoting effects (Wolfgang and Hoflich, 1995).

**Corresponding author.*

MATERIALS AND METHODS

Screening of AM association

To cover the entire North Eastern India survey was conducted in four different geographical regions i.e. Cachar, North Bank and South Bank of Brahmaputra river and Upper Assam. Different commercial tea gardens were selected from each belt. Three different age group of tea plants were considered i.e. 0-5 years, 6-15 years and above 15 years from where three to five replicates of tea feeder roots and rhizosphere soil samples were collected randomly.

Subsequently feeder roots of dominant weed flora of each representative gardens (5 gardens in each belt) were also collected for screening of their AM association. The per cent mycorrhizal colonization of the root samples was determined according to the techniques of Philips and Haymanns (1970) and Nicholson's (1960).

Field experiment on AM symbiosis

A randomized field trial was laid out where previously (AM fungi) inoculated tea cuttings with *Glomus fasciculatum* in the nursery were transplanted to the field with different doses of single super phosphate (SSP) and rock phosphate combinations to see the effect of AM fungi in relation to phosphate uptake. The per cent colonization of the AM fungi and the effect on the crop yield was recorded simultaneously as per standard methodology.

From each treatment the succulant leaf samples were collected for determination of phosphate content by Tri-acid digestion method (Jackson, 1958).

Analysis and estimation of rhizosphere microbes

Isolation and estimation of tea rhizosphere microbes, viz., diazotrophs and phosphate solubilizers from soil samples were done by Serial Dilution plate method, (Waksman, 1922). Triplicate plates were maintained for each treatment and numbers of cfu per g of soil were recorded after 48h and 15 days for bacteria and others respectively. Recommended media namely Nutrient agar/soil extract, Rose Bengal/Czapek-dox, Yeast extract mannitol agar, Kenknight, Okon's, Winogrdsky's/ Ashby's and Pikovskaya's were used for isolation of different groups of microbes.

Effect of PGPR microbes on vegetative growth of test plants

To see the effect of the isolated PGPR microbes, on test plant maize was taken into consideration. Isolated microbes as described above were subjected to study their effect of growth promoting factors. Each isolate was cultured in the potato dextrose broth for 10 days at 25±2°C in Erlenmeyer flasks. The seeds of the test plants were surface sterilized by 0.01% $HgCl_2$ followed by several changes by sterilized distilled water to remove the trace of $HgCl_2$. The treated seeds were soaked with the specific culture filtrates for overnight. Healthy seeds were then allowed to germinate in the Petriplates providing culture filtrates to maintain moisture content for 48 hr. Germinated seeds were planted in earthen pots by inoculating 1 ml of the PGPR stock filtrates/pot. Second round of treatments were imposed at 30 days interval having 5 replicates in each treatments including one control. The soil taken for the trials were air-dried, ground, sieved and sterilized twice at 121°C for 1 hr. Then the earthen pots were filled with 100 g of soil and sand at 1 : 1 proportion and germinated seeds are planted out. Plants were harvested at the time to flowering and total dry biomass was recorded.

Effect of PGPR microbes on tea cuttings

After screening the effect of PGPR microbes on test plants, these strains were subjected for trial on TV 18 cuttings in the green house. The plants were allowed to grow freely for one year in the earthen pots. Isolates of PGPR microbes mainly *Azospirillum, Azotobacter, Rhizobium,* Phosphate solubilizers and *Trichoderma viride* were inoculated to the potted plants @ 10 ml/pot. A second dose was also applied after 45 days of first application. The number of leaves, height and girth of stem were recorded.

RESULTS AND DISCUSSION

Screening of AM association

The analysis of the association of AM fungi in tea feeder roots are presented in Tables 1-4. The data showed the presence of moderate to high mycelial association irrespective of age group in all the four belts. However, the presence of arbuscule "the functional unit" of AM fungi was found to decrease in respect of to the increase of age of the plants. From this analysis, the tea root system showed the viable presence of AM fungi, which helped in better nutrient uptake of the plant.

Table 1 : Per cent association of AM fungi in different tea plants under different age group (Site : Cachar)

	Age group of tea roots (Year)								
	0-5			6-15			Above 15		
Tea Estates	M	V	A	M	V	A	M	V	A
Rosekandy	36	4	0	32	6	0	44	0	0
Narsingpore	48	8	0	40	2	0	36	8	0
Bundookmara	48	16	4	46	12	2	40	0	0
South Cachar	60	20	12	36	6	0	32	0	0
Chandighat	52	4	12	28	2	2	40	12	0

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 2 : Per cent association of AM fungi in different tea plants under different age group (Site : North bank)

	Age group of tea roots (Year)								
	0-5			6-15			Above 15		
Tea Estates	M	V	A	M	V	A	M	V	A
Durrung	24	0	4	40	8	0	36	12	0
Kolony	28	8	8	36	8	0	48	8	0
Harchurah	28	0	0	40	4	8	40	8	0
Addabarie	16	0	0	28	0	0	36	12	0
Phulbari	28	4	8	24	8	4	44	8	4

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 3 : Per cent association of AM fungi in different tea plants under different age group (Site : South Bank)

	Age group of tea roots (Year)								
	0-5			6-15			Above 15		
Tea Estates	M	V	A	M	V	A	M	V	A
Kotalgoorie	24	8	16	16	4	0	20	0	0
Hunwal	48	8	12	60	0	0	52	4	0
Teok	12	4	4	20	0	0	12	0	0
Dolaguri	32	12	0	44	4	0	28	8	0
Kakodonga	36	4	4	20	4	0	20	0	0

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 4 : Per cent association of AM fungi in different tea plants under different age group (Site : Upper Assam)

	Age group of tea roots (Year)								
	0-5			6-15			Above 15		
Tea Estates	M	V	A	M	V	A	M	V	A
Khowang	28	8	16	32	4	16	36	4	12
Margherita	32	8	8	36	8	8	16	12	0
Nahorhabi	24	0	8	32	4	12	28	16	4
Dikom	56	44	24	16	0	0	20	0	4
Pengaree	32	4	0	28	4	0	28	0	0

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 5 : Per cent association of VAM fungi in different weeds species of tea plantation (Site : Cachar)

Weed species	Tea Estates														
	Rosekandy			Chandighat			Narsingpore			Bundookmara			S.Cachar		
	M	V	A	M	V	A	M	V	A	M	V	A	M	V	A
Ageratum conyzoides	84	40	20	84	44	20	80	52	12	96	44	52	96	56	60
Borreria hispida	72	8	44	68	32	40	80	0	48	88	24	48	76	0	52
Mimosa pudica	84	24	0	48	8	4	96	44	32	-	-	-	-	-	-
Mimosa invisa	48	12	0	-	-	-	-	-	-	92	32	4	80	56	28
Mikania micrantha	-	-	-	-	-	-	96	68	0	76	24	8	-	-	-
Spermacoea ocymoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jussiaea suffruticosa	-	-	-	76	36	36	-	-	-	-	-	-	80	0	73
Peperomia pellucida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoparia dulcis	64	40	28	85	50	42	88	0	50	80	36	16	72	0	54
Solanum nigrum	76	28	8	-	-	-	-	-	-	40	0	16	-	-	-
Leucas linifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 6 : Per cent association of VAM fungi in different weeds species of tea plantation (Site : North Bank)

Weed species	Tea Estates														
	Durrung			Kolony			Harchurah			Addabarie			Phulbarie		
	M	V	A	M	V	A	M	V	A	M	V	A	M	V	A
Ageratum conyzoides	72	20	36	80	16	48	-	-	-	-	-	-	34	16	4
Borreria hispida	72	24	40	72	16	40	-	-	-	68	8	36	22	12	4
Mimosa pudica	76	40	16	-	-	-	-	-	-	-	-	-	-	-	-
Mimosa invisa	64	24	12	-	-	-	-	-	-	-	-	-	-	-	-
Mikania micrantha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spermacoea ocymoides	64	4	52	60	0	48	52	12	24	60	16	24	30	12	6
Jussiaea suffruticosa	60	0	16	-	-	-	-	-	-	-	-	-	-	-	-
Peperomia pellucida	84	16	8	-	-	-	-	-	-	-	-	-	-	-	-
Scoparia dulcis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leucas linifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 7 : Per cent association of VAM fungi in different weeds species of tea plantation (Site : Upper Assam)

Weed species	Tea Estates														
	Khowang			Margherita			Naharhabi			Dikom			Pengaree		
	M	V	A	M	V	A	M	V	A	M	V	A	M	V	A
Ageratum conyzoides	76	40	28	-	-	-	36	0	12	56	8	4	68	28	24
Borreria hispida	68	48	36	68	12	44	-	-	-	52	12	28	-	-	-
Mimosa pudica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mimosa invisa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mikania micrantha	-	-	-	46	26	13	-	-	-	-	-	-	-	-	-
Spermacoea ocymoides	32	0	4	-	-	-	72	48	40	56	20	20	-	-	-
Jussiaea suffruticosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peperomia pellucida	88	16	4	-	-	-	68	24	4	-	-	-	-	-	-
Scoparia dulcis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leucas linifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M = Mycelia ; V = Vesicles ; A = Arbuscules.

Table 8 : Per cent association of VAM fungi in different weeds species of tea plantation (Site : South Bank)

Weed species	Tea Estates														
	Kotalgoorie			Hunwal			Teok			Dolaguri			Kakodonga		
	M	V	A	M	V	A	M	V	A	M	V	A	M	V	A
Ageratum conyzoides	60	8	8	72	32	24	68	56	36	68	20	24	52	44	16
Borreria hispida	60	8	32	64	36	28	60	16	36	-	-	-	56	4	40
Mimosa pudica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mimosa invisa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mikania micrantha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spermacoea ocymoides	-	-	-	53	0	40	-	-	-	-	-	-	-	-	-
Jussiaea suffruticosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peperomia pellucida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoparia dulcis	-	-	-	-	-	-	44	28	8	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	56	12	31
Leucas linifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M = Mycelia ; V = Vesicles ; A = Arbuscules.

The results presented in Tables 5-8 showed moderate to high AM association in most of the weed species. The association of mycelium ranged upto 96 % whereas the presence of arbuscules and vesicles are less in all the analysed weed species. The association of AM fungi was comparatively more in Cachar gardens than others.

Field experiment of AM symbiosis

The results presented in Table 9 showed the per cent colonization of AM fungi in different doses of SSP and rock phosphate treatments which was more in case of AM fungi inoculated ones. The association was maximum in the inoculated series in presence of rock phosphate ; where release of P_2O_5 was naturally slow. However, the presence of arbuscules the functional unit of AM fungi was very low in all the treatments during the assessment period. Natural association of AM fungi was also observed in case of non-inoculated plants, which indicated the host perference of the AM fungi in the roots of tea plants.

Table 9 : Per colonization of AM fungi

Treatments	% M colonization after (months)		% V colonization after (months)		% A colonization after (months)	
	12	24	12	24	12	24
SSP 30g + RP30g/ pit & M plant	44	52	6	12	0	0
SSP 30g + RP30g/ pit & NM plant	28	20	2	5	0	0
SSP 71g/pit & NM plant	68	76	2	4	2	0
SSP71g/pit & NM plant	36	40	4	4	0	0
RP 52 g/pit & NM plant	80	78	16	12	6	2
RP52g/pit & NM plant	38	35	2	4	4	0
No phosphate & M plant	48	53	10	8	0	0
No phosphate & NM plant	22	27	2	2	0	0

M = Mycelium; V = Vesicles; A = Arbuscules; SSP = Single Super phosphate; RP = Rock phosphate; M plant = Mycorrhizal plant; NM plant = Non Mycorrhizal plant

It was evident from the Table 10 that the beneficial effect of AM fungi in terms of the green leaf harvest in tea plants which reflected in better productivity upto 4th year even in absence of P_2O_5. AM fungi can be utilized in the tea plantation as a tool for increasing productivity.

Table 10 : Effect of Mycorrhizal association on yield

Treatments	Green leaf yield * in Kg			
	1st year	2nd year	3rd year	4th year
SSP30g+RP30g/pit & M plant	21.540	38.910	41.775	43.440
SSP30g+RP30g/pit & NM plant	17.697	34.015	38.345	40.880
SSP 71g/pit & M plant	22.245	40.290	32.775	41.070
SSP71g/pit & NM plant	15.328	32.190	37.025	40.860
RP52g/pit & M plant	21.750	40.210	45.155	45.200
RP52g/pit & NM plant	19.477	38.250	42.810	41.890
No phosphate & M plant	23.977	41.155	39.805	43.700
No phosphate & NM plant	19.845	33.860	38.770	40.455

M = Mycelium; V = Vesicles; A = Arbuscules; SSP = Single Super phosphate; RP = Rock phosphate; M plant = Mycorrhizal plant; NM plant = Non Mycorrhizal plant

Uptake of P_2O_5 by the tender shoots was also found to be more in case of AM inoculated plants as shown in the Table 11.

Table 11 : Uptake of P_2O_5 by tender tea shoots

Treatments	% P_2O_5	
	after 12 months	after 24 months
SSP30g+RP30g/pit & M plant	0.92	0.62
SSP30g+RP30g/pit & NM plant	0.82	0.57
SSP 71g/pit & M plant	0.93	0.71
SSP71g/pit & NM plant	0.94	0.48
RP52g/pit & M plant	0.97	0.47
RP52g/pit & NM plant	0.95	0.46
No phosphate & M plant	0.95	0.63
No phosphate & NM plant	0.92	0.43

M = Mycelium; V = Vesicles; A = Arbuscules; SSP = Single Super phosphate; RP = Rock phosphate; M plant = Mycorrhizal plant; NM plant = Non Mycorrhizal plant

Analysis and estimation of rhizosphere microbes

The results presented in Table 12-15 showed the microbial load of the soil samples in their specific growth medium. In all the gardens of Cachar, North Bank, South Bank and Upper Assam total count of fungal and bacterial population are recorded more than other specific groups of microbes i.e. Actinomycetes, *Azospirillum, Azotobacter,* PSB, etc.

Table 12 : Microbial analysis of rhizosphere microflora of different tea Estate of Cachar

Tea Estate	Bacteria cfu/g soil	Fungi cfu/g soil	Actino-mycetes cfu/g soil	Azospi-rillum cfu/g soil	PSB cfu/g soil	Azoto-bacter cfu/g soil
Rosekandy	23×10^5	6×10^4	4×10^5	3×10^5	ND	ND
Narsingpore	26×10^5	12×10^4	6×10^5	3×10^5	2×10^5	ND
Bundookmara	75×10^5	10×10^4	4×10^5	4×10^5	5×10^5	ND
S. Cachar	29×10^5	14×10^4	4×10^5	1×10^5	6×10^5	ND
Chandighat	29×10^5	11×10^4	2×10^5	3×10^5	ND	ND

ND = Not detected.

Table 13 : Microbial Analysis of rhizosphere microflora of different Tea Estates of North Bank

Tea Estate	Bacteria cfu/g soil	Fungi cfu/g soil	Actino-mycetes cfu/g soil	Rhizo-bium cfu/g soil	Azospi-rillum cfu/g soil	PSB cfu/g soil	Azoto-bacter cfu/g soil
Durrung	27×10^5	7×10^4	5×10^5	ND	ND	ND	ND
Kolony	20×10^5	25×10^4	4×10^5	5×10^5	1×10^5	ND	4×10^5
Harchurah	17×10^5	4×10^4	3×10^5	7×10^5	2×10^5	ND	ND
Addabarie	24×10^5	4×10^4	1×10^5	1×10^5	3×10^5	1×10^5	ND
Phulbari	6×10^5	10×10^4	ND	ND	2×10^5	1×10^5	ND

Table 14 : Microbial Analysis of rhizosphere microflora of different Tea Estates of South Bank

Tea Estate	Bacteria cfu/g soil	Fungi cfu/g soil	Actino-mycetes cfu/g soil	Rhizo-bium cfu/g soil	Azospi-rillum cfu/g soil	PSB cfu/g soil	Azoto-bacter cfu/g soil
Kotalgoorie	29×10^5	8×10^4	8×10^5	2×10^5	ND	ND	ND
Hunwal	18×10^5	11×10^4	9×10^5	2×10^5	1×10^5	1×10^5	1×10^5
Teok	12×10^5	2×10^4	3×10^5	1×10^5	1×10^5	2×10^5	ND
Kakodonga	19×10^5	11×10^4	1×10^5	1×10^5	1×10^5	1×10^5	ND
Dolaguri	24×10^5	5×10^4	3×10^5	95×10^5	3×10^5	ND	ND

Table 15 : Microbial Analysis of rhizosphere microflora of different Tea Estates of Upper Assam

Tea Estate	Bacteria cfu/g soil	Fungi cfu/g soil	Actino-mycetes cfu/g soil	Rhizo-bium cfu/g soil	Azospi-rillum cfu/g soil	PSB cfu/g soil	Azoto-bacter cfu/g soil
Dikom	24×10^5	7×10^4	4×10^5	1×10^5	ND	ND	ND
Nahorhabi	66×10^5	11×10^4	2×10^5	2×10^5	2×10^5	1×10^5	ND
Khowang	41×10^5	6×10^4	2×10^5	2×10^5	2×10^5	1×10^5	1×10^5
Margherita	39×10^5	9×10^4	3×10^5	2×10^5	3×10^5	1×10^5	ND
Pengaree	30×10^5	10×10^4	ND	3×10^5	ND	3×10^5	1×10^5

ND = Not detected.

The rhizosphere soil samples collected from the gardens showed its suitability in terms physico-chemical properties for the growth of the tea plant and rhizosphere microbes (Table 16).

Table 16 : PH and nutrient status of soil samples collected from different regions

Tea regions	PH (water extract)	% OC dry wt. soil.	Average nutrients (PPM)		
			N	P	K
Cachar	4.59	1.60	122.8	78.29	203.8
North Bank	4.79	1.08	177.46	42.10	182.6
South Bank	4.41	1.11	98.81	41.22	136.6
Upper Assam	4.51	1.51	110.00	77.42	188.5

Effect of PGPR microbes on the vegetative growth of test plants

The results presented in the Table 17 below showed the beneficial effects of the PGPR microbe in terms of biomass. It was seen that the % weight gain was maximum upto 97.20 and 94.04 when plants were treated with MMPDS/01 and MMBC/04 respectively. Next to these were the MMFUN/02, MMFUN/01. MMAZM/10 and MMRZM/04 where more than 80 % increase of biomass was achieved.

Table 17 : Effect of certain PGP microbes on growth and biomass of Maize plants

Isolates of PGP	Mean dry weight in g (5 replicates)	Wt. % gain over control
MMPDS/O1	3.67	97.20
MMBC/O1	2.84	52.68
MMBC/O3	3.28	76.34
MMBC/O4	3.61	94.08
MMFUN/O1	3.50	8.17
MMFUN/O2	3.53	89.78
MMFUN/O3	3.29	76.88
MMAZM/10	3.38	81.72
MMAZM/O4	3.38	81.72
MMAZR/O8	3.28	76.34
MMPSB/O7	2.15	15.59
MMPSB/10	3.17	70.32
CONTROL	1.86	-

Table 18 : Effect of certain PGP microbes on growth of young tea plants

Treatments	% Increase over control		
	No. of leaves	Girth	Height
MMPDS/O1	21.2	25.0	39.9
MMBC/O1	60.6	37.5	96.4
MMBC/O3	51.4	50.0	29.2
MMBC/O4	54.5	37.5	69.0
MMFUN/O1	87.9	75.0	42.9
MMFUN/O2	63.9	37.5	25.6
MMFUN/O3	69.7	25.0	89.3
MMAZM/10	97.0	87.5	49.4
MMAZM/O4	97.0	25.0	45.8
MMAZR/O8	36.4	50.0	66.7
MMPSB/O7	18.2	37.5	51.2
MMPSB/10	87.9	75.0	97.6

Effect of PGPR microbes on tea cuttings

The experiments conducted to assess the effect of certain PGPR microbes proved their beneficial effect in terms of vegetative growth of young tea plants as shown in Table 18. The data showed a distinct gain in number of leaves, girth of stem and height of the plant over control. This was found to be maximum when the soil of the pot was inoculated with MM-PSB/10 and MM-Azm/10.

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