Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 1718-1728
Received: 01-01-2020
Accepted: 04-02-2020

Dr. Kaki Ranjit
Department of Plantation Crops and Processing, FOH, Main Campus, Pundibari, UBKV-West Bangla, India

Dr. Bhattacharjee H
Associate Professor, Department of Plantation Crops and Processing, FOH, Main Campus, Pundibari, UBKV-West Bangla, India

Dr. Medda PS
Associate Professor. Department of Plantation Crops and Processing, FOH, Main Campus, Pundibari, UBKV-West Bangla, India

Dr. Mukhopadhyay D
Associate Professor. Department of Plantation Crops and Processing, FOH, Main Campus, Pundibari, UBKV-West Bangla, India

Corresponding Author:
Dr. Kaki Ranjit
Department of Plantation Crops and Processing, FOH, Main Campus, Pundibari, UBKV-West Bangla, India

Efficacy of nitrogen fixing and phosphorous Solublizing bio-inoculants on growth performance of tea nursery seedlings

Kaki Ranjit, Bhattacharjee H, Medda PS and Mukhopadhyay D

Abstract
Tea is one of the important plantation crops of India as well as West Bengal, contributes considerably in national economy and earns foreign exchange. During 2014-15, total production of tea in India was 1233.14 m kg, out of which only100 m kg were organic tea. Mainly due to importers demand of organic tea, there is urgent need to enhance organic production of tea crop. Indiscriminate use of inorganic agricultural inputs-fertilizers, weedicides, pesticide and fungicides and lesser use of organic matters deplete soil health, residues remain beyond MRL in processed tea, ultimately reduction in export. Tea Board provides 55% subsidy for organic tea production. For organic cultivation of tea, the planting materials should also be organically produced in nursery, which is very scanty for perennial crops in general and plantation crops in particular. With this background, the present investigation was carried out at instructional farm of the department of Plantation Crops and Processing, UBKV, Pundibari, located at $26^0 19'86''$ N Latitude and $89^0 23'53''$ E Longitude at an elevation of 43 m msl with the objective to study the efficacy of N- and P-fixing bio-inoculants in the nursery plants, The experiment was conducted from 2013 to 2015 and laid out in completely randomized block design. The efficiency of nitrogen and phosphorous fixation by bio inoculants and other supplementary source of phosphorous to seed stock TS-462, a dose of 5 g rock phosphate and application of bio fertilizers produced best results, but treatment T_8 *i.e.,* dose of 3 g rock phosphate along with bio fertilizers 10g (*Azotobacter*+*Azospirillium*+PSB+*VAM* @2.5 g each)/sleeve proved best over other treatments to meet the standards of ideal planting materials of tea for 9-13 months.

Keywords Tea nursery, growth, bio-inoculants and planting materials

Introduction
Tea (*Camellia sinensis* (L.) O.Kuntze) belongs to family Theaceae is one of the most economically important evergreen woody plantation crops predominantly grown in the subtropical regions of India. It is most popular and low cost beverage in the world and consumed by a large number of people. Tea is grown mainly for young tender apical two leaves and a bud, which is a rich source of polyphenols, caffeine etc. Owing to its increasing demand, tea is considered to be one of the major components of world beverage market.

The plantation crops are high value commercial crops of great economic importance and play a vital role in Indian economy. India was the second largest producer of tea in the world, grown in an area of about 563.98 thousand ha with a production of 1,233.14 million kg which was about 23% of total world production. About 80% of the production was consumed internally which was about 21% of the total world consumption. During the same period India exported 232.92 million kg and valued at US$ 686.67 million and ranked fourth in terms of export of tea. The tea industry is India's second largest employer with over 3.5 million people across some 1,686 estates and 1,57,504 small holdings; most of them are women. In West Bengal, tea was grown in an area of 140.44 thousand ha and production was about 312.10 million kg (IBEF, 2016) [19]. Over the last 20 years, India's world ranking as an exporter of tea has come down from number one to number four, in the face of stiff competition from Sri Lanka, Kenya, and China (Majumdar *et al.*, 2012) [9]. Main importing countries of Indian tea were Russian Federation (48.23 million kg), Iran (22.13 million kg) and Pakistan (19.37 million kg). Recent trends showed drastic reduction in tea exports from India, as the importing countries prefered residue free superior quality tea. Only one per cent of total tea produced in India is organic tea. However, organic tea constituted only two per cent of the total organic products exported from India during 2012-13 (FAO, 2014).

United State Department of Agriculture (USDA) report on organic farming during 1980 defined, organic farming as a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock additives.

To the maximum extent feasible, organic farming system rely upon crop rotation, crop residues, animal manures, legumes, green manures, off farm organic wastes, mechanical cultivation, nutrient bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests. This is the most widely recognised alternative farming system in the modern era.

An organic product is free from chemicals, antibiotics, synthetic hormones, genetic modifications and field use of sewage sludge as fertiliser. Organic cultivation is a sustainable way to combat climate change. Use of naturally available products, such as organic manure or compost, increases climate resilience. A minimum of three years is needed for an established conventional garden to be converted to organic, which has to be certified by a certifying agency. The problems for established tea gardens that wish to go organic are two fold, *i.e* yield drop up to an extent of 44 per cent and over 65 per cent increase in cost of production as compared to the conventional cultivation (Goswami, 2015; FAO, 2014). In India, the cultivation of organic tea started during 1986 and gradually spread to the tea areas of West Bengal, Assam and South India (Prayukth, 2005) [15].

For establishment of organic tea plantation, the planting materials also have to be produced following organic methods. Tea nurseries generally use chemical inputs especially fertilizers and plant protection chemicals for production of planting materials which affect the physical and chemical properties of soil, leaves residues and disturb ecosystem. Therefore, inputs chosen for better planting material production also play key role to guarantee the desired crop performance and economic returns to the farmers. For producing planting materials of tea using nutrients in elemental forms and organic inputs like farm yard manure, vermicompost, biofertilizers and biopesticides.

Organic manures are main source of plant nutrition in organic farming due to its multiple functions in soil (Mamaril *et al.*, 1986) [10]. The important organic amendments are crop residues, vermicompost, farm yard manure and green manure and use of these inputs are increasingly becoming important aspects of environmentally sound sustainable agriculture (Timsina and Connor, 2001) [18]. The basic principle of plant nutrition is universal but optimum fertilizer requirement will vary with plant types and nature of soil. Nitrogen, phosphorus and potassium are the major nutrients required by the plants. Other nutrients required are calcium, sulphur and magnesium. Nitrogen is an important constituent of chlorophyll, amino acids, proteins and nucleic acids. Phosphorus is one of the vital nutrients that could be limiting in tea soils. It is responsible for cell division and plays a key role in the formation of new wood and root. While, potassium plays a key role as an activator of enzymes involved in carbohydrate and protein metabolism, membrane permeability and stomatal opening (Marschner, 2012) [11].

Biofertilizers are carrier based preparations containing beneficial microorganisms in a viable state. They improve soil fertility and help in plant growth by improving nutrient availability. Nitrogen fixers and phosphate solubilizers are naturally present in almost all soils but their population level may not be sufficient to bring out these biological processes to a significant level. Addition of efficient strains of these microorganisms was successfully practised in many crops (Pandya and Saraf, 2010) [14].

The use of biofertilizers and organic manure offer a great opportunity to increase the crop productivity with less cost. With this objective, experiments were conducted to find out the success of biofertilizers in an organic farming system. The beneficial microorganisms are generally applied through various carrier materials. Without carrier materials, the applied beneficial microorganisms will not survive for longer period. The carrier materials should have high organic matter content, high water holding capacity, neutral pH for better survival of the organisms. Various organic materials and agricultural wastes such as composted coir pith, lignite, organic manure, vermicompost and vermiculite were tested as carrier materials *in vitro* and field conditions to select the best ones. Selected strains were mass multiplied and conditions for mass multiplication were standardized (Bhagyaraj and Suvarna, 1999) [4].

Tea is one of the important plantation crops of West Bengal, particularly North Bengal, known all over the world for the best quality. Most of the tea gardens follow conventional cultivation practices using various chemical inputs. Though, there are a few gardens cultivating tea organically but there are few reports on cultivation practices and more particularly production of planting materials. Keeping this in view the present investigation was conducted with the following objective; to study the efficacy of N and P-fixing bio-inoculants in the nursery plants of tea.

Materials and Methods

For the present investigation, a temporary nursery was in the instruction cum research plot of the Department of Plantation Crops and Processing, UBKV, Pundibari, during August, 2013. The details of various materials used and methods employed in the investigation have been presented below.

Location and climate: The experimental site Was the instruction cum research plot of Department of Plantation Crops and Processing, UBKV, located at $26^{0}19'86''$ N Latitude and $89^{0}\ 23'53''$ E Longitude at an elevation of 43 m above mean sea level. Agroclimatologically, the location represents Terai region of West Bengal and is characterized by subtropical climate. The place experiences hot summers, hot and humid rainy season and cool winters. In the nursery, beds of size 1.2 m width and 13 m length were prepared in East-West direction with a drain of 30 cm in between the two beds. All the beds were covered using green coloured agronet (50% light transmittance) on all the sides, a height of 2.0 m on Northern side and 1.5 m on Southern side was maintained.

For filling (black polythene) sleeves of size 20 x 30 cm, lay flat 250 guage thickness, sealed at the bottom, punctured eight holes on the lower one-third, which can hold 2.5 kg soil. Top soil from the plantation area was collected dried, pulvarized and sieved through an 8 mm mesh size of sieve. Similarly, FYM and VC were also dried, pulvurized, sieved and heaped separately, then mixed with the soil at required rates.

Experimental materials: Different organic nutrients sources such as farm yard manure (FYM) and vermicompost (VC) were collected from Directorate of Farms, UBKV, Pundibari. Rock phosphate as a source of phosphorous @ 22.5% P_2O_5 was procured from local market (manufactured by Nagarjuna Fertilizers) and bio- inoculants such as *Azotobacter*, *Azospirillium*, Phosphate solubulising bacteria (PSB), *Trichoderma*, vesicular arbuscular mychorrhiza (VAM) were collected from bio-control unit of the Department of Plant Pathology, UBKV, Pundibari. All other chemicals used during investigation for analysis of soil, FYM, VC and for microbial culture requisite chemicals with AR or GR grades were purchased from the authorized dealer of Hi-Media and Merck Mumbai, India located at Jalpaiguri, West Bengal.

Experimental layout: The experimental plot was situated at the experimental plot of the Department of Plantation Crops and Processing, UBKV, Pundibari. The experimental plot was laid out in shade net under young aged (6years) arecanut garden in North South direction, the interspaces among the garden are utilized by preparing raised beds with proper drainage facilities in East-West direction. The polythene sleeves filled up with fine sieve soils and organic manures are kept systematically *i.e* treatment wise.

Nursery sowings and transplanting: Seeds were placed in aluminium trays containing 5-7 cm thick layer of sand then covered with fine shallow layer of seived sand for proper cracking and then moisture provided at alternate days for proper sprouting and germination. It took 18 days to complete cracking and sprouting. Later on cracked seeds are sown at depth of 3-5 cm in polythene sleeves filled up with fine sieve soils and organic manures which are kept systematically *i.e* treatment wise.

Cultural practices: Irrigation: After transplanting once light irrigation was given for quick establishment of seedlings followed by pouring water whenever irrigation is required. Hoeing and weeding: The experimental beds and sleeves are kept free from weeds by hand weeding. Drainage channels around the raised beds are cleared at periodic intervals. Sometimes water accumulated in polythene sleeves are removed by puncturing with nail, which allow excess water to drain out. Pest and disease management: Incidence of pests were observed, to check the infestation of pests neem oil at a concentration of 0.1% was sprayed at monthly intervals. There was no incidence of disease during the period of experimentation.

To study the efficacy of nitrogen and phosphorous fixing bio-inoculants in nursery plants, one seed stock namely TS-462 (released by Tocklai Experimental Station (Tocklai Tea Research Institute), Tea Research Association, Jorhat, Assam) was chosen with 12 treatments combinations replicated thrice with 33 plants each. There were different combinations of biofertilizer mixture as a source of nitrogen and phosphorous, rock phosphate as a source of phosphorous at different levels *viz.*, 5 levels of phosphorous and 1 level of biofertilizers chosen as there are 2 factors under consideration, design opted for statistical analysis is factorial complete randomised design. Details of the treatments have been given below:

Treatments	Treatment details	No. of plants
T_1 (P_0B_0)	(only soil) Control	100
T_2((P_0B_1)	Soil + 0 g rock phosphate + 10 g Bio-inoculants #	100
T_3(P_1B_0)	Soil + 1 g rock phosphate + 0 g Bio-inoculants #	100
T_4(P_1B_1)	Soil + 1 g rock phosphate + 10 g Bio-inoculants #	100
T_5(P_2B_0)	Soil + 2 g rock phosphate + 0 g Bio-inoculants #	100
T_6(P_2B_1)	Soil + 2 g rock phosphate + 10 g Bio-inoculants #	100
T_7(P_3B_0)	Soil + 3 g rock phosphate + 0 g Bio-inoculants #	100
T_8(P_3B_1)	Soil + 3 g rock phosphate + 10 g Bio-inoculants #	100
T_9(P_4B_0)	Soil + 4 g rock phosphate + 0 g Bio-inoculants #	100
T_{10}(P_4B_1)	Soil + 4 g rock phosphate + 10 g Bio-inoculants #	100
T_{11}(P_5B_0)	Soil + 5 g rock phosphate + 0 g Bio-inoculants #	100
T_{12}(P_5B_1)	Soil + 5 g rock phosphate + 10 g Bio-inoculants #	100

(*Azotobacter* + *Azospirillium* + PSB* + *VAM*** @ 2.5 g each)

* phosphorous solublising bacteria ** vesicular arbuscular mycorrhiza

Results

Plant height: Various observations recorded on plant height for tea seedlings of stock TS-462 to find out the efficacy of nitrogen and phosphorous fixing biofertilizers have been presented in Table 01 (a) & (b). Data revealed that statistically significant differences were observed for the interactions between phosphorous (rock phosphate) and biofertilizers applied in all treatments shown in Table 01(a). Highest plant height 23.25 and 76.44 cm was obtained in treatment T_{11} (P_5B_0) on initial and final observation *i.e.*, on 120, 480 days after sowing. While on 210, 300, 390 DAS maximum plant height 40.44 cm, 44.11 and 47.78 cm was reported from treatment T_{12} (P_5B_1). The minimum plant height 8.50 cm, 16.67 cm, 23.22 cm, 29.78 and 43.77 cm was reported from control treatments at all observations on 120, 210, 300, 390 and 480 days after sowing respectively. Data on individual effects of phosphatic and bio fertilizers applied for seed stock TS-462 depicted significant differences on all observations shown in Table 01(b). Maximum plant height of 17.21 cm, 30.68 cm, 38.34 and 70.44 cm recorded with P_5 *i.e.*, 5 g Rock phosphate on 120, 210, 300 and 480 DAS except 46.55 cm recorded with P_3 *i.e.*, 3 g Rock phosphate on 390 DAS respectively. Where as, bio fertilizer application (B_1) resulted maximum plant height of 15.60 cm, 27.24 cm, 35.35 cm, 43.46 and 63.94 cm on all observations at frequent intervals after sowing.

Table 1(a): Efficacy of N and P fixing bio-inoculants on plant height for seedlings of stock (TS-462)

Plant Height (cm) on DAS						
Treatments		120	210	300	390	480
T_1	P_0B_0	8.50	16.67	23.22	29.78	43.78
T_2	P_0B_1	10.42	21.83	35.31	48.78	59.44
T_3	P_1B_0	12.58	25.42	32.38	39.33	52.11
T_4	P_1B_1	9.17	21.33	32.83	44.33	65.22
T_5	P_2B_0	8.58	18.50	26.69	34.89	45.22
T_6	P_2B_1	10.75	20.92	31.13	41.33	62.78
T_7	P_3B_0	10.75	23.50	31.19	38.89	47.22

T_8	P_3B_1	14.83	20.22	31.89	43.56	67.00
T_9	P_4B_0	10.58	21.75	28.32	34.89	56.00
T_{10}	P_4B_1	11.42	20.92	32.57	44.22	65.22
T_{11}	P_5B_0	23.25	32.50	39.69	46.89	76.44
T_{12}	P_5B_1	23.00	40.44	44.11	47.78	75.67
S.Em (±)		1.071	1.882	2.862	4.744	9.121
CD at (0.05)		3.125	5.494	8.354	13.846	26.622
CD at (0.01)		4.232	7.441	11.324	18.761	36.072

Table 1(b): Individual effects of Phosphatic fertilizers and bio-inoculants on plant height for seedlings of stock (TS-462)

Plant Height (cm) on DAS						
Treatments		120	210	300	390	480
PHOS	P_0 (0gm)	10.54	21.04	27.80	34.56	47.94
	P_1 (1gm)	9.67	21.00	28.94	36.89	46.22
	P_2 (2gm)	16.92	27.13	34.01	40.89	66.22
	P_3 (3gm)	9.79	21.58	34.07	46.56	62.33
	P_4 (4gm)	12.79	20.57	31.51	42.44	64.89
	P_5 (5gm)	17.21	30.68	38.34	46.00	70.44
SEm (±)		0.757	1.331	2.024	3.354	6.449
CD at (0.05)		2.210	3.885	5.907	9.791	18.824
CD at (0.01)		2.992	5.263	8.001	13.262	25.512
BIOF	B_0 (0gm)	10.04	20.10	29.54	38.98	55.41
	B_1(10gm)	15.60	27.24	35.35	43.46	63.94
SEm (±)		0.437	0.768	1.169	1.937	3.724
CD at (0.05)		1.276	2.243	3.411	5.653	10.868
CD at (0.01)		1.721	3.032	4.623	7.661	14.721

Number of leaves per plant: Observations recorded on number of leaves per plant for tea seedlings of stock TS-462 have been presented in Table 02 (a) & (b).

Data recorded on number of leaves per plant shows statistically significant differences for treatments applied on all observations. Initially maximum number of leaves 13.33, 15.69 per plant was obtained in treatment T_{11} (P_5B_0) on 120 and 210 DAS. Later on 300 and 390 DAS, maximum number of 20.24 and 25.22 leaves were observed in treatment T_{12} (P_5B_1). On final observation 480 DAS, maximum number of 37.22 leaves were produced in treatment T_{11} (P_5B_0) which was at par with 36.56 leaves produced in T_{12} (P_5B_1) treatment. The minimum number 5.58, 7.33, 10.28, 13.22 and 20.33 of leaves per plant was recorded with treatment T_1 (P_0B_0 *i.e.*, control) on 120, 210, 300, 390 and 480 DAS respectively. The perusal of data on individual effects of five levels of P_2O_5 phophorous (0.0 g to 5.0 g rock phosphate per sleeve) and two levels of bio fertilizers (0.0 g to 10.0 g per sleeve) for number of leaves produced per plant revealed significant differences in all observations *i.e.*, age of the seedlings after sowing. The maximum dose of P_2O_5 in the form of 5.0 g rock phosphate per plant and bio fertilizers mixture of 10 g per plant showed superior performance with regard to number of leaves produced per seedlings. Whereas minimum number of leaves were reported from control treatments.

Number of branches: Observations recorded on number of branches produced per seedlings of stock TS-462 to find out the efficacy of nitrogen and phosphorous fixing bio fertilizers have been presented in Table 03(a) & (b). Data revealed that with the application of various P_2O_5 levels as rock phosphate, with or without bio inoculants and their interactions as treatments shows statistically significant variation. On 120, 390 and 480 DAS maximum number of 1.89, 4.72 and 7.67 branches per plant were obtained in treatment T_{12} (P_5B_1). On 210 DAS maximum numbers of 2.33 branches were observed in T_2 (P_0B_1) which was at par 2.06 with T_{12} (P_5B_1). On 300 DAS maximum number 3.42 of branches were reported from treatment T_6 which was at par (3.39) with T_{12}. However, subsequent observations showed that the plants under treatment T_{12} performed better in producing more number of branches as compared to other treatments [Table 03 (a)].

Table 2(a): Efficacy of N and P fixing bio-inoculants on number of leaves for seedling of stock (TS-462)

Number of leaves per plant on DAS						
Treatments		120	210	300	390	480
T_1	P_0B_0	5.58	7.33	10.28	13.22	20.33
T_2	P_0B_1	7.50	8.17	12.25	16.33	24.56
T_3	P_1B_0	6.44	8.17	12.86	17.56	22.78
T_4	P_1B_1	8.17	9.25	14.96	20.67	24.56
T_5	P_2B_0	6.00	7.83	11.64	15.44	20.89
T_6	P_2B_1	7.89	9.56	15.22	20.89	26.89
T_7	P_3B_0	8.67	9.50	12.36	15.22	25.67
T_8	P_3B_1	9.25	10.33	16.11	21.89	32.89
T_9	P_4B_0	6.25	7.89	10.61	13.33	22.00
T_{10}	P_4B_1	10.33	12.97	16.99	21.00	30.89
T_{11}	P_5B_0	13.33	15.69	18.35	21.00	37.22
T_{12}	P_5B_1	11.58	15.25	20.24	25.22	36.56
S.Em (±)		0.896	1.360	1.702	2.935	5.221
CD at (0.05)		2.615	3.970	4.969	8.566	15.240
CD at (0.01)		3.541	5.382	6.731	11.602	20.654

Table 2(b): Individual effects of Phosphatic fertilizers and bio-inoculants on number of leaves for seedlings of stock (TS-462)

Number of leaves per plant on DAS						
Treatments		120	210	300	390	480
PHOS	P_0 (0gm)	6.01	7.75	11.57	15.39	21.56
	P_1 (1gm)	7.33	8.67	12.00	15.33	23.28
	P_2 (2gm)	9.79	11.79	14.48	17.17	29.61
	P_3 (3gm)	7.83	8.71	13.60	18.50	24.56
	P_4 (4gm)	8.57	9.94	15.67	21.39	29.89
	P_5 (5gm)	10.96	14.11	18.61	23.11	33.72
S.Em (±)		0.634	0.962	1.204	2.075	3.692
CD at (0.05)		1.849	2.807	3.513	6.057	10.776
CD at (0.01)		2.501	3.802	4.761	8.208	14.601
BIOF	B_0 (0gm)	7.26	8.96	12.83	16.70	24.26
	B_1(10gm)	9.57	11.37	15.81	20.26	29.94
S.Em (±)		0.366	0.555	0.695	1.198	2.132
CD at (0.05)		1.068	1.621	2.028	3.497	6.222
CD at (0.01)		1.442	2.195	2.742	4.731	8.437

Table 3(a): Efficacy of N and P fixing bio-inoculants on number of branches for seedlings of stock (TS-462).

Number of branches per plant on DAS						
Treatments		120	210	300	390	480
T_1	P_0B_0	1.00	1.00	1.21	2.08	2.45
T_2	P_0B_1	1.11	2.33	2.47	2.61	3.17
T_3	P_1B_0	1.29	1.39	2.03	2.67	3.17
T_4	P_1B_1	1.50	1.88	2.15	3.06	4.44
T_5	P_2B_0	1.69	2.00	2.28	2.83	3.06
T_6	P_2B_1	1.78	2.11	3.42	4.72	5.06
T_7	P_3B_0	1.00	1.25	1.47	2.11	2.50
T_8	P_3B_1	1.00	1.75	2.28	3.39	4.17
T_9	P_4B_0	1.00	1.10	1.11	1.89	2.56
T_{10}	P_4B_1	1.00	1.44	2.11	2.78	3.00
T_{11}	P_5B_0	1.88	2.03	2.44	3.39	5.06
T_{12}	P_5B_1	1.89	2.06	3.39	4.72	7.67
S.Em (±)		0.340	0.266	0.415	0.706	0.731
CD at (0.05)		1.025	0.802	1.250	2.127	2.203

Table 3(b): Individual effects of Phosphatic fertilizers and bio-inoculants on number of branches per plant for seedlings of stock (TS-462).

Number of branches per plant on DAS						
Treatments		120	210	300	390	480
PHOS	P_0 (0gm)	1.06	1.67	1.84	2.35	2.81
	P_1 (1gm)	1.40	1.63	2.09	2.86	3.81
	P_2 (2gm)	1.74	2.06	2.58	3.78	4.06
	P_3 (3gm)	1.00	1.50	1.88	2.75	3.33
	P_4 (4gm)	1.00	1.22	1.61	2.34	2.78
	P_5 (5gm)	1.15	1.78	2.92	4.06	6.36
S.Em (±)		0.241	0.188	0.293	0.499	0.517
CD at (0.05)		0.725	0.567	0.884	1.504	1.557
CD at (0.01)						
BIOF	B_0 (0gm)	1.31	1.36	1.67	2.50	3.13
	B_1(10gm)	1.38	1.93	2.64	3.55	4.58
S.Em (±)		0.139	0.109	0.169	0.288	0.298
CD at (0.05)		0.419	0.328	0.510	0.868	0.899

It is clear from Table 03 (b) that individual effects of five levels of P_2O_5 as rock phosphate and two levels of bio-fertilizers in tea seedlings of Stock TS-462 showed significant differences on all observations except on 120 DAS. The maximum dose of P_2O_5 *i.e.*, 5.0 g rock phosphate per plant produced maximum number of branches 2.92, 4.06, 6.36 per plant on 300, 390 and 480 DAS respectively and bio fertilizers mixture of 10.0 g per plant (B_1) showed superior results or performance when compared to other treatments.

Collar girth of plants: Various observations on plant girth at collar region of tea seedlings of stock TS-462 have been presented in Table 04 (a) & (b). The data observed on girth of plants at collar when biofertilizers alone or in combination with phosphatic fertilizers used show significant variation [Table 04 (a)]. Maximum plant girth of 9.55 mm, 13.08 mm, 15.26 mm and 17.44 mm was observed in T_{12} (P_5B_1), on 120, 210, 300 and 390 DAT respectively. The lowest girth of 3.98 mm, 12.56 mm and 14.30 mm was recorded in T_1 (control) on120, 390 and 480 DAS (P_0B_0). On 210 and 300 DAS minimum plant girth was observed in treatment combination T_6 (P_2B_1) 6.28 and 9.42 mm respectively. Whereas collar girth of 24.77 mm was obtained in treatment T_{11} (P_5B_0) on 480 DAS respectively. This was statistically superior to all other treatment combinations. Observation recorded on plant girth revealed significant differences for individual effects of phosphorous and bio-fertilizers except on 390 DAS. The data in Table 04 (b) revealed that highest plant girth of 9.05 mm, 12.47 mm, 14.26 and 16.05 mm was recorded in treatment P_5 *i.e.,* 5 g Rock phosphate on 120, 210, 300 and 390 DAS respectively. Where as, 20.76 mm maximum girth was obtained in P_2 treatment *i.e.,* 2 g Rock phosphate application on 480 DAS. On 390 DAS there was non significant differences among treatments were observed. The maximum plant girth 6.88 mm, 10.18 mm, 13.12 mm, 16.05 mm and 19.36 mm was recorded with biofertilizer application B_1 treatment *i.e.,* 10 g biofertilizer mixture at 120, 210, 300, 390 and 480 DAS respectively.

Fresh weight of seedlings: Various observations recorded on fresh weight per plant for tea seedlings of stock TS-462 have been presented in Table 05 (a) & (b). Interaction effects of N fixing bio inoculants and phosphate solublizing mycorrhizae [Table 05 (a)] showed significant variation for all the treatment combinations. Maximum fresh weight of 4.28 g and 19.82 g was obtained in treatment T_{12} (P_5B_1) on 120 and 300 DAS. Whereas of maximum fresh weight of 14.25 g was obtained in treatment T_{11} (P_5B_0) on 210 DAS. Fresh weight of 26.83 g in (T_2) was recorded in 390 DAS (P_0B_1) and on 480 DAS (40.53 g) in T_{10} treatment combination of (P_4B_1) respectively. Treatment combinations of 1 g of P_2O_5 with biofertilizer showed (P_1B_1) minimum fresh weight 2.33 g on 120 days after sowing, followed by (T_1) control. Later on, least fresh weight of 7.75 g and 12.70 g was noticed in treatment T_7 (P_3B_0) on 300 and 390 DAS, finally on 480 days after sowing minimum fresh weight of 14.36 g reported from control T_1 (P_0B_0). Fresh weight of plants showed significant differences for both phosphorous and biofertilizers [Table 05 (b)] individual effects. Data revealed that maximum fresh weight 4.16 g, 11.29 g, 40.40 g was observed at maximum dose of phosphorous P_5 *i.e.,* 5 g Rock phosphate in 120, 210 and 480 DAS respectively. Whereas on 300 DAS maximum fresh weight 14.92 g was observed at P_2 *i.e.,* 2 g rock phosphate and on 390 DAS maximum fresh weight 23.12 g was observed at P_3 *i.e.,* 3 g rock phosphate. In case of biofertilizers application maximum fresh weight 7.43 g, 13.32 g, 19.21 g, 26.69 g was observed when compared to non application of biofertilizers at 210, 300, 390 and 480 DAS intervals of observation.

Table 4(a): Efficacy of N and P fixing bio-inoculants on collar girth for seedlings of stock (TS-462).

Collar girth of plants (mm) on DAS						
Treatments		**120**	**210**	**300**	**390**	**480**
T_1	P_0B_0	3.98	7.07	9.81	12.56	14.30
T_2	P_0B_1	4.95	7.33	10.12	12.91	15.70
T_3	P_1B_0	4.71	8.37	11.69	15.00	15.70
T_4	P_1B_1	6.63	7.85	11.60	15.35	17.44
T_5	P_2B_0	4.45	7.59	10.25	12.91	15.70
T_6	P_2B_1	4.95	6.28	9.42	12.56	15.70
T_7	P_3B_0	5.23	8.24	11.62	15.00	16.40
T_8	P_3B_1	7.59	11.51	14.30	17.10	19.54
T_9	P_4B_0	4.45	10.21	12.43	14.65	16.75
T_{10}	P_4B_1	8.56	11.86	13.26	14.65	18.14
T_{11}	P_5B_0	7.59	12.04	14.22	16.40	24.77
T_{12}	P_5B_1	9.55	13.08	15.26	17.44	22.33
S.Em (±)		0.388	0.567	0.809	1.359	1.929
CD at (0.05)		1.133	1.655	2.362	3.966	5.632
CD at (0.01)		1.531	2.224	3.209	5.371	7.634

Table 4(b): Individual effects of Phosphatic fertilizers and bio-inoculants on collar girth for seedlings of stock (TS-462).

Collar girth of plants (mm) on DAS						
Treatments		**120**	**210**	**300**	**390**	**480**
PHOS	P_0 (0gm)	4.34	7.72	10.75	13.78	15.00
	P_1 (1gm)	4.84	7.92	10.94	13.96	16.05
	P_2 (2gm)	6.02	11.12	13.32	15.53	20.76
	P_3 (3gm)	5.79	7.59	10.86	14.13	16.57
	P_4 (4gm)	6.27	8.90	11.86	14.83	17.62
	P_5 (5gm)	9.05	12.47	14.26	16.05	20.24
S.Em (±)		0.274	0.401	0.572	0.961	1.364
CD at (0.05)		0.801	1.170	1.670	2.804	3.982
CD at (0.01)		1.081	1.582	2.263	3.804	5.392
BIOF	B_0 (0gm)	5.22	8.39	10.88	13.37	16.05
	B_1(10gm)	6.88	10.18	13.12	16.05	19.36
S.Em (±)		0.158	0.232	0.330	0.555	0.788
CD at (0.05)		0.462	0.676	0.964	1.619	2.299
CD at (0.01)		0.625	0.919	1.307	2.194	3.112

Table 5(a): Efficacy of N and P fixing bio-inoculants on fresh weight for seedlings of stock (TS-462).

Fresh weight (g) of plant on DAS						
Treatments		120	210	300	390	480
T_1	P_0B_0	2.38	2.50	8.43	14.01	14.36
T_2	P_0B_1	2.73	4.67	15.75	26.83	27.91
T_3	P_1B_0	2.36	3.67	10.93	14.40	15.96

T_4	P_1B_1	2.33	4.00	11.71	19.41	24.37
T_5	P_2B_0	2.88	4.95	8.11	13.44	19.96
T_6	P_2B_1	3.79	5.17	11.18	17.20	33.42
T_7	P_3B_0	2.71	2.81	7.75	12.70	20.12
T_8	P_3B_1	3.78	6.00	10.88	15.77	34.06
T_9	P_4B_0	2.49	4.00	11.03	18.07	29.62
T_{10}	P_4B_1	4.04	8.75	8.94	9.12	40.53
T_{11}	P_5B_0	2.53	14.25	18.80	23.36	29.70
T_{12}	P_5B_1	4.28	13.83	19.82	25.81	40.26
S.Em (±)		0.290	1.157	1.882	3.444	0.310
CD at (0.05)		0.847	3.377	5.493	10.051	0.904
CD at (0.01)		1.142	4.572	7.441	13.621	1.223

Table 5(b): Individual effects of Phosphatic fertilizers and bio-inoculants on fresh weight for seedlings of stock (TS-462).

Fresh weight (g) of plant on DAS						
Treatments		120	210	300	390	480
PHOS	P_0 (0gm)	2.37	3.08	9.68	11.67	16.28
	P_1 (1gm)	2.80	4.84	7.93	13.07	20.04
	P_2 (2gm)	2.51	9.13	14.92	20.71	29.66
	P_3 (3gm)	2.53	4.33	13.73	23.12	24.31
	P_4 (4gm)	3.78	5.58	11.03	16.48	33.74
	P_5 (5gm)	4.16	11.29	14.38	17.47	40.40
S.Em (±)		0.205	0.818	1.331	2.435	0.219
CD at (0.05)		0.599	2.388	3.884	7.107	0.639
CD at (0.01)		0.812	3.231	5.267	9.631	0.864
BIOF	B_0 (0gm)	3.05	4.64	10.57	16.50	26.59
	B_1(10gm)	3.00	7.43	13.32	19.21	26.69
S.Em (±)		0.118	0.472	0.768	1.406	0.126
CD at (0.05)		0.346	1.378	2.243	4.103	0.369
CD at (0.01)		0.463	1.862	3.032	5.567	0.509

Dry weight of seedlings: Various observations recorded on dry weight per plant for tea seedlings of stock TS-462 to find out the efficacy of nitrogen and phosphorous fixing biofertilizerss have been presented in Table 06 (a) & (b). The data for interaction effects of rockphosphate as phosphorous source and biofertilizers as nitrogen source showed significant differences [Table 06 (a)]. On initial observation 120 DAS maximum dry weight was observed from treatment T_{12} (P_5B_1) about 1.11 g. Similarly on 210, 300, 390 and 480 DAS maximum dry weight of 3.59 g, 4.75 g, 6.71 and 10.46 g was obtained in treatment T_{12} (P_5B_1) *i.e.*, 5 g rock phosphate and biofertilizer application respectively. Whereas, minimum dry weight was varied rapidly from different treatments on all observations. On initial and final observations *i.e.*, 120, 390 and 480 DAS the lowest 0.47 g, 1.61 and 2.81 g values of dry weight was recorded with treatment T_1 (control). Whereas on 210 and 300 DAS minimum dry weight 0.57 and 1.55 g was reported in treatment T_7 (P_3B_0) respectively.

It is clear from Table 06 (b) that individual effects of phosphatic and biofertilizers in tea seedlings of Stock TS-462 showed significant differences on all observations. Data revealed that maximum dry weight of 0.81 g, 3.22 g, 4.73 g, 5.73 and 8.20 g was observed at maximum dose of phosphorous P_5 *i.e.*, 5 g Rock phosphate on 120, 210, 300, 390 and 480 days after sowing respectively. In case of biofertilizers main effect, maximum dry weight of 0.84 g, 1.71 g, 2.76 g, 4.61 and 7.84 g was observed on 120, 210, 300, 390 and 480 DAS. Minimum dry weight of 0.54 and 4.02 g were reported from P_0 (control) on 120 and 480 DAS, while on 210 DAS minimum dry weight of 0.81 g was reported from P_1, where as on 300 and 390 DAS low dry weight of 2.08 and 3.23 g was obtained respectively.

Volume of root and shoot of seedlings: Various observations recorded on volume of root and shoot for the seedlings of stock chosen (TS-462) have been presented in Table 07 (a) & (b) respectively. It is clear from Table 07 (a) that in case of treatment T_{12} *i.e.*, P_5B_1 where 5 g rock phosphate with biofertilizer application, the total volume of root and shoot showed consistently higher values. Maximum volume of root were observed to be 1.95 cc, 6.88 cc, 7.83 cc, 8.85 and 12.06 cc on 120, 210, 300, 390 and 480 DAS respectively. Similarly maximum volume of shoot was also observed from treatment T_{12} 3.63 cc, 12.78 cc, 14.34 cc, 16.44 and 22.39 cc at 120, 210, 300, 390 and 480 DAS respectively. While, minimum volume of root varies with time, initially on 120 DAS root volume of 0.67 cc observed to be in treatment T_1 and T_3, later on 1.31 and 2.65 cc root volume was observed from treatments T_9 and T_3 on 210 and 300 DAS. But in contrast with initial readings minimum root volume of 3.92 and 4.24 cc was reported from treatment T_7 on final observations *i.e.*, 390 and 480 DAS respectively. Similar pattern of observations were also found in case of minimum shoot volume, initially on 120 DAS shoot volume of 1.25 cc observed to be in treatment T_1 and T_3. On 210 DAS minimum shoot volume of 2.44 cc was observed from treatment T_9. But in contrast with initial readings minimum shoot volume of and 5.16 cc, 7.29 and 9.08 cc was reported from treatment T_7 on final observations *i.e.*, 300, 390 and 480 DAS respectively.

Table 6(a): Efficacy of N and P fixing bio-inoculants on dry weight for seedlings of stock (TS-462).

Dry weight (g) of plant on DAS						
Treatments		120	210	300	390	480
T_1	P_0B_0	0.47	0.81	1.61	2.61	2.81
T_2	P_0B_1	0.60	1.01	1.90	4.52	5.23
T_3	P_1B_0	0.48	0.73	2.11	2.83	3.35
T_4	P_1B_1	0.55	0.88	2.51	4.07	5.36
T_5	P_2B_0	0.57	0.99	1.62	2.68	3.99
T_6	P_2B_1	0.87	1.19	2.57	4.00	7.67
T_7	P_3B_0	0.54	0.57	1.55	2.68	4.02
T_8	P_3B_1	0.90	1.44	2.61	3.78	8.17
T_9	P_4B_0	0.49	0.81	2.20	3.14	5.92
T_{10}	P_4B_1	1.01	2.15	2.23	4.59	10.15
T_{11}	P_5B_0	0.51	2.85	4.71	4.75	5.94
T_{12}	P_5B_1	1.11	3.59	4.75	6.71	10.46
S.Em (±)		0.055	0.055	0.338	0.376	0.410
CD at (0.05)		0.161	0.160	0.985	1.098	1.197
CD at (0.01)		0.446	1.032	3.242	6.615	0.851

Table 6(b): Individual effects of Phosphatic fertilizers and bio-inoculants on dry weight for seedlings of stock (TS-462).

Dry weight (g) of plant on DAS						
Treatments		120	210	300	390	480
PHOS	P_0 (0gm)	0.54	0.91	1.76	3.57	4.02
	P_1 (1gm)	0.52	0.81	2.31	3.45	4.36
	P_2 (2gm)	0.72	1.09	2.10	3.34	5.83
	P_3 (3gm)	0.72	1.00	2.08	3.23	6.10
	P_4 (4gm)	0.75	1.48	2.22	3.87	8.04
	P_5 (5gm)	0.81	3.22	4.73	5.73	8.20
S.Em (±)		0.04	0.04	0.24	0.27	0.29
CD at (0.05)		0.11	0.11	0.70	0.78	0.85
CD at (0.01)		0.315	0.730	2.292	4.678	0.601
BIOF	B_0 (0gm)	0.51	1.13	2.30	3.11	4.34
	B_1(10gm)	0.84	1.71	2.76	4.61	7.84
S.Em (±)		0.02	0.02	0.14	0.15	0.17
CD at (0.05)		0.07	0.07	0.40	0.45	0.49
CD at (0.01)		0.182	0.421	1.323	2.701	0.347

Table 7(a): Efficacy of N and P fixing bio-inoculants on volume of root and shoot of plant for seedlings of stock (TS-462)

Volume of Root and Shoot (cc) of plant on DAS											
Treatments		120		210		300		390		480	
		R	S	R	S	R	S	R	S	R	S
T_1	P_0B_0	0.67	1.25	3.67	6.81	3.88	7.20	5.93	11.00	7.97	14.81
T_2	P_0B_1	0.79	1.46	4.48	8.32	4.70	8.74	6.11	11.34	10.11	18.78
T_3	P_1B_0	0.67	1.25	2.53	6.87	2.65	8.52	6.19	11.49	9.72	18.06
T_4	P_1B_1	0.90	1.68	4.52	8.40	7.35	13.65	7.47	13.87	7.58	14.08
T_5	P_2B_0	1.11	2.06	1.56	2.89	4.08	7.58	5.66	10.51	6.61	12.28
T_6	P_2B_1	1.28	2.38	2.92	5.42	5.35	9.93	6.53	12.12	7.78	14.44
T_7	P_3B_0	0.90	1.68	1.75	3.25	2.78	5.16	3.92	7.29	4.24	9.08
T_8	P_3B_1	1.20	2.22	3.03	5.63	5.21	9.68	6.56	12.18	7.39	13.72
T_9	P_4B_0	0.88	1.63	1.31	2.44	3.11	5.77	4.95	9.19	5.37	9.95
T_{10}	P_4B_1	1.66	3.09	4.48	8.32	5.48	10.18	8.74	13.04	9.37	13.25
T_{11}	P_5B_0	0.93	1.73	3.98	8.05	5.41	9.91	6.34	12.38	7.78	14.44
T_{12}	P_5B_1	1.95	3.63	6.88	12.78	7.83	14.34	8.85	16.44	12.06	22.39
S.Em (±)		0.127	0.236	0.061	0.114	0.717	1.332	1.099	2.041	1.893	3.515
CD at (0.05)		0.371	0.689	0.179	0.332	2.093	3.887	3.208	5.957	5.524	10.259
CD at (0.01)		0.504	0.935	0.243	0.451	2.836	5.267	4.349	8.076	7.485	13.901

Table 7(b): Individual effects of Phosphatic fertilizers and bio-inoculants on volume of root and shoot for seedlings of stock (TS-462)

Treatments		120		210		300		390		480	
		R	S	R	S	R	S	R	S	R	S
PHOS	P_0 (0gm)	0.67	1.25	3.27	6.07	6.06	11.25	8.85	12.22	9.62	16.43
	P_1 (1gm)	1.01	1.87	1.65	3.07	3.43	6.37	5.21	9.68	5.34	10.46
	P_2 (2gm)	0.90	1.68	3.81	7.07	5.07	9.29	6.34	9.42	7.32	11.77
	P_3 (3gm)	0.85	1.57	4.73	8.36	6.79	8.78	8.85	12.60	10.13	16.43
	P_4 (4gm)	1.24	2.30	2.98	5.53	5.28	9.80	7.58	12.15	8.07	14.08
	P_5 (5gm)	1.81	3.36	6.53	12.13	7.48	13.88	8.42	15.64	9.47	16.33
S.Em (±)		0.090	0.167	0.507	0.942	0.777	1.443	1.338	2.485	0.043	0.080

CD at (0.05)		0.262	0.487	1.480	2.748	2.268	4.212	3.906	7.254	0.127	0.235
CD at (0.01)		0.356	0.661	2.005	3.724	3.075	5.710	5.293	9.830	0.172	0.319
BIOF	B_0 (0gm)	1.06	1.98	2.99	5.56	5.01	9.30	5.67	10.53	7.03	13.05
	B_1(10gm)	1.09	2.03	4.66	8.66	6.36	9.61	6.65	10.62	8.06	14.96
S.Em (±)		0.052	0.096	0.293	0.544	0.449	0.833	0.025	0.046	0.773	1.435
CD at (0.05)		0.151	0.281	0.854	1.587	1.310	2.432	0.073	0.136	2.255	4.188
CD at (0.01)		0.206	0.382	1.158	2.150	1.776	3.297	0.099	0.184	3.056	5.675

Table 8(a): Efficacy of N and P fixing bio-inoculants on dry matter content for seedlings of stock (TS-462)

Partitioning of dry matter of plant on DAS											
Treatments		**120**		**210**		**300**		**390**		**480**	
		R	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**
T_1	P_0B_0	0.09	0.37	0.16	0.64	0.32	1.28	0.52	2.08	0.56	2.24
T_2	P_0B_1	0.12	0.46	0.21	0.79	0.39	1.48	0.94	3.57	1.15	4.10
T_3	P_1B_0	0.10	0.37	0.15	0.57	0.44	1.65	0.60	2.27	0.70	2.64
T_4	P_1B_1	0.12	0.42	0.20	0.67	0.57	1.89	0.93	3.13	1.23	3.85
T_5	P_2B_0	0.12	0.44	0.21	0.77	0.35	1.26	0.58	2.09	0.87	3.11
T_6	P_2B_1	0.20	0.65	0.28	0.90	0.61	1.95	0.96	3.04	1.84	5.82
T_7	P_3B_0	0.13	0.41	0.12	0.43	0.35	1.19	0.61	2.06	0.92	3.09
T_8	P_3B_1	0.22	0.67	0.36	1.08	0.65	1.93	1.26	2.83	2.04	6.12
T_9	P_4B_0	0.11	0.37	0.19	0.61	0.52	1.67	0.75	2.38	1.42	4.49
T_{10}	P_4B_1	0.26	0.74	0.56	1.61	0.57	1.72	1.21	3.47	2.63	7.51
T_{11}	P_5B_0	0.11	0.38	0.71	2.13	1.17	3.53	1.18	3.56	1.48	4.45
T_{12}	P_5B_1	0.29	0.81	0.96	2.62	1.28	3.46	1.81	4.89	2.82	7.61
S.Em (±)		0.029	0.058	0.042	0.055	0.053	0.055	0.118	0.174	0.053	0.293
CD at (0.05)		0.085	0.169	0.122	0.161	0.154	0.161	0.344	0.508	0.154	0.855
CD at (0.01)											

Table 8(b): Individual effects of Phosphatic fertilizers and bio-inoculants on dry matter content for seedlings of stock (TS-462)

Treatments		**120**		**210**		**300**		**390**		**480**	
		R	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**
PHOS	P_0 (0gm)	0.11	0.42	0.19	0.72	0.36	1.38	0.73	2.83	0.86	3.17
	P_1 (1gm)	0.11	0.40	0.18	0.62	0.51	1.77	0.77	2.70	0.97	3.25
	P_2 (2gm)	0.16	0.55	0.25	0.84	0.48	1.61	0.77	2.57	1.36	4.47
	P_3 (3gm)	0.18	0.54	0.24	0.76	0.50	1.56	0.93	2.45	1.48	4.61
	P_4 (4gm)	0.19	0.56	0.38	1.11	0.55	1.70	0.98	2.93	2.03	6.00
	P_5 (5gm)	0.20	0.60	0.84	2.38	1.23	3.50	1.50	4.23	2.15	6.03
S.Em (±)		0.02	0.04	0.03	0.04	0.04	0.04	0.08	0.12	0.04	0.21
CD at (0.05)		0.06	0.12	0.09	0.11	0.11	0.11	0.24	0.36	0.11	0.60
CD at (0.01)											
BIOF	B_0 (0gm)	0.11	0.39	0.26	0.86	0.53	1.76	0.71	2.41	0.99	3.34
	B_1(10gm)	0.20	0.63	0.43	1.28	0.68	2.07	1.18	3.49	1.95	5.84
S.Em (±)		0.01	0.02	0.02	0.02	0.02	0.02	0.05	0.07	0.02	0.12
CD at (0.05)		0.03	0.07	0.05	0.07	0.06	0.07	0.14	0.21	0.06	0.35
CD at (0.01)											

It is clear from Table 07 (b) that the individual effects of phosphatic and biofertilizers in tea seedlings of Stock TS-462 showed significant differences on all observations. Data revealed that maximum volume of root and shoot (1.81, 3.36 cc), (6.53, 12.13 cc), (7.48, 13.88 cc) was observed at maximum dose of phosphorous P_5 *i.e.,* 5 g Rock phosphate on 120, 210 and 300days after sowing respectively. While on 480 DAS maximum root and shoot volume of 10.33, 16.43 cc were observed from P_3. In case of biofertilizers main effect, maximum root and shoot volume of (1.09, 2.03 cc), (4.66, 8.66 cc), (6.36, 9.61 cc), (6.65, 10.62 cc) and (8.06, 14.66 cc) was observed on 120, 210, 300, 390 and 480 DAS. Minimum volume of root and shoot were reported from P_0 (control) on 120 and 210 DAS, while on 480 DAS minimum root and shoot volume of (5.34, 10.46 cc) was reported from P_1.

Dry matter partitioning of plants: to find out the efficacy of nitrogen fixing and phosphorous solubilizing biofertilizers observations were recorded on dry matter partitioning of root and shoot in seedlings of TS-462 have been presented in Table 08(a) & (b). Observations recorded on dry matter partitioning of root and shoot per seedlings of stock TS-462 Interaction effects of N fixing bio inoculants and phosphate solubilizing mycorrhizae [Table 08 (a)] showed significant variation for all the treatment combinations. Maximum dry matter of (0.29, 0.81 g), (0.96, 2.62 g), (1.28, 0.53 g), (1.81, 4.89 g) and (2.82, 7.61 g) root and shoot was obtained in treatment T_{12} (P_5B_1) on 120, 210, 300, 390 and 480 DAS. Where as minimum dry matter of root and shoot (0.09, 0.37 g), (0.52, 2.08 g) and (0.56, 2.24 g) was found in control treatment T_1 (P_0B_0) on 120, 390 and 480 DAS respectively. While on 210 and 300 DAS minimum shoot dry matter found in T_7 treatment (P_3B_0). It is clear from Table 08 (b) that the individual effects of phosphatic and biofertilizers in tea seedlings of Stock TS-462 showed significant differences on all observations. Data revealed that maximum dry matter of root and shoot (0.20, 0.60 g), (0.84, 2.38 g), (1.23, 3.50 g), (1.50, 4.23 g) and (2.5, 6.03 g) was observed at maximum dose of phosphorous P_5 *i.e.,* 5 g Rock phosphate on 120, 210, 300, 390 and 480 days after sowing respectively. In case of biofertilizers main effect, maximum root and shoot dry matter of (0.20, 0.63 g), (0.43, 1.28 g), (0.68, 2.07 g), (1.18, 3.49 g) and (1.15, 5.84 g) was observed on 120, 210, 300, 390 and 480 DAS. Minimum dry matter of root and shoot (0.11, 0.40 g), (0.18, 0.62 g) were reported from P_1 on 120 and 210 DAS, while on 300 and 480 DAS minimum root and shoot volume of (0.36, 1.38 g), (0.86, 3.17 g) was reported from P_0 (control).

Plate 1: Efficacy of N and P- fixing bio- inoculants on growth parameters of seed stock TS-462 on 300 days after sowing

Plate 2: Efficacy of N and P- fixing bio- inoculants on growth parameters of seed stock TS-462 on 390 days after sowing

Discussion

In the present investigation, statistically significant differences were observed for the interactions between phosphorous (rock phosphate) and biofertilizers applied in all the treatments (Table 01.a). The maximum dose of P_2O_5 in the form of 5.0 g rock phosphate per plant and biofertilizers mixture of 10 g per plant showed superior performance with regard to number of leaves and branches produced per seedlings. Plants inoculated with bio-VAM and *Azospirillum* fixed more nitrogen and produced more yield than singly inoculated plants in pearl millet (Tilak, 1995) [17], black pepper with *Azospirillum*, *Azotobacter* and Phosphobacteria (Bopaiah and Khadeer, 1989) [5]. Ahmed *et al.*, (1999) [1] found that, applying phosphorein improved growth of Shemlali olive seedlings in comparison to the phosphate fertilizer alone. The contribution of biofertilizers for the crop yield increment varied in range from 8-30%. Biofertilizers positively influenced crop production quality. Reliable increase of protein content and the improvement of amino acid composition in cereal grains were also observed Mikhailouskaya and Bogdevitch, (2009) [12].

Observations recorded on plant girth revealed significant differences for individual effects of phosphorous and biofertilizers except on 390 DAS. The data (Table 04 b) revealed that highest plant girth of 9.05 mm, 12.47 mm, 14.26 and 16.05 mm was recorded in treatment P_5 *i.e.*, 5 g Rock phosphate Singh *et al*., (1988). The rooting of cuttings and plant growth up to one year were either as good or better in when decomposed organic matter such as tea waste or cowdung was added along with single superphosphate to the sub-soil before filling the plastic sleeves. Best results were achieved in sub-soil from the 45-60 cm depth + decomposed tea waste and single superphosphate. Both AM fungal consortia were found to promote growth of tea plants significantly in non-sterilized acidic soil. That crude AM fungal consortia can promote plant growth; more efficiently in case of AM fungal consortia where cultural practices can reduce the potential of native AM fungi. The NTR consortium has significant potential as a biofertilizer in tea plantations of colder regions (Singh *et al.*, 2008). Organic matter of 72 samples of tea soils of Assam was fractionated and the carbon content of different fractions were determined. Co-relationship was also studied between yield and different fractions of organic matter. Relative efficiency of cattle manure, conservation of NH_4-N, nitrification inhibition and increased availability of P should be the selection criteria of organic manures. A mixture of decomposed cattle manure, deoiled neem cake and either decaffinated tea waste or mukta appears to be suitable for tea soils (Phukan *et al.*, 1994). As a result of application of bio fertilizers maximum fresh weight of 7.43 g, 13.32 g, 19.21 g, 26.69 g was observed on 210, 300, 390 and 480 DAS as compared to non application of biofertilizers in the present observation. Similarly on 210, 300, 390 and 480 DAS maximum dry weight of 3.59 g, 4.75 g, 6.71 and 10.46 g was obtained in treatment T_{12} (P_5B_1) *i.e.*, 5 g rock phosphate and biofertilizer application respectively. (Barthakur *et al.*, 1994) opined that tea plants inoculated with vesicular arbuscular mycorrhiza (VAM) fungus *Glomus fasciculatum* showed enhanced leaf harvest and phosphate uptake. This effect was more pronounced when P_2O_5 was omitted from the fertilizer mixture applied. It is clear from Table 07 (b) that the individual effects of phosphatic and biofertilizers in tea seedlings of Stock TS-462 showed significant differences on all observations. Data revealed that maximum volume of root and shoot (1.81, 3.36 cc), (6.53, 12.13 cc), (7.48, 13.88 cc) was observed at maximum dose of phosphorous P_5 *i.e.*, 5 g Rock phosphate on 120, 210 and 300days after sowing respectively. While on 480 DAS maximum root and shoot volume of 10.33, 16.43 cc were observed from P_3. In case of biofertilizers main effect, maximum root and shoot volume of (1.09, 2.03 cc), (4.66, 8.66 cc), (6.36, 9.61 cc), (6.65, 10.62 cc) and (8.06, 14.66 cc) was observed on 120, 210, 300, 390 and 480 DAS. Microorganisms with phosphate solubilising potential increased the availability of soluble phosphate and enhance the plant growth by improving biological nitrogen fixation

(Kucey *et al.,* 1989) [7]. Association VAM played an important role such as overall increase in nutrient uptake, protection to feeder roots against pathogens, resistance to moisture stress and improved uptake of P from insoluble phosphates in many agro- ecological systems **(**Barthakur *et al.*, 1992) [2].

Summary and conclusion: Salient findings of the investigation have been summarized that,
Significant increase in microbial population (log CFU) was observed from the initiation to the end of the period of experiment. Incase of seedlings of TS-462, initial and final population with respect to various micro rganisms were- *Azotobacter* 6.38 to 9.04, PSB 6.97 to 11.30 on 7 and 14 MAS, *Azospirillium* 7.38 to 9.04 at 7 MAS and 8.32 on 14 MAS. While for TV 26, respective values were 7.32, 8.18 and 8.18 on 14 MAT. Rock phosphate @ 3.0 g along with biofertilizer produced the plantable plants with optimum morphological characters with in 300-390 days in case of TS-462 which was comparable with the plantlets of 460 days when produced with an application of rock phosphate or SSP or P_2O_5 @ 10.0 g per plant. Using various biofertilizers *viz., Azotobacter, Azospirillium,* PSB, *Trichoderma, VAM* @ 2.0 g each along with organic manures showed very encouraging results. By following this method we can save about 5.0 to 7.0 g of SSP per plant, as per recommended practice only SSP @500 g/meter cube of soil is added at the time of filling of sleeves. So for production of 1.0 lakh seedlings we could save about 500 kg of SSP. Ultimately, the duration and cost of production of seedlings will be less

References

1. Ahmed FF, El-Dawwey GM, Papadopoulos AP. Efficiency of phosphorene (as a source of phosphate solubilizing bacteria) in enhancing growth and P nutrition of Chemlali olive seedlings. Acta Horticulture. 1999; 481:701-705.
2. Barthakur BK, Dutta P, Kotoky B,m Karan Singh. Two and a Bud (The j. Of the Tocklai Experimental station). 1992; 39(2):41-42.
3. Barthakur BK, Dutta P, Begum R, Sarmah SR, Gohain KK. Souvenir 32nd Tocklai conference, 1994, 16-17.
4. Bhagyaraj DJ, Suvarna CV. Bio-fertilizers and their application. AGRIEAS. 1999; 1:16-21.
5. Bopaiah BM, Khadeer BA. Effect of biofertilizers on growth of black pepper (*Piper nigrum*). Indian J Agric. Sci. 1989; 59:682-683.
6. Goswami R. Big push for organic tea in India The Telegraph Calcutta times news paper 4th June; Report of the working group on organic tea, 2nd intersessional meeting on 6th may, 2014-2015.
7. Kucey RMN, Janzen HH, Legget ME. Microbial mediated increases in plant available phosphorus. Adv Agron. 1989; 42:1 99-228.
8. FAO. Working group on organic Tea. Intersessional meeting of the intergovernmental group on tea, Rome, 2014, 5-6.
9. Majumder AB, Bera B, Rajan A. Tea Statistics: Global Scenario. Inc. J Tea Sci. 2012; 8(1):121-124.
10. Mamaril CP, Rosales RT, Cabrora MS. Inorganic nitrogen fertilizer and green manure in lowland rice. Paper presented at the INSFFER Planning Meeting Workshop in Hangzhon, China, 1986, 22-24.
11. Marschner P. Marschner's Mineral Nutrition of Higher Plants. 3rd ed. Academic Press, London, UK, 2012, 178-189.
12. Mikhailouskaya N, Bogdevitch I. Effect of biofertilizers on yield and quality of long-fibred flax and cereal grains. Agronomy Research. 2009; 7(I):412-418.
13. Phukan I, Gohain KK, Gosh P. Studies on soil organic matter and the effect of different sources of organic manure on nutrient availability. Souvenir 32nd Tocklai conference, 1994, 16-17.
14. Pandya U, Saraf M. Application of fungi as a biocontrol agent and their biofertilizer potential in agriculture. J Advan. Develop. and Res. 2010; 1:90-99.
15. Prayukth KV. Coomunications Coordinator at the Indo Norwegian Environment Program, in Bangalore, 2005.
16. Singh ID, Nandi NC, Kujur R. Vegetative propagation of tea in sub soils in Dooars. Two and a Bud. 1987; 34(1-2):5-9.
17. Tilak KVBR. Vesicular-arbuscular myccorhizae and *Azospirillum brailiense* rhizocoenosis in pearl millet in semi-arid tropics In: Adholeya A & S. Singh (Eds.) Proceedings of Third National Conference on Mycorrhiza. Tata Energy Research Institute, New Delhi, 1995, 177-179.
18. Timsina J, Connor DJ. Productivity and management of rice-wheat systems: Issues and challenges. Field Crops Research. 2001; 69:93-132.
19. IBEF. India Brand Equity Foundation, 2016. www.teacoffeespiceofindia.com.