Int.J.Curr.Microbiol.App.Sci (2019) *8*(11): 2144-2157

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 11 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.811.249

Efficacy of Indigenous Liquid Compatible Microbial Consortia on Seed Germination and Seedling Vigour in Tomato (*Solanum lycopersicum* L.)

Raghuveer Singh[1*], N. Tiameren Ao[2], Valenta Kangjam[2], L. Daiho[2], Susanta Banik[2] and N. Bidyaleima Chanu[3]

[1]ICAR Research Complex for NEH Region, A.P. Centre, Basar-791101, Arunachal Pradesh, India
[2]Department of Plant Pathology, SASRD, Nagaland University, Medziphema Campus-797106, Nagaland, India
[3]Department of Vegetable Science, College of Horticulture & Forestry, CAU, Pasighat-791102, Arunachal Pradesh, India

**Corresponding author*

Keywords

Indigenous compatible microbial consortia, Tomato, Plant growth promoting activities

Article Info

Accepted:
17 October 2019
Available Online:
10 November 2019

A B S T R A C T

In vitro study conducted to check out the efficacy of indigenous liquid compatible microbial consortia (CMC-1; *P. fluorescens* Pf-2 + *P. fluorescens* Pf-3 + *T. asperellum* T-11 + *T. asperellum* T-14 and CMC-2; *P. fluorescens* Pf-2 + *P. fluorescens* Pf-3 + *T. asperellum* T-11) on plant growth promoting activities like seed germination, seedling vigour index, shoot length, root length, dry and fresh weight of shoot, dry and fresh weight of root was carried out by standard filter paper method. *In vitro* result shows that, CMC-1 significantly increased vigour index of tomato seedlings (124.30 %), including germination per cent (22.99 %), shoot length (83.44 %) and root length (81.37 %) over control at 10 DAS. *In vivo* study also conducted during 2017-18 and 2018-19. *In vivo* experimental results also revealed that, CMC-1 significantly increased seedling vigour index (116.87 % at 20 DAS and 81.14 % at 30 DAS), germination per cent (20.75 % at 10 DAS), shoot length (67.12 % at 20 DAS and 33.74 % at 30 DAS) and root length (103.16 % at 20 DAS and 147.62 % at 30 DAS) over control. Among the tested microbial consortia, outstanding results were obtained in CMC-1 indicating better plant growth promoting potential and thus exhibiting tremendous potential for their commercial exploitation.

Introduction

Tomato is an indispensable vegetable crop which is the major source of nutrients and medicinal values, hence known as 'Neutraceutical vegetable' (Afroz *et al.*, 2009; Saleem *et al.*, 2009; Noureen *et al.*, 2010). Tomato is a highly adaptive to warm season and can be grown successfully in plains as well as in hills. Cultivation of tomato in monsoon season is assuming a great importance in the north-eastern region of India in general and Nagaland in particular owing to its high prices of produce obtained from other parts of the country during this period (Babu, 2006).

Plant growth-promoting rhizobacteria (PGPR) and microorganisms (PGPM) either live together with non PGPR strains in the rhizosphere in different combinations (Vacheron *et al.,* 2013). Considering this community-based living style of PGPR strains, the current trend is to mix BCAs of diverse microbial species having plant growth-promoting activities to achieve desired agricultural outcomes. Application of microbial consortium consisting of efficient strains for biological control may be a superior technique compared to application of alone microbes for managing plant diseases.

Moreover, application of microbes in a consortium may improve efficacy, consistency and reliability of the microbes under diverse environmental and soil conditions soil (Stockwell *et al.,* 2011). Compatible microbes are applied together as a consortium, the crop plants are expected to get a combined benefit of high N and P availabilities for uptake leading to better plant health and yield.

Combining an antagonist bioagent may further facilitate disease free growth of the plants. Therefore, applying microbes as a consortium has great potentiality particularly in modern agriculture where minimization of chemical fertilizers and pesticides is one of the priorities.

However, in most of these studies conducted earlier, the fate of the microbes in soil when inoculated as consortia in the rhizosphere was not assessed and a greater emphasis should therefore be given to this aspect for better utilization of microbial consortia in enhancing their efficacies (Jain *et al.,* 2012; Singh *et al.,* 2013).

Materials and Methods

Preparation of liquid compatible microbial consortia (CMC)

A 250 ml suspension of each selected native isolates of *T. asperellum* (T-11 and T-14) was prepared from 9 days old cultured PDA medium plates. The plates were rinsed with sterile distilled water and the mycelia were carefully scraped off the agar with a bent glass rod. This suspension was filtered through filter paper (Whatman No. 1) to separate the spores from the mycelia. The concentration was adjusted to 3.7×10^8 spores/ml (Dubos, 1987) with the help of haemocytometer.

A 250 ml of each selected native isolates of *P. fluorescens* (Pf-2 and Pf-3) cell suspension was prepared by inoculating the strain into King's B broth followed by shaking for 48 hrs (150 rpm) at room temperature. The bacterial suspension was roughly adjusted optically at 1 x 10^9 cfu/ml (O.D. 600= 1) (Mulya *et al.,* 1996). Liquid consortia were prepared by mixing equal volume of each selected isolate just before use (Srinivasan and Mathivanan, 2009).

In vitro efficacy of liquid CMC on tomato seedlings

The healthy seeds of tomato cv. Pusa Ruby were selected for experimental purpose. The seeds were obtained from local market. Tomato seeds were surface sterilized with 1.0 % sodium hypochlorite for 2 min for all treatments followed by three rinsed with sterile distilled water. The *in vitro* experiment was conducted in a complete randomised design (CRD) and six replications were maintained for each treatment. The total four numbers of treatments viz., T1- CMC-1 (*P. fluorescens* Pf-2 + *P. fluorescens* Pf-3 + *T. asperellum* T-11 + T. asperellum T-14), T2-CMC-2 (*P. fluorescens* Pf-2 + *P. fluorescens*

Pf-3 + *T. asperellum* T-11), T3- chemical control and T4- control were used. This experiment was carried out by standard filter paper method (three layered moistened filter papers in Petri plates, 10 seeds/ plate and 20 seeds/replication) (ISTA, 1993).

Wet seed treatment

The surface sterilized seeds were soaked with liquid formulations of consortia [@ 1.0 % or 10 µl/ 1 g seeds; 10 µl formulation of CMC added in 990 µl of sterile distilled water/1 g seed (400 tomato seeds)] and shade dried in laminar air flow for 5 hrs (Srinivasan and Mathivanan, 2009).

For chemical control treatment

The surface sterilized seeds were treated with captan 50 % WP (seed dressing @ 0.3 % or 3 mg/1 g seed) (Srinivasan and Mathivanan, 2009).

For control treatment

The surface sterilized seeds were soaked in sterile distilled water (@1 ml/1 g seed) and shade dried in laminar air flow for 5 hrs (Srinivasan and Mathivanan, 2009).

In vivo efficacy of liquid CMC on tomato seedlings

Tomato cv. Pusa Ruby seeds were surface sterilized with 1.0 % sodium hypochlorite for 2 min for all treatments followed by three rinsed with sterile distilled water. The *in vivo* experiment was conducted during 2017-18 and 2018-19 in a complete randomised design (CRD) and six replications were maintained for each treatment.

Tomato treated seeds (400 seeds/treatment) were sown in pre sterilized nursery beds with 2 per cent formalin.

Observations and recording procedures

Per cent germination at 10 DAS

Per cent germination was calculated using the following formula –

$$\text{Per cent germination} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Seedlings shoot length and root length (cm)

The root length and shoot length of individual seedlings (10 seedlings/replication) were measured. The shoot length was measured from collar region to the tip of the seedling with the help of a scale and the mean shoot length was expressed in cm. The root length measured from collar region to the tip of primary root with the help of a scale and the mean root length was expressed in cm.

Seedling vigour index (SVI)

The vigour index of seedlings was calculated by adopting the method suggested by Abdul-Baki and Anderson (1973) and expressed in number by using the below formula.

SVI = Germination (%) x [Mean shoot length (cm) + Mean root length (cm)].

Fresh weight (mg) of seedling shoot and root

The fresh weight (mg) of root and shoot of individual seedlings (10 seedlings /replication) were measured.

Dry weight (mg) of seedling shoot and root

The dry weight of root and shoot of individual seedlings (10 seedlings/replication) were measured after oven drying at 60° C (when constant weight obtained) for 24 hrs.

The weight of shoot and root was recorded and mean dry weight of seedlings was calculated and was expressed in mg.

Per cent increase of plant growth promotion over control

Per cent increase (%)

$$= \frac{\text{Treatment value} - \text{Control value}}{\text{Control value}} \times 100$$

Results and Discussion

In vitro efficacy of liquid CMC on tomato seedlings

In vitro study conducted to check out the efficacy of indigenous liquid consortia (CMC-1 and CMC-2) on seed germination, tomato seedling vigour index was carried out by standard filter paper method.

Per cent germination at 10 DAS

Tomato seed germination per cent was significantly higher in the seed treatment with CMC-1 (89.17 %) followed by CMC-2 (80.00 %) and chemical control (74.16 %).

The lowest seed germination per cent was observed in control treatment (72.50 %) (Table 1). These results revealed that the CMC-1 significantly increased seed germination per cent (22.99 %) over control treatment (Table 2). The result of the present finding is in harmony with the finding of Murthy *et al.,* (2013) reported that the application of liquid consortia of *Trichoderma* spp., significantly increased the tomato seed germination per cent at 10 DAS.

Maximum seed germination per cent was obtained from seed treated with *T. harzianum* + *T. asperellum* + *T. viride* (92.00 %) followed by *T. harzianum* + *T. asperellum* (90.0 %) as compared to control (73.8 %).

Seedlings shoot length and root length (cm) at 10 DAS

Among the tested treatments, significantly maximum shoot length and root length was observed in seed treated with CMC-1 (5.54 cm), (5.84 cm) respectively (Table 1) than the other treatment.

Minimum shoot length and root length was observed in control treatment (3.02 cm) and (3.22 cm) respectively (Table 1).

The CMC-1 significantly increased shoot length (83.44 %) and root length (81.37 %) over control treatment (Table 2).

In corroboration to the present work, the application of liquid consortia of *Trichoderma* spp., significantly increased the shoot length and root length of tomato seedling at 10 DAS (Murthy *et al.,* 2013).

Seedling vigour index (SVI) at 10 DAS

Among the tested treatments, significantly maximum seedling vigour index was recorded in seed treated with CMC-1 (1014.75) than the other treatment.

Minimum seedling vigour index was observed in control treatment (452.40) (Table 1). These results revealed that the CMC-1 significantly increased vigour index of tomato seedlings (124.30 %) over control treatment (Table 2).

The finding of present work is in harmony with the finding of Manikandan *et al.,* (2010) recorded plant growth promotion by liquid formulation of *P. fluorescens* Pf1. They found that it significantly promoted tomato plant growth compared to untreated control.

Fresh weight (mg) of seedling shoot and root at 10 DAS

Significantly maximum fresh weight of shoot and root was recorded in CMC-1 (14.44 mg), (0.38 mg) and minimum in control (4.85 mg) and (0.10 mg) respectively (Table 1). These results revealed that the CMC-1 significantly increased shoot fresh weight (197.73 %) and root fresh weight (280.0 %) over control treatment (Table 2). The finding of present work is in agreement with Murthy *et al.*, (2013) reported that application of liquid consortia of *Trichoderma* spp., significantly increased the fresh weight of shoot at 10 DAS.

Dry weight (mg) of seedling shoot and root at 10 DAS

Among the tested treatments, significantly maximum dry weight of shoot and root was recorded in CMC-1 (0.76 mg), (0.05 mg) and minimum in control (0.43 mg) and (0.017 mg) respectively (Table 1). The CMC-1 significantly increased shoot dry weight (76.74 %) and root dry weight (194.12 %) over control treatment (Table 2).

The report of Murthy *et al.*, (2013), that the application of liquid consortia of *Trichoderma* spp., significantly increased the dry weight of shoot at 10 DAS attests the finding of the present investigation.

***In vivo* efficacy of liquid CMC on tomato seedlings**

In vivo study was also carried out during 2017-18 and 2018-19 to check out the efficacy of selected liquid consortia (CMC-1 and CMC-2) on seed germination and tomato seedling vigour index in nursery stage.

Per cent germination at 10 DAS

Tomato seed germination per cent was significantly higher in the seed treatment with CMC-1 (86.76 %) followed by CMC-2 (78.19 %) and chemical control (73.10 %).

The lowest seed germination per cent was observed in control (71.85 %) treatment (Table 3). The result revealed that the CMC-1 significantly increased seed germination per cent (20.75 %) at 10 DAS over control treatment (Table 7).

The results of the present findings confirms the findings of earlier workers (Raj *et al.*, 2004; Manikandan *et al.*, 2010; Bhakthavatchalu *et al.*, 2013; Eutesari *et al.*, 2013).

Seedlings shoot length and root length (cm) at 20 DAS and 30 DAS

Among the tested treatments, significantly longer shoot was recorded in seed treated with CMC-1 (4.88 cm at 20 DAS and 15.22 cm at 30 DAS) than the other treatment (Table 3 and 5). Minimum shoot length was observed in control (2.92 cm at 20 DAS and 11.38 cm at 30 DAS). The CMC-1 significantly increased shoot length (67.12 % at 20 DAS and 33.74 % at 30 DAS) over control treatment (Table 5 and 7).

Maximum root length was recorded in CMC-1 (3.21 cm at 20 DAS and 4.68 cm at 30 DAS) and minimum in control (1.58 cm at 20 DAS and 1.89 cm at 30 DAS). The CMC-1 significantly increased root length (103.16 % at 20 DAS and 147.62 % at 30 DAS) over control treatment (Table 7).

The results of the present findings are in conformity with the findings of earlier workers (Raj *et al.*, 2004; Eutesari *et al.*, 2013; Sandheep *et al.*, 2013).

Table.1 *In vitro* efficacy of liquid CMC on tomato seed germination (%), seedling shoot length, root length, shoot fresh and dry weight, root fresh and dry weight and vigour index at 10 DAS

Treatment	Seed Germination (%) At 10 DAS	Seedling shoot at 10 DAS			Seedling root at 10 DAS			Seedling Vigour index at 10 DAS
		Shoot Length (cm)	Shoot Fresh wt. (mg)	Shoot Dry wt. (mg)	Root Length (cm)	Root Fresh wt. (mg)	Root Dry wt. (mg)	
T_1 (CMC-1)	89.17 (71.88)*	5.54	14.44	0.76	5.84	0.38	0.050	1014.75
T_2 (CMC-2)	80.00 (63.74)	5.00	09.17	0.65	5.21	0.25	0.030	816.80
T_3 (Chemical control)	74.16 (59.94)	3.32	05.35	0.45	3.59	0.14	0.020	512.44
T_4 (Control)	72.50 (58.68)	3.02	04.85	0.43	3.22	0.10	0.017	452.40
SEm±	3.74 (1.88)	0.13	0.56	0.04	0.17	0.05	0.00	30.76
C.V. (%)	11.60 (10.85)	7.38	16.35	17.60	9.24	13.59	14.19	10.78
CD (P=0.01)	12.90 (10.52)	0.51	2.27	0.17	0.68	0.18	0.03	123.76
CD (P=0.05)	11.03 (8.31)	0.37	1.66	0.12	0.50	0.14	0.02	90.74

***Values in parenthesis are angular transformed values.**

Table.2 *In vitro* efficacy of liquid CMC on per cent increase of tomato seed germination (%), shoot length, root length, shoot fresh and dry weight, root fresh and dry weight and seedling vigour index at 10 DAS

Treat.	Per cent increase of plant growth promotion over control at 10 DAS							
	Seed germination (%)	Seedling shoot			Seedling root			Seedling Vigour index
		Shoot Length	Shoot Fresh wt.	Shoot Dry wt.	Root Length	Root Fresh wt.	Root Dry wt.	
T_1 (CMC-1)	22.99	83.44	197.73	76.74	81.37	280.00	194.12	124.30
T_2(CMC-2)	10.34	65.56	89.07	51.16	61.80	150.00	76.47	80.55
T_3(Chemical control)	02.29	09.93	10.31	04.65	11.49	40.00	17.64	13.27
T_4 (Control)	-	-	-	-	-	-	-	-

Table.3 *In vivo* efficacy of liquid CMC on tomato seed germination (%) at 10 DAS, seedling shoot length, root length and vigour index at 20 DAS

Treatment	Seed Germination (%) at 10 DAS			Seedling shoot length (cm) at 20 DAS			Seedling root length (cm) at 20 DAS			Seedling Vigour indexat 20DAS		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-17	Pooled	2017-18	2018-19	Pooled
T_1 (CMC-1)	86.92 (69.06)*	86.61 (68.67)	86.76 (68.82)	4.70	5.06	4.88	3.19	3.23	3.21	685.80	718.00	701.90
T_2 (CMC-2)	78.46 (62.48)	77.93 (62.05)	78.19 (62.26)	3.83	3.92	3.87	2.20	2.41	2.30	473.11	493.30	483.20
T_3 (Chemical control)	73.85 (59.45)	72.36 (58.42)	73.10 (58.93)	2.92	2.99	2.95	1.57	1.63	1.60	331.59	334.30	332.94
T_4 (Control)	72.31 (58.46)	71.39 (57.81)	71.85 (58.12)	2.89	2.95	2.92	1.55	1.62	1.58	321.06	326.25	323.65
SEm±	2.75 (1.88)	2.27 (1.53)	2.44 (1.59)	0.11	0.15	0.09	0.09	0.11	0.09	18.78	15.10	14.72
C.V. (%)	8.65 (7.41)	7.21 (6.07)	7.73 (6.54)	7.71	10.30	6.32	10.67	12.39	10.57	10.16	7.91	7.83
CD (P=0.01)	11.06 (7.59)	9.13 (6.16)	9.83 (6.66)	0.45	0.63	0.38	0.37	0.45	0.38	75.56	60.77	59.22
CD (P=0.05)	8.11 (5.56)	6.70 (4.51)	7.21 (4.88)	0.33	0.46	0.28	0.27	0.33	0.28	55.40	44.56	43.42

*Values in parenthesis are angular transformed values.

Table.4 *In vivo* efficacy of liquid CMC on tomato seedling shoot fresh and dry weight, root fresh and dry weight at 20 DAS

Treatment	Seedling shoot at 20 DAS						Seedling root at 20 DAS					
	Fresh wt. (mg)			Dry wt. (mg)			Fresh wt. (mg)			Dry wt. (mg)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1 (CMC-1)	107.62	114.23	110.92	06.25	06.28	06.26	10.57	10.98	10.76	0.88	0.84	0.86
T_2 (CMC-2)	89.25	95.00	92.12	05.32	05.30	05.31	07.49	08.15	07.82	0.76	0.72	0.74
T_3 (Chemical control)	64.54	63.15	63.84	04.66	04.40	04.53	04.47	04.57	04.52	0.41	0.53	0.47
T_4 (Control)	61.46	62.96	62.21	04.25	04.33	04.29	04.33	04.61	04.47	0.37	0.51	0.44
SEm±	5.30	3.75	3.60	0.28	0.21	0.21	0.52	0.63	0.45	0.07	0.03	0.04
C.V. (%)	16.16	10.95	10.72	13.64	10.18	10.07	19.15	15.84	15.92	11.27	18.18	16.25
CD (P=0.01)	21.32	15.07	14.49	1.15	0.85	0.84	2.11	2.54	1.80	0.30	0.14	0.17
CD (P=0.05)	15.63	11.05	10.62	0.84	0.62	0.62	1.55	1.86	1.32	0.22	0.10	0.12

Table.5 *In vivo* efficacy of liquid CMC on tomato seedling shoot length, root length and vigour index at 30 DAS

Treatment	Seedling shoot length (cm) at 30 DAS			Seedling root length (cm) at 30 DAS			Seedling vigour index at 30 DAS		
	2017-18	2018-19	Pooled	2017-18	2018-17	Pooled	2017-18	2018-19	Pooled
T_1 (CMC-1)	15.08	15.37	15.22	4.79	4.57	4.68	1727.10	1727	1727.05
T_2 (CMC-2)	14.15	14.75	14.45	3.24	3.36	3.30	1364.42	1411.31	1387.86
T_3 (Chemical control)	11.80	11.64	11.72	1.93	1.91	1.92	1013.96	980.48	997.22
T_4 (Control)	11.31	11.45	11.38	1.92	1.86	1.89	956.66	950.20	953.43
SEm±	0.50	0.37	0.32	0.15	0.16	0.11	54.55	44.71	42.37
C.V. (%)	9.35	6.90	5.97	12.85	13.26	8.99	10.56	8.64	8.20
CD (P=0.01)	2.01	1.51	1.29	0.63	0.64	0.43	219.49	179.11	170.49
CD (P=0.05)	1.47	1.10	0.95	0.46	0.47	0.32	160.49	131.91	125.01

Table.6 *In vivo* efficacy of liquid CMC on tomato seedling shoot fresh and dry weight, root fresh and dry weight at 30 DAS

Treatment	Seedling shoot						Seedling root					
	Fresh wt. (mg) at 30 DAS			Dry wt. (mg) at 30 DAS			Fresh wt. (mg) at 30 DAS			Dry wt. (mg) at 30 DAS		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1 (CMC-1)	1103.70	1178.37	1141.03	58.57	65.97	62.27	88.58	98.76	93.67	4.47	5.21	4.84
T_2 (CMC-2)	790.00	798.93	794.46	42.60	43.07	42.83	50.66	52.79	51.72	2.73	2.77	2.75
T_3 (Chemical control)	648.50	631.03	639.76	34.68	30.99	32.83	43.38	41.57	42.47	2.53	2.36	2.44
T_4 (Control)	528.90	611.35	570.12	30.65	30.23	30.48	39.40	39.84	39.62	2.24	2.22	2.23
SEm±	42.94	35.04	33.18	2.50	3.14	2.02	4.06	4.06	3.43	0.25	0.28	0.21
C.V. (%)	13.70	10.66	10.34	14.71	10.09	11.80	17.90	12.39	14.79	19.25	16.54	16.67
CD (P=0.01)	172.75	141.0	133.50	10.06	12.66	8.15	16.32	16.35	13.82	0.99	1.11	0.84
CD (P=0.05)	126.67	103.38	97.89	7.37	9.28	5.78	11.92	11.99	10.13	0.73	0.81	0.61

Table.7 *In vivo* efficacy of liquid CMC on per cent increase of tomato seed germination (%), shoot length, root length, shoot fresh and dry weight, root fresh and dry weight and seedling vigour index

Treat.	Per cent increase of plant growth promotion over control														
	Seed germination (%) At 10 DAS	Seedling shoot						Seedling root						Seedling Vigour index	
		Length		Fresh wt.		Dry wt.		Length		Fresh wt.		Dry wt.			
		At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS	At 20 DAS	At 30 DAS
T_1 (CMC-1)	20.75	67.12	33.74	78.30	100.14	45.92	104.30	103.16	147.62	140.71	136.42	95.45	117.04	116.87	81.14
T_2 (CMC-2)	08.82	32.53	26.98	48.08	39.44	23.78	40.52	45.57	74.60	74.94	30.54	68.18	23.32	49.30	45.56
T_3 (Chemical control)	01.74	01.03	02.99	02.62	12.21	05.59	07.71	01.26	01.59	01.12	07.19	06.82	09.42	02.87	04.59
T_4 (Control)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Seedling vigour index (SVI) at 20 DAS and 30 DAS

Significantly higher seedling vigour index was recorded in CMC-1 (701.90 at 20 DAS and 1727.05 at 30 DAS) and also significantly increased vigour index of tomato seedlings (116.87 % at 20 DAS and 81.14 % at 30 DAS) over control treatment (Table 3, 5 and 7).

The finding of present work is in conformity with the findings of earlier workers (Raj *et al.*, 2004; Bhakthavatchalu *et al.*, 2013; Sudharani *et al.*, 2014).

Fresh weight (mg) of seedling shoot and root at 20 DAS and 30 DAS

Significantly maximum fresh weight of shoot was recorded in CMC-1 (110.92 mg at 20 DAS and 1141.03 mg at 30 DAS) and significantly increased shoot fresh weight (78.30 % at 20 DAS and 100.14 % at 30 DAS) over control treatment (Table 4 and 6).

Among the tested treatments, significantly higher fresh weight of root was recorded in CMC-1 (10.76 mg at 20 DAS and 93.67 mg at 30 DAS) than the other treatment. The CMC-1 significantly increased root fresh weight (140.71 % at 20 DAS and 136.42 % at 30 DAS) over control treatment (Table 4, 6 and 7).

The finding of present work is in agreement with the findings of earlier workers (Sandheep *et al.*, 2013; Kumar *et al.*, 2015; Khan *et al.*, 2018).

Dry weight (mg) of seedling shoot and root at 10 DAS and 30 DAS

Significantly maximum dry weight of shoot was recorded in CMC-1 (6.26 mg at 20 DAS and 62.27 mg at 30 DAS) and minimum in control (4.29 mg at 20 DAS and 30.48 mg at 30 DAS). These result revealed that CMC-1 significantly increased shoot dry weight (45.92 % at 20 DAS and 104.30 % at 30 DAS) over control treatment (Table 4, 6 and 7).

Significantly higher dry weight of root was recorded in seed treated with CMC-1 (0.86 mg at 20 DAS and 4.84 mg at 30 DAS) and significantly increased root dry weight (95.45 % at 20 DAS and 117.04 % at 30 DAS) over control treatment (Table 4, 6 and 7).

The finding of present work is in confirmation with the findings of earlier workers (Eutesari *et al.*, 2013; Sandheep *et al.*, 2013; Kumar *et al.*, 2015; Khan *et al.*, 2018).

In this present investigation, an attempt has been made to study the efficacy of indigenous liquid CMC on tomato seedlings in the plant growth promotion aspect in which effective results were obtained with CMC-1 in both *in vitro* as well as *in vivo* experiments. The improvement in tomato seed germination might be due to reserve mobilization of food materials. The increase in mean tomato seedling dry weight upon CMC-1 treatment may be due to higher metabolic activity that leads to the better mobilization efficiency of stored food that might contribute for the better growth of seedlings which in turn result in increased seed germination, shoot length and root length and hence increase in the mean seedling dry weight. The increase in seedling vigour index upon CMC-1 treatment may be due to increased seed germination percentage, shoot length, root length and dry weight of tomato seedlings.

References

Abdul-Baki, A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science*. 13: 630-633.

Afroz, A., Chaudhry, Z., Khan, R., Rashid, H.

and Khan, S. A. 2009. Effect of GA_3 on regeneration response of three tomato cultivars (*Lycopersicon esculentum*). *Pakistan Journal of Botany*. 41: 143-151.

Babu, N. 2006. Performance of tomato (*Lycopersicon esculentum* L.) as influenced by transplanting times and cultivation methods in foot hills of Nagaland. *Annual Agriculture Research New Series*. 27 (2): 159-161.

Bhakthavatchalu, S., Shivakumar, S. and Sullia, S.B. 2013. Characterization of multiple plant growth promotion traits of *Pseudomonas aeruginosa* FP6, a potential stress tolerant biocontrol agent. *Annals of Biological Research*. 4 (2): 214-223.

Dubos, B. 1987. Fungal antagonism in aerial agrobiocenoses. In: Innovative approaches to plant disease control (ed. I. Chet, W. John, Sons), New York. 107-135.

Eutesari, M., Sharifzadeh, F., Ahmadazadeh, M. and Farhangfar, M. 2013. Seed biopriming with *Trichoderma* sp. and *Pseudomonas fluorescens* on growth parameters, enzymes activity and nutritional status of soybean. *International Journal of Agronomy and Plant Production*. 4 (4): 610-619.

International Seed Testing Association (ISTA). 1993. International rules for seed testing. *Seed Science and Technology*. 21: 1-288.

Jain, A., Singh, S., Sarma, B.K. and Singh, H.B. 2012. Microbial consortium-mediated reprogramming of defence network in pea to enhance tolerance against *Sclerotinia sclerotiorum*. *Journal of Applied Microbiology*. 112: 537-550.

Khan, P., Bora, L. C., Borah, P. K., Bora, P. and Talukdar, K. 2018. Efficacy of microbial consortia against bacterial wilt caused by *Ralstonia solanacearum* in hydroponically grown lettuce plant. *International Journal of Current Microbiology and Applied Sciences.* 7 (6): 3046-3055.

Kumar, M. S.P., Chowdappa, P. and Krishna, V. 2015. Development of seed coating formulation using consortium of *Bacillus subtilis* OTPB1 and *Trichoderma harzianum* OTPB3 for plant growth promotion and induction of systemic resistance in field and horticultural crops. *Indian Phytopathology*. 68 (1): 25-31.

Manikandan, R., Saravanakumar, D., Rajendran, L., Raguchander, T. and Samiyappan, R. 2010. Standardization of liquid formulation of *Pseudomonas fluorescens* Pf 1 for its efficacy against *Fusarium* wilt of tomato. *Biological control*. 54: 83-89.

Mulya, K., Wataneabe, M., Goto, M., Takikawa, Y. and Tsuyumu, S. 1996. Suppression of bacterial wilt disease of tomato by root dipping with *P. fluorescens*. *Annual Phyto pathological Society of Japan*. 62: 134-140.

Murthy, N. K., Devi, N.K. and Srinivas, C. 2013. Efficacy of *Trichoderma asperellum* against *Ralstonia solanacearum* under greenhouse conditions. *Annals of Plant Sciences*. 02 (09): 342-350.

Noureen, F., Jilani, M. S., Waseem, K. and Kiran, M. 2010. Performance of tomato hybrids under hydroponic culture. *Pakistan Journal of Agricultural Science.* 47: 19-25.

Raj, S. N., Shetty, N. P. and Shetty, H. S. 2004. Seed bio-priming with *Pseudomonas fluorescens* isolates enhances growth of pearl millet plants and induces resistance against downy mildew. *International Journal of Pest Management.* 50 (1): 41-48.

Saleem, M., Asghar, M., Haq, M. A., Rafique, T., Kamran, A. and Khan, A. A. 2009. Genetic analysis to identify suitable parents for hybrid seed production in tomato (*Lycopersicon esculentum* Mill.). *Pakistan Journal of Botany*. 41: 1107-1116.

Sandheep, A.R., Asok, A.K. and Jisha, M.S. 2013. Combined inoculation of *Pseudomonas fluorescens* and *Trichoderma harzianum* for enhancing plant growth of vanilla (*Vanilla planifolia*). *Pakistan Journal of Biological Sciences*. 16 (12): 580-584.

Singh, A., Sarma, B.K., Upadhyay, R.S. and Singh, H.B. 2013. Compatible rhizosphere microbes mediated alleviation of biotic stress in chickpea through enhanced antioxidant and phenylpropanoid activities. *Microbiological Research*. 168: 33-40.

Srinivasan, K. and Mathivanan, N. 2009. Biological control of sunflower necrosis virus disease with powder and liquid formulations of plant growth promoting microbial consortia under field conditions. *Biological Control*. 51: 395-402.

Stockwell, V.O., Johnson, K.B., Sugar, D. and Loper, J.E. 2011. Mechanistically compatible mixtures of bacterial antagonists improve biological control of fire blight of pear. *Phytopathology*. 101: 113-123.

Sudharani, M., Shivaprakash, M. K. and Prabhavathi, M.K. 2014. Role of consortia of biocontrol agents and PGPRs in the production of cabbage under nursery condition. *International Journal of Current Microbiology and Applied Science*. 3 (6): 1055-1064.

Vacheron, J., Desbrosses, G., Marie-Lara, B., Touraine, B., Mo€enne-Loccoz, Y., Muller, D., Legendre, L., Wisniewski-Dye, F. and Prigent-Combaret, C. 2013. Plant growth promoting rhizobacteria and root system functioning. *Frontiers in Plant Science*. 4: 356.

How to cite this article:

Raghuveer Singh, N. Tiameren Ao, Valenta Kangjam, L. Daiho, Susanta Banik and Bidyaleima Chanu, N. 2019. Efficacy of Indigenous Liquid Compatible Microbial Consortia on Seed Germination and Seedling Vigour in Tomato (*Solanum lycopersicum* L.). *Int.J.Curr.Microbiol.App.Sci*. 8(11): 2144-2157. doi: https://doi.org/10.20546/ijcmas.2019.811.249