Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 3077-3082

Cheke AS
M.Sc. Agri, Ph.D Agri in Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S), India

Patil VD
Director of Instruction and Dean, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S), India

Srivastava AK
Principal Scientist, National Research Centre for Citrus – [NRCC], Nagpur, (M.S), India

Correspondence
Cheke AS
M.Sc. Agri, Ph.D Agri in Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S)., India

Studies on rhizosphere hybridization and nutrient dynamics in sweet orange seedling from pot culture experiment

Cheke AS, Patil VD and Srivastava AK

Abstract
The research entitled "Studies on rhizosphere hybridization and nutrient dynamics in sweet orange" was conducted during the year 2013-14 two phases. In the first phase, representative soil samples from rhizosphere of sacred *Ficus* species (*Ficus racemosa* L. i.e Umber tree, *Ficus benghalensis* L. i.e. Banyan tree and *Ficus religiosa* L. i.e. Pipal tree) and non rhizosphere soil samples were collected and pot culture experiment was carried out to test the germination of sweet orange seeds. In the second phase, pot culture experiment was carried out with nine set of treatments replicated thrice to study the effect of rhizosphere soil hybridization on growth of sweet orange, soil properties. The results revealed that growth media comprising *Ficus* species rhizosphere soil resulted in improved seed germination and plant growth. Amongst the three species germination percentage of seeds of sweet orange was highest in Umber rhizosphere soil followed by Banyan rhizosphere soil and Pipal rhizosphere soil as compared to non- rhizosphere soil. The growth of sweet orange seedlings was improved in all the rhizosphere and rhizosphere hybridized soils over non rhizosphere and, Sweet orange rhizosphere soil. Amongst all sacred *Ficus* tree species *Ficus racemosa* L. rhizosphere soil was best followed by Banyan rhizosphere soil and Pipal rhizosphere soil. Sacred species rhizosphere soil was slightly acidic to neutral in pH, highest content of organic carbon and lowest level of lime.

Keywords: Rhizosphere, Ficus racemosa, Ficus benghalensis, Ficus religiosa

Introduction

The rhizosphere refers to the soil region nearest to the plant root system and is characterized by a high microbial activity (De Ridder-Duine *et al.*, 2005). Roots release large quantity of metabolites from living root hairs or fibrous root systems into rhizosphere (Nihorimbere *et al.*, 2011). The rhizosphere inhabits lots of soil microorganisms, such as bacteria and fungi, which compete for water, nutrients and space and sometimes improve their competitiveness by developing an intimate association with plant. The metabolites act as chemical signals for bacteria to move to the root surface, also represent the main nutrient sources available to support growth and persistence in the rhizosphere. Some of the microbes that inhabit this area are bacteria that are able to colonize very efficiently the roots or the rhizosphere soil of crop plants. These bacteria are referred to as plant growth promoting rhizobacteria (PGPR). The most common objective of developing microbial consortium is to capitalise on both the capabilities of individual microbes and their interactions to create useful systems in tune with enhanced productivity and, soil health improvements through efficient metabolic functionality (Brenner *et al.*, 2008). Pipal **(***Ficus religiosa* L.), Banyan tree (*Ficus benghalensis* L.) *and* Umber (*Ficus racemosa* L.*)* trees belong to the family *Moraceae.* They are large deciduous trees, distributed throughout India; wild as well as cultivated. Various parts of the plant like bark, leaves, tender shoots, fruits, seeds, and latex are medicinally important.

Materials and Methods

The research entitled "Studies on rhizosphere hybridization and nutrient dynamics in sweet orange" was conducted during the year 2013-14 in two phase's research project was planned and implemented research work. In the first phase, rhizosphere soil samples were collected underneath the sacred three *Ficus* species trees and were tested for its quality by conducting pot culture experiment on seed germination of sweet orange seedlings. While in second phase these three *Ficus* species rhizosphere soils were used to develop the rhizosphere soil microbial consortium. This microbial consortium was tested by conducting the pot culture experiment on sweet orange seedling over a period of 425 days. Treatment details T_1 (NRS) Non rhizosphere soil (Non sweet orange growing orchard), T_2 (NRSW)- Non rhizosphere soil from sweet orange orchard, T_3 PRS *Ficus religiosa* L. (Pipal tree) Rhizosphere soil, T_4 BRS *Ficus* *benghalensis* L. (Banyan tree) Rhizosphere soil, T_5 URS *Ficus racemosa* L. (Umber tree) Rhizosphere soil, T_6 PRS + SRS *Ficus religiosa* L.(Pipal) Rhizosphere soil + Sweet orange tree Rhizosphere soil T_7 BRS + SRS *Ficus benghalensis* L. (Banyan tree) Rhizosphere soil + Sweet orange tree Rhizosphere soil T_8 URS + SRS *Ficus racemosa* L.(Umber) Rhizosphere soil + Sweet orange tree Rhizosphere soil T_9 SRS Sweet orange tree Rhizosphere soil

Following observation was recorded at 137, 273 and 425 Days after Transplanting (DAT).

Observation		**At 137, 273 and 425 (Days After Transplanting) DAT**
Growth observation		Height of sweet orange seedling, Number of leaves, Leaf area and Stem diameter
Soil Analysis	Physical properties	Bulk density, Porosity
	Chemical properties	pH, Electrical conductivity, Organic carbon and Calcium carbonate

Results and Discussion

Effect of Various *Ficus* Species Rhizosphere Soil on Germination of Seeds of Sweet Orange

The data presented in Table 1 on the effect of rhizosphere soils from *Ficus religiosa* L. (Pipal), *Ficus benghalensis* L. (Banyan tree) and *Ficus racemosa* L. (Umber tree) and non rhizosphere soil on germination of seeds of sweet orange revealed that maximum number of seeds were germinated from the rhizosphere soil of Umber tree (100 %) followed by Banyan tree (70 %) and Pipal tree (40%) rhizosphere soil. Lowest germination was recorded in non rhizosphere soil (30 %).

Table 1: Effect of various rhizosphere soil on number of germinated seeds (out of 10) and percent germination.

Symbol	Soil Type	Number of Germinated seed N=10	Seed Germination (%)
T_1	Control (Non rhizosphere)	3	30 (%)
T_2	Rhizosphere soil of *Ficus religiosa* L. (Pipal tree)	4	40 (%)
T_3	Rhizosphere soil of *Ficus benghalensis* L. (Banyan tree)	7	70 (%)
T_4	Rhizosphere soil of *Ficus racemosa* L. (Umber tree)	10	100 (%)

The improvement in germination due to rhizosphere soil may be attributed to the congenial environment created by secretion of roots exudates, enzymes and proton released by roots there by lowering down the pH of root rhizosphere soil. Shen *et al.*, (2001) reported that the acidic pH under most of the tree species was probably due to the release of acidic exudates. Pandey and Palni (2007) further observed decrease in the pH of rhizosphere soil over the non rhizosphere soil samples to the extent of 0.6 to 0.9 units.

Studies on Effect of Rhizosphere Soil Hybridization on Growth of Sweet Orange Seedling

A pot culture experiment consisting nine treatments and 3 replication was conducted during the year 2013-14. The results emerged out are presented in Table 2 to Table 5 and interpreted and discussed below.

Effect of rhizosphere soil hybridization on, growth of sweet orange seedling and Physic-chemical properties of soil Growth parameter of sweet orange seedlings

The data in relation to growth parameters recorded are presented in Table 2 to Table 5.

Height of seedling

The data presented in Table 2, revealed that the initial height of the sweet orange seedling under various treatment was non significant. It was ranged between 23.57 to 34.82 cm. The height of seedling At 137, 273 and 425 Days After Transplanting (DAT) varied from 41.60 to 67.37, 46.22 to 81.70 and 56.78 to 119.52 cm. At 137 DAT maximum incremental height of seedling 41.97 cm was recorded in treatment T_5 i.e. Umber rhizosphere soil (URS) followed by URS+SRS (Umber rhizosphere soil + Sweet orange rhizosphere soil). At 425 DAT same treatment showed maximum height of seedling followed by URS + SRS. The maximum growth rate of sweet orange seedlings was recorded from 273 to 425 DAT.

Table 2: Effect of rhizosphere soil on height (cm) of sweet orange seedling

Symbol	Treatment Details	Initial	137 DAT	IG	273 DAT	IG	CIG	425 DAT	IG	CIG
T_1	NRS	34.82	41.60	10.69	49.08	3.73	14.26	56.78	7.69	21.96
T_2	NRSW	29.30	45.51	12.69	46.22	4.62	16.92	62.63	16.41	33.33
T_3	PRS	29.27	53.33	24.06	70.20	16.67	40.73	88.03	18.03	58.76
T_4	BRS	30.30	64.56	34.26	75.65	12.68	46.93	110.0	32.77	79.70
T_5	URS	25.40	67.37	41.97	81.70	14.33	56.30	119.52	37.82	94.12
T_6	PRS +SRS	33.13	50.44	17.31	66.09	15.65	32.96	79.54	13.45	46.41
T_7	BRS+SRS	24.43	51.27	26.84	69.19	17.92	44.76	84.96	15.77	60.53
T_8	URS+SRS	23.57	57.89	34.33	77.23	17.76	52.08	108.12	30.89	84.55
T_9	SRS	25.51	47.09	21.58	53.61	6.52	28.61	67.23	13.62	41.72
	S. Em.±	2.60	2.65		2.38			3.01		
	C.D. at 5 %	NS	7.94		7.14			9.03		
	Mean	28.41	53.23	24.86	65.44	12.21	37.06	86.31	20.72	57.90

DAT-Days After transplanting, **IG**- Incremental growth, **CIG**- Cumulative Incremental Growth.

Number of leaves and Leaf area

The data presented in table 3 and Table 4 showed increase in number of leaves and leaf area from date of transplanting to 425 DAT. The increase in number of leaves was from 60.42 to 93.67, while leaf area was increased from 14.41 to 33.05 cm^2 at 137 DAT to 425 DAT. At 425 DAT, among the treatments, sweet orange seedling grown in URS recorded significantly higher number of leaves (128.33) followed by

URS+ SRS (119.67), which was at par with URS. The sweet orange seedling grown under PRS (Pipal Rhizosphere Soil) and BRS (Banyan Rhizosphere Soil) and their combinations with SRS (sweet orange rhizosphere soil) showed considerable increase in number of leaves over non rhizosphere soil. Similar trend was recorded in respect of increase in leaf area.

Table 3: Effect of rhizosphere soil on number of leaves in sweet orange seedling

Symbol	Treatment details	Initial	137 DAT	IG	273 DAT	IG	CIG	425 DAT	IG	CIG
T_1	NRS	15.37	37.33	21.96	42.33	5.00	26.96	56.67	14.34	41.3
T_2	NRSW	15.33	40.33	25.00	57.33	17.00	42.00	69.33	12.00	54.00
T_3	PRS	15.67	54.33	38.66	78.00	23.67	62.33	93.00	15.00	77.33
T_4	BRS	15.22	82.74	67.52	90.33	7.59	75.11	111.67	21.34	96.45
T_5	URS	14.33	89.05	74.72	115.67	26.62	101.34	128.33	12.66	114.0
T_6	PRS +SRS	13.33	48.45	35.12	74.33	25.88	61.00	85.71	11.38	72.38
T_7	BRS+SRS	16.00	59.51	43.51	82.33	22.82	66.33	96.33	14.00	80.33
T_8	URS+SRS	20.00	85.74	65.74	92.97	7.23	72.97	119.67	26.70	99.67
T_9	SRS	14.33	46.33	32.00	72.33	26.00	58.00	82.34	10.01	68.01
	S.Em.±	1.27	2.63		4.04			2.95		
	C.D. at 5%	NS	7.89		12.12			8.86		
	Mean	15.51	60.42	44.91	78.40	17.98	62.89	93.67	15.27	78.16

Table 4: Effect of rhizosphere soil on leaf area (cm^2) of sweet orange seedling

Symbol	Treatment details	Initial	137 DAT	IG	273 DAT	IG	CIG	425 DAT	IG	CIG
T_1	NRS	6.12	11.43	5.31	13.81	2.38	7.69	18.1	4.29	11.98
T_2	NRSW	5.78	12.64	6.86	14.68	2.04	8.9	22.45	7.77	16.67
T_3	PRS	6.02	14.28	8.26	22.7	8.42	16.68	33.14	10.44	27.12
T_4	BRS	6.90	16.68	9.78	24.48	7.80	17.58	42.51	18.03	35.61
T_5	URS	7.38	17.83	10.45	26.34	8.51	18.96	45.66	19.32	38.28
T_6	PRS +SRS	7.45	13.51	6.06	20.95	7.44	13.50	30.53	9.58	23.08
T_7	BRS+SRS	6.69	13.94	7.25	21.18	7.24	14.49	32.89	11.71	26.20
T_8	URS+SRS	7.50	16.58	9.08	24.15	7.57	16.65	42.23	18.08	34.73
T_9	SRS	7.62	12.81	5.19	20.19	7.38	12.57	29.95	9.76	22.33
	S.Em.±	0.19	0.54		0.69			1.04		
	C.D. at 5 %	0.56	1.61		2.07			3.13		
	Mean	6.83	14.41	7.58	20.94	6.53	14.11	33.05	12.11	26.22

Stem Diameter

The stem diameter was varied from 6.54 to 7.90 mm at the time of transplanting (Table 5). Data on stem diameter of sweet orange seedling at 137, 273 and 425 days after transplanting are presented in Table 5 showed that the stem diameter was increased from 9.38 to 11.87, 11.72 to 15.54 and 13.89 to 19.40 mm, respectively. The minimum diameter was observed in NRS (9.38, 11.72 and 13.89 mm) and maximum diameter was found in URS (11.87, 15.54 and 19.40 mm) treatment. The exploratory investigation clearly indicated that growing of sweet orange seedling under URS was significantly superior to the rest of the treatments. Next to URS treatment, other treatments followed were BRS, URS+SRS, PRS, BRS+SRS, PRS +SRS and SRS. The minimum stem girth was recorded in non rhizosphere soil.

Table 5: Effect of rhizosphere soil on stem diameter (mm) of sweet orange seedling

Symbol	Treatment Details	Initial	137 DAT	IG	273 DAT	IG	CIG	425 DAT	IG	CIG
T_1	NRS	7.69	9.3 8	1.69	11.72	2.34	4.03	13.89	2.17	6.20
T_2	NRSW	7.43	9.64	2.21	12.58	2.94	5.15	14.68	2.10	7.25
T_3	PRS	7.70	11.25	3.55	13.89	2.64	6.19	16.92	3.03	9.22
T_4	BRS	7.57	11.65	4.08	14.74	3.09	7.17	18.54	3.80	10.97
T_5	URS	6.54	11.87	5.33	15.54	3.67	9.00	19.40	3.86	12.86
T_6	PRS +SRS	7.61	10.2	2.59	12.97	2.77	5.36	15.52	2.55	7.91
T_7	BRS+SRS	7.90	10.92	3.02	13.58	2.66	5.68	15.89	2.31	7.99
T_8	URS+SRS	7.33	11.68	4.35	14.8	3.12	7.47	18.86	4.06	11.53
T_9	SRS	7.01	10.06	3.05	12.79	2.73	5.78	15.29	2.50	8.28
	S.Em.±	0.46	0.31		0.52			0.68		
	C.D. at 5 %	NS	0.94		1.55			2.03		
	Mean	7.42	10.91	3.32	13.62	2.88	6.20	16.55	2.93	9.13

Improvement in the growth parameters viz. Height of seedling, Number of leaves, Leaf area and Stem diameter due to rhizosphere soil in general and URS in particular was attributed to the secretion of acidic root exudates, enzymes protons and mucilages. These substances produced by tree roots might be responsible for multiplication and development of microbes and microbial activities around the roots. These processes are responsible for transfer of water and nutrients to the functional roots due to which congenial environment around the roots results in vigorous growth of sweet orange seedlings. The synergetic effects of rhizosphere soil making the soil condition favorable for growth of plants are reported by Amellal *et al.*, (1998) and Srivastava *et al.*, (2000).

Effect of Rhizosphere soil on physical properties of sweet orange growing pot culture soil

The data tabulated on physical properties of soil (Bulk density and Porosity) of pot culture experiment are presented in Table 6.

Bulk density

The data on bulk density and porosity as influenced by various treatments are presented in Table 6. It was evidenced that on an average the bulk density was not influenced significantly at various stages of seedling. It was ranged between 1.30 to 1.36 Mg m^{-3}. At the time of transplanting (Initial stage) bulk density was lowest in treatment T_5 (URS) followed by URS+SRS, BRS, PRS, BRS+SRS and PRS+SRS, which was 1.13, 1.16, 1.18, 1.21, 1.23 and 1.27 Mg m^{-3}, respectively. The highest bulk density was recorded in NRS (1.74 Mg m^{-3}). Further it was observed that with increase in growth stages the bulk density was increased.

The Porosity

The data regarding percent porosity at different growth stages are presented in Table 6. At initial stage the percent porosity was varied between 34.58 to 54.69 %.

The lowest porosity was found in NRS treatment at 137, 273 and 425 DAT, respectively. While highest porosity was in the pots treated with (*Ficus racemosa* L. (Umber tree) Rhizosphere soil) treatment (53.88, 53.48 and 52.55 %, respectively). There was significant decrease in porosity from 137 to 425 DAT in all the treatments.

In the present investigation lower bulk density and more porosity was recorded in URS followed by BRS and PRS as well as in hybridized soil of *Ficus* rhizosphere soils and sweet orange orchard rhizosphere soil. Brady and Weil (2002) represented low bulk density in Histisols as compared to mineral soil. Similarly, Viro(1951) and Tamminen (1991) reported lower bulk density in forest soil.

Table 6: Effect of rhizosphere soil on bulk density (Mg m^{-3}) and porosity (%) of sweet orange growing pot culture soil

Treatment Symbol	Treatment	Bulk density (Mg m^{-3})				Porosity (%)			
		Initial	137 DAT	273 DAT	425 DAT	Initial	137 DAT	273 DAT	425 DAT
T_1	NRS	1.74	1.75	1.76	1.79	34.58	34.20	33.82	32.70
T_2	NRSW	1.43	1.45	1.47	1.50	39.80	38.95	38.11	36.85
T_3	PRS	1.21	1.23	1.25	1.30	50.63	49.82	49.00	47.10
T_4	BRS	1.18	1.19	1.19	1.24	51.29	50.73	50.74	48.80
T_5	URS	1.13	1.15	1.16	1.18	54.69	53.88	53.48	52.55
T_6	PRS +SRS	1.27	1.28	1.30	1.33	47.72	46.89	46.06	44.80
T_7	BRS+SRS	1.23	1.25	1.27	1.29	49.82	49.03	48.18	47.37
T_8	URS+SRS	1.16	1.17	1.18	1.21	53.95	53.55	53.15	51.96
T_9	SRS	1.38	1.41	1.42	1.43	40.13	38.38	37.95	37.65
	S.Em.±	0.02	0.03	0.03	0.03	0.90	0.90	1.16	0.81
	C.D. at 5(%)	0.07	0.08	0.08	0.10	2.71	2.71	3.46	2.42
	Mean	1.30	1.32	1.33	1.36	46.96	46.16	45.61	44.42

Effect of rhizosphere soil on chemical properties of sweet orange growing pot culture soil

The data in respect of chemical properties under various treatments at different Days after Transplanting (DAT) are given in Table 7.

pH

The data presented in Table 7 clearly indicated that at initial stage rhizosphere soils (Treatment T_2 to T_8) had lower pH values. Among these treatments pH was varied between 6.61 (URS) to 7.80 (NRSW), while NRS recorded maximum pH i.e. 8.17. Even through the treatment differences were non significant, there was increase in pH with each stage of seedling growth up to 273DAT. At 425 DAT significantly low pH value 6.63 was seen in URS, while significantly high pH value was recorded in NRS (8.21). The pH of the tree rhizosphere soil generally ranged from well below to just above 7. Among various rhizosphere soils, URS showed lowest pH value followed by other *Ficus* species and hybridized soil of *Ficus* species. Further release of acidic exudates decreases the pH of rhizosphere soil (Shen *et al.,* 2001; Radhapriya *et al.,* 2013; Mukhopadhyay *et al.,* 2013). Dinesh *et al.,* (2010) showed variation in rhizosphere pH due to different tree species, while Shilpkar *et al.,*(2010) showed seasonal variation in pH of some rhizosphere soil.

Electrical conductivity

The data depicted in Table 7, revealed that the electrical conductivity was found to be low in rhizosphere soil as compared to non rhizosphere soil at all stages of seedling growth. Significantly lowest electrical conductivity was recorded in URS which was 0.15, 0.14 and 0.16 dSm^{-1} at 137, 273 and 425 DAT, respectively, while NRS showed significantly higher EC values of 0.51, 0.53, 0.55 and 0.58 dSm^{-1} at initial, 137, 273 and 425 DAT, respectively. The electrical conductivity was found to be low in rhizosphere soil than the non rhizosphere soil. There was little increase in EC over a period of time, however differences were very narrow. The EC under various rhizospheres was variable. The observed variation in the EC is probably due to variation in root exudates of the tree species. Shen *et al.,* (2001) reported that root exudates increase salinity of the rhizosphere soil.

Table 7: Effect of rhizosphere soil on pH and electrical conductivity (dSm^{-1}) of sweet orange growing pot culture soil

Treatment Symbol	Treatment	pH				Electrical conductivity (dSm^{-1})			
		Initial	137 DAT	273 DAT	425 DAT	Initial	137 DAT	273 DAT	425 DAT
T_1	NRS	8.17	8.18	8.19	8.21	0.51	0.53	0.55	0.58
T_2	NRSW	7.80	7.81	7.81	7.83	0.34	0.35	0.37	0.38
T_3	PRS	6.94	6.94	6.93	6.95	0.23	0.23	0.23	0.24
T_4	BRS	6.77	7.17	7.18	7.19	0.20	0.21	0.21	0.21
T_5	URS	6.61	6.61	6.61	6.63	0.14	0.15	0.14	0.16
T_6	PRS +SRS	7.09	7.09	7.09	7.01	0.27	0.27	0.28	0.29
T_7	BRS+SRS	7.00	7.00	7.02	7.04	0.25	0.26	0.26	0.27
T_8	URS+SRS	7.03	7.03	7.03	7.04	0.22	0.23	0.23	0.24
T_9	SRS	7.63	7.63	7.64	7.67	0.24	0.28	0.31	0.36
	S.Em. ±	0.27	0.37	0.29	0.28	0.07	0.07	0.08	0.08
	C.D. at 5 (%)	NS	NS	NS	0.84	0.21	0.21	0.23	0.23
	Mean	7.23	7.27	7.28	7.29	0.27	0.28	0.29	0.30

Organic carbon

The organic carbon content showed very high degree of variation among (Table 8) the treatments. The organic carbon content of sacred tree species rhizosphere soil was nearly 4 to 7 times more than non rhizosphere soil (Treatment T_1 and T_2). Among the sacred tree species URS had highest organic carbon content (28.15 g kg^{-1}) followed by BRS (24.15 g kg^{-1}) and PRS (21.41 g kg^{-1}). Further combination of sacred tree species rhizosphere soil with sweet orange rhizosphere soil recorded more organic carbon values (14.21 g kg^{-1} in PRS+ SRS, 15.72 g kg^{-1} in BRS +SRS, and 18.48 g kg^{-1} in URS +SRS). The NRS showed very low organic carbon (3.75 g kg^{-1}). Among the NRSW and SRS, the sweet orange rhizosphere soil had highest organic carbon content (7.72 g kg^{-1}), while NRSW has lower organic carbon content (7.55 g kg^{-1}). In general there was decrease in organic carbon content from initial to 425 DAT in all the treatments. Very high degree of organic carbon content in rhizosphere soil of URS, BRS and PRS was ascribed to the habitat of sacred tree species. The continuous addition of dead, semi dead leaves, branches, twings, fruits, sheets of birds found to be responsible in improving the high organic carbon content. Further the dense root system and its exudates also add organic carbon. In addition, the rate of decomposition of organic matter was low underneath the tree because of low temperature that varies between 22 ^{0}C to 27 ^{0}C. Many research papers (Lynch and Whips, 1991; Priha *et al*., 1999; Bielinska, 2008) indicated that rhizosphere zone soils contain higher concentration of soluble carbon than non rhizosphere zone soils.

Calcium carbonate content

At initial stage the calcium carbonate content of sacred tree species rhizosphere soil was 2.31 g kg^{-1} (URS), 3.74 g kg^{-1}(BRS) and 4.99 g kg^{-1} (PRS). While Non rhizosphere soil showed 9.17 g kg^{-1} and non rhizosphere soil of sweet orange orchard recorded 7.13 g kg^{-1}. Treatment T_6, T_7 and T_8 i.e. PRS+SRS, BRS+SRS and URS + SRS also recorded lower calcium carbonate content than Non rhizosphere soil. Irrespective of treatment the calcium carbonate content was decreased from initial to final stage of experiment.

The lower content of free calcium carbonate in sacred tree rhizosphere was probably due to high organic carbon, acidic secretions and higher concentration of CO_2 which in turn solublize the insoluble calcium carbonate in to soluble calcium bicarbonate. The similar effect of high organic matter content on calcium carbonate was also recorded by Patil, 1997, 2013.

Table 8: Effect of rhizosphere soil on organic carbon (g kg^{-1}) and calcium carbonate content (g kg^{-1}) of sweet orange growing pot culture soil

Treatment Symbol	Treatment	Organic carbon (g kg^{-1})				Calcium carbonate (g kg^{-1})			
		Initial	137 DAT	273 DAT	425 DAT	Initial	137 DAT	273 DAT	425 DAT
T_1	NRS	3.75	2.98	2.25	1.94	9.17	9.18	9.20	9.23
T_2	NRSW	7.55	6.89	6.17	4.80	7.13	7.72	7.75	7.74
T_3	PRS	21.41	20.31	19.89	17.83	4.99	4.86	4.62	3.18
T_4	BRS	24.15	23.28	21.11	18.58	3.74	3.60	3.44	2.15
T_5	URS	28.15	27.66	25.50	23.09	2.31	2.11	1.98	1.85
T_6	PRS +SRS	14.21	13.57	12.16	10.26	5.85	5.68	5.43	4.89
T_7	BRS+SRS	15.72	14.96	13.65	11.34	5.21	5.09	4.82	4.29
T_8	URS+SRS	18.48	17.39	15.90	13.14	4.63	4.46	4.24	3.62
T_9	SRS	7.72	7.05	5.80	5.07	5.87	5.86	5.87	5.88
	S.Em.±	0.43	0.28	0.43	0.40	0.11	0.11	0.13	0.08
	C.D. at 5 (%)	1.28	0.84	1.28	1.19	0.32	0.33	0.40	0.25
	Mean	15.68	14.90	13.60	11.78	5.43	5.40	5.26	4.76

Conclusions

1. Growth media comprising *Ficus* species rhizosphere soil resulted in improved seed germination and plant growth. Amongst the three species germination percentage of seeds of sweet orange was highest in Umber rhizosphere soil followed by Banyan rhizosphere soil and Pipal rhizosphere soil as compared to Non- rhizosphere soil.
2. Growth of sweet orange seedlings found to be improved in all the rhizosphere and rhizosphere hybridized soils over non rhizosphere and, Sweet orange rhizosphere soil. Amongst all sacred *Ficus* tree species *Ficus racemosa* L. rhizosphere soil was best followed by Banyan rhizosphere soil and Pipal rhizosphere soil.
3. Initial properties of these rhizosphere soils showed slightly acidic to neutral in pH, highest content of organic carbon and lowest level of lime.

References

1. Amellal N, Burtin G, Bartoli F, Heulin T. Colonization of wheat roots by an exopolysaccharide-producing *pantoea agglomerans* strain and its effect on rhizosphere soil aggregation. Applied and Environmental Microbiology. 1998; 64(10):3740-3747.
2. Bielinska EJ. Enzymatic activity of soil in sour chery orchard depending on cultiviation method. Rozprawy Naukowe Akademii Rolniczej Lublinie. 2008; 251:432-436.
3. Ridder-Duine De, Kowalchuk A, Paulien JA, Gunnewiek K, Wiecher S, Johannes A *et al.* Rhizosphere bacterial community composition in natural stands of *Carex arenaria* (sand sedge) is determined by bulk soil community composition. Soil Biology and Biochemistry. 2005; 37:349-357.
4. Dinesh R, Srinivasan V, Hamza S, Parthasarathy VA, Aipe KC. Physico-chemical, biochemical and microbial properties of the rhizospheric soils of tree species used as supports for black pepper cultivation in the humid tropics. Journal of Geoderma. 2010; 158:252- 258.
5. Lynch JM, Whipps JM. Substrate flow in the rhizosphere. In: The rhizosphere and plant growth. In: Keister, D.L, Cregan, B. (Beltsville Symposium Agriculture Research., Kluwer, Dordrecht, the Netherlands, 1991, 15-24
6. Mukhopadhyaya S, Maitia SK, Mastob RE. Use of Reclaimed Mine Soil Index (RMSI) for screening of tree species for reclamation of coal mine degraded land Journal of Ecological Engineering. 2013; 57:133-142.
7. Nihorimbere V, Ongena M, Smargiassi M, Thonart P. Beneficial effect of the rhizosphere microbial community for plant growth and health. Biotechnology Agronomy Society. 2011; 15:327-337.
8. Pandey S, Palni LMS. The rhizosphere effect in trees of the Indian Central Himalaya with special reference to altitude. Applied Ecology and Environmental Research. 2007; 5:93-102.
9. Patil VD. Assessment of chemical and biochemical indices for diagnosting zinc deficiency and soil associated facters of citrus nutrition. Ph.D Thesis submitted Marathwada Krishi Vidyapeeth, Parbhani. (M.S), 1997.
10. Patil VD. Assessment of chemical and biochemical indices for diagnosting zinc deficiency and soil associated facters of citrus (*Citrus sinensis* L. Osbeck.) nutrition. VIIth IS on Mineral Nutrition of Fruit Crops. Acta Horticulture. 2013; 984:297-305.
11. Radhapriya P, Ramachandran A, Dhanya P, Remya K, Malini P. An appraisal of physico-chemical and microbiological characteristics of Nanmangalam. Reserve forest soil. Journal of Environmental Biology. 2013; 35:1137-1144.
12. Shen H, Wang XC, Shi WM. Isolation and identification of specific root exudates in elephant grass in response to mobilization of iron- and aluminum- phosphates. Journal of Plant Nutrition. 2001; 24:1117-1130.
13. Shilpkar P, Shah MC, Modi KR, Patel SM. Seasonal changes in microbial community structure and nutrients content in rhizospheric soil of *Aegle marmelos* tree. Annals Forest Research. 2010; 53(2):135-140.
14. Srivastava AK, Singh S, Huchche AD. An analysis on citrus flowering a review. Agriculture Review. 2000; 21(1):1-15.
15. Tamminen P. Kangasmaan ravinnetunnusten ilmaiseminen ja viljavuuden alueellinen vaihtelu Etela-Suomessa. Summary: Expression of soil nutrient status and regional variation in soil fertility of forested sites in southern Finland. Folia Forest-Talia. 1991; 27:40.
16. Viro PJ. Nutrient status and fertility of forest soil. I. Pine stands. Communication Instand Forest Pennular. 1951; 39(4):54.