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# Rhizosphere hybridization: Soil nutrient availability

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## Abstract
This review paper critically assesses the literature on soil-microbe-plant interactions influencing availability of micronutrients in the rhizosphere. The research entitled **"**Effect of rhizsophere hybridization on macro and micronutrient activities of soil" was conducted during the year 2013-14 in three 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 replicated thrice, to study the effect of rhizosphere soil hybridization on growth of sweet orange seedling, soil macro and micro nutrients in 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. Further the Umber rhizosphere soil recorded maximum content of available N, P, K, etc.

**Keywords:** Rhizosphere Hybridization, Sweet orange**,** Ficus racemosa, Ficus benghalensis Ficus religiosa, Nutrient availability

## Introduction
A narrow zone of soil affected by the presence of plant roots is defined as rhizosphere. The rhizosphere is known to be a hot spot of microbial activities. This is caused by an increased nutrient supply for microorganisms, since roots release a multitude of organic compounds (e.g., exudates and mucilage) derived from photosynthesis and other plant processes (Brimecombe *et al.* 2007). The concept of "rhizosphere hybridization" is (Srivastava *et al.*, 2015). Therefore, advocated to harness the value added benefit of nutrient -microbe synergy, besides providing dynamism to microbial consortium suiting to wide range of perennial fruits (Srivastava *et al.*, 2015).Therefore, rhizosphere is an environment with a high microbial diversity. Micronutrient availability in the rhizosphere is controlled by soil and plant properties, and interactions of roots with microorganisms and the surrounding soil. Plants exude a variety of organic compounds (carboxylate anions, phenolics, carbohydrates, amino acids, enzymes, etc.) and inorganic ions (protons, phosphate, etc.) to change chemistry and biology of the rhizosphere and increase micronutrient availability. Increased availability may result from solubilisation and mobilization by short-chain organic acid anions, amino acids and other low-molecular-weight organic compounds. Acidification of the rhizosphere soil increases mobilization of micronutrients (eg. for Zn, 100-fold increase in solubility for each unit of pH decrease). Pipal **(***Ficus religiosa* L.), Banyan tree (*Ficus benghalensis* L.) *and* Umber (*Ficus racemosa* L.) trees belong to the family *Moraceae.*

## Materials and methods
To increase reliability of results 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.

## Selection of tree species
Three *Ficus* species trees were selected. These are viz. Pipal tree i.e *Ficus religiosa* (L.), Banyan tree i.e *Ficus benghalensis* (L.) and Umbar tree i.e *Ficus racemosa* (L.).

### Collection of rhizosphere soil samples
The rhizosphere soil samples were collected from of three different *Ficus* species trees Viz. *Ficus religiosa* L. (Pipal), *Ficus benghalensis* L. (Banyan tree) and *Ficus racemosa* L. (Umber tree). Nearly 200 kg rhizosphere soil samples were collected from a depth of 0 to 20 cm underneath the trees through root rhizosphere.

### Effect of rhizosphere soil hybridization on growth of sweet orange seedling
In phase 2, pot culture experiment was conducted during September 2013 to October 2014, to study the effect of rhizosphere soil and their hybridization on soil microbial population and its effects on growth of sweet orange seedling. There were nine treatments and three replication.

### Filling of pots
Three rhizosphere soil samples collected from three *Ficus* species, three hybridized soils (In the proportion of 1:1), one non rhizosphere soil from non-sweet orange orchard, one soil sample from non rhizosphere soil of sweet orange orchard and one rhizosphere soil sample from healthy sweet orange tree were filled in nine pots having capacity of 15 kg. These were replicated thrice. In all there were 27 pots in the experiment. Before filling the soil in earthen pots, earthen pots were lined up by polythene paper to avoid the nutrient losses. The rock fragments, pebbles etc. were removed from soils and air dried 15 kg soils were filled in pots.

### Observations recorded
**Following observation were recorded at 137, 273 and 425 Days after Transplanting (DAT).**

| Observation | | At 137, 273 and 425 (Days After Transplanting) DAT |
|---|---|---|
| | | Soil analysis |
| | Macro nutrients | Available nitrogen, Available phosphorus, Available potassium and Available sulphur |
| | Micronutrients | Available-Fe, Available-Mn, Available-Cu, Available Zn and Available-B |

### Results and discussion
The present investigation was undertaken under the title of "Effect of rhizosphere hybridization on growth of sweet orange seedling and, macro and micronutrient activities of soil**"** during the year 2013 -2014. In this research project, the study was conducted in 2 phases.

### Effect of Rhizosphere Soil Hybridization on Growth of Sweet Orange Seedling
A pot culture experiment consisting nine treatments ($T_1$ Non rhizosphere soil (non-sweet orange growing orchard -NRS), $T_2$ Non rhizosphere soil from sweet orange orchard-NRSW, $T_3$ *Ficus religiosa* L. (Pipal tree) Rhizosphere soil- PRS, $T_4$ *Ficus benghalensis* L. (Banyan tree) Rhizosphere soil- BRS, $T_5$ *Ficus racemosa* L. (Umber tree) Rhizosphere soil- URS, $T_6$ *Ficus religiosa* L.(Pipal tree) Rhizosphere soil + Sweet orange orchard Rhizosphere soil -PRS + SRS, $T_7$ *Ficus benghalensis* L. (Banyan tree) Rhizosphere soil + Sweet orange orchard Rhizosphere soil - BRS + SRS, $T_8$ *Ficus racemosa* L. (Umber tree) Rhizosphere soil + Sweet orange orchard Rhizosphere soil- URS + SRS, and $T_9$ Sweet orange orchard rhizosphere soil- SRS) was conducted during the year 2013-14. The results emerged out are presented in Table and interpreted and discussed below.

### Effect of rhizosphere soil on macro nutrient in sweet orange growing pot culture soil
The data presented in Table 1 showed the available nitrogen and available phosphorus content as influenced by various rhizosphere soils and their combinations with SRS (Sweet orange rhizosphere soil).

### Available nitrogen
The available N content at inception of experiment in URS, BRS and PRS was 1226.73, 1207.15 and 1084.82 kg $ha^{-1}$. This shows very high initial available N status in these rhizosphere soils. Among these, *Ficus* tree species URS showed highest available N content. It was also observed that when sweet orange orchard rhizosphere soil (618.87 kg $ha^{-1}$) was combined with *Ficus* tree species rhizosphere soil, the available N content was increased. It was between 794.57 to 872.31 kg $ha^{-1}$.The non rhizosphere soil depicted 223.87 to 520.12 kg $ha^{-1}$, which was significantly lower than rhizosphere soil. Further it was noticed that available N content was decreased from initial stage of experiment (Day of transplanting) to final stage of experiment (425 DAT).The average decrease in available N content was from 823.22 kg $ha^{-1}$ to 713.54 kg $ha^{-1}$ over a period of 425 Days.

### Available phosphorus
At initial stage, the available $P_2O_5$ content in sacred tree rhizosphere soil was 38.91 kg $ha^{-1}$ in URS, 35.20 kg $ha^{-1}$ in BRS and 32.12 kg $ha^{-1}$ in PRS followed by combination of *Ficus* species rhizosphere soil. The significantly lower available $P_2O_5$ content was found in NRS (10.38 kg $ha^{-1}$ control) and NRS from sweet orange orchard (18.08 kg $ha^{-1}$). Further available $P_2O_5$ content was decreased from 25.85 kg $ha^{-1}$ to 16.48 kg $ha^{-1}$ during seedling growth period from 137 to 425 DAT.

### Available potassium
In general average available potassium content of nine treatments was 1226.18 kg $ha^{-1}$ at initial stage, 1208 kg $ha^{-1}$ at 137 DAT, 1187.50 kg $ha^{-1}$ at 273 DAT and 1151.59 kg $ha^{-1}$ at 425 DAT, which shows gradual decrease in available potassium (Table 1). Among the various rhizosphere soils URS recorded 2341.39 kg $ha^{-1}$ $K_2O$ showing significantly higher available $K_2O$ over rest of the treatments, followed by BRS (2149.91 kg $ha^{-1}$) and PRS (1454.07 kg $ha^{-1}$). Among the sweet orange growing orchards NRS content 447.49 kg $ha^{-1}$ $K_2O$, while rhizosphere soil content relatively higher $K_2O$ (670.87 kg $ha^{-1}$) than NRS. The control i.e. NRS content significantly low availability of potassium among all treatments.

### Available sulphur
Fourth important macro nutrient in sweet orange nutrition is sulphur. It's availability under nine treatments (Table 1) shows pronounced variability at initial stage and it was continued till the end of experiment. As observed earlier in respect of higher availability of N, P and K content in sacred *Ficus* tree rhizosphere soil. The trend was continued for sulphur content too. The maximum available sulphur content was in URS followed by BRS, PRS, URS+SRS, BRS+SRS and PRS+ SRS. Non rhizosphere soil ($T_1$) and NRSW ($T_2$) evidenced lower availability of sulphur amongst all

treatments.

Rhizosphere soil affects availability of nitrogen, phosphorus, potassium and sulphur through its mineralization. The data presented in Table 1 shows very high availability of N, P, K and S in rhizosphere soil over non rhizosphere soil. The availability of these nutrients in rhizosphere soil primarily resulted from the rhizosphere "Priming Effect" on soil organic matter decomposition. (Phillps and Fahey, 2006). More also, Bardgett *et al.*, (1999) observed microbial communities nutrient recycling and nitrogen availability to the plant markedly differ in soils planted with different plants. They explained these differences largely in terms of variations in exudation pattern and plant nutrient acquisition strategies. Although the roots are predominant factors governing soil properties in the rhizosphere, litter fall and its decomposition play an important role in relationships between plant and soils including the rhizosphere and non rhizosphere (Reich *et al*., 2005). The higher availability of the nutrients in URS, BRS, PRS and its hybridization with SRS in the present investigation indicates that, the phosphorus accumulated in the rhizosphere is immediately taken up by the plant. Plant roots may influence the availability and uptake of mineral nutrients by mechanisms such as the release of root exudates, protons, bicarbonates ions and ectoenzymes.

Foehse *et al.*, (1991) found that a higher concentration of phosphorus at the root hair surface caused a higher influx. In respect of potassium many authors have already observed an increase in exchangeable potassium in the rhizosphere soil. The higher available sulphur status in the rhizosphere soil was mainly due to high organic matter and microbial activity. Lin *et al*., (2004) observations are in accordance with the present results, They stated these soil microorganisms are involved in transformation of organic matter enriching soils and they are also a 'source' and 'pool' of soil nutrients such as nitrogen, phosphorus and sulphur. Higher level of N, P, K and S in rhizosphere soil was also reported by (Qureshi *et al*., 2012)

**Table 1:** Effect of rhizosphere soil on available N, P, K and S content (kg $ha^{-1}$) of sweet orange growing pot culture soil

| Treatment Symbol | Treatment | Available N (kg $ha^{-1}$) | | | | Available $P_2O_5$ (kg $ha^{-1}$) | | | | Available $K_2O$ (kg $ha^{-1}$) | | | | Available sulphur (mg $kg^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT |
| $T_1$ | NRS | 223.87 | 198.81 | 166.58 | 131.45 | 10.38 | 8.84 | 6.29 | 2.93 | 369.66 | 361.99 | 352.90 | 340.24 | 11.36 | 10.15 | 8.56 | 7.62 |
| $T_2$ | NRSW | 520.12 | 496.84 | 462.18 | 423.35 | 18.08 | 15.51 | 12.34 | 7.80 | 447.49 | 437.46 | 423.66 | 398.51 | 12.37 | 12.05 | 10.36 | 8.18 |
| $T_3$ | PRS | 1084.82 | 1055.61 | 1016.10 | 973.39 | 32.12 | 28.64 | 23.52 | 21.07 | 1454.07 | 1438.66 | 1416.56 | 1382.39 | 19.95 | 18.42 | 16.69 | 14.68 |
| $T_4$ | BRS | 1207.15 | 1172.98 | 1136.24 | 1089.44 | 35.20 | 34.31 | 31.41 | 27.15 | 2149.91 | 2131.56 | 2103.09 | 2061.47 | 24.20 | 23.58 | 22.72 | 21.28 |
| $T_5$ | URS | 1226.73 | 1206.03 | 1167.83 | 1118.92 | 38.91 | 36.12 | 33.71 | 28.85 | 2341.39 | 2311.03 | 2278.88 | 2213.87 | 28.21 | 26.48 | 25.20 | 24.39 |
| $T_6$ | PRS +SRS | 794.57 | 752.93 | 729.33 | 688.95 | 24.43 | 22.49 | 18.98 | 15.52 | 940.79 | 932.46 | 914.26 | 886.20 | 16.10 | 15.34 | 13.27 | 11.36 |
| $T_7$ | BRS+SRS | 860.54 | 823.07 | 786.45 | 746.94 | 25.56 | 26.18 | 22.51 | 17.44 | 1273.90 | 1251.89 | 1234.51 | 1203.71 | 18.34 | 17.46 | 16.58 | 14.69 |
| $T_8$ | URS+SRS | 872.31 | 837.82 | 800.23 | 752.91 | 28.22 | 26.80 | 23.72 | 17.75 | 1387.56 | 1355.99 | 1319.08 | 1259.66 | 20.42 | 19.13 | 18.70 | 16.46 |
| $T_9$ | SRS | 618.87 | 588.08 | 547.10 | 496.55 | 19.78 | 17.33 | 13.50 | 9.79 | 670.87 | 659.83 | 644.60 | 618.33 | 14.95 | 13.55 | 11.27 | 8.85 |
| | S.Em.± | 19.52 | 16.24 | 23.19 | 12.63 | 0.50 | 0.53 | 0.38 | 0.36 | 34.64 | 23.79 | 35.60 | 33.55 | 0.51 | 0.33 | 0.25 | 0.30 |
| | C.D. at 5(%) | 58.51 | 48.68 | 69.52 | 37.87 | 1.50 | 1.59 | 1.12 | 1.06 | 103.85 | 71.33 | 106.74 | 100.60 | 1.54 | 0.99 | 0.74 | 0.90 |
| | Mean | 823.22 | 792.46 | 756.89 | 713.54 | 25.85 | 24.02 | 20.66 | 16.48 | 1226.18 | 1208.99 | 1187.50 | 1151.60 | 18.43 | 17.35 | 15.93 | 14.17 |

**Effect of rhizosphere soil on micronutrient content in sweet orange growing pot culture soil**

The data pertaining to the DTPA-Extractable Fe, Mn, Zn, Cu and hot water soluble boron are presented in Table 2

**Available Iron**

The data presented in Table 2 indicates the available iron content in URS was to the extent of 18.89 mg $kg^{-1}$ at inception of pot culture experiment. Next to URS, BRS showed 16.63 mg $kg^{-1}$ followed by PRS. In depth scrutiny of data revealed that sacred *Ficus* tree species rhizosphere soil in combination with SRS recorded higher DTPA-Iron. The Non rhizosphere soil (control) had lowest DTPA-Fe than rhizosphere soil. The DTPA-Fe content was decreased with increase in the growth period. The decrease was from 11.56 mg $kg^{-1}$ DTPA-Fe to 8.95 mg $kg^{-1}$ DTPA-Fe.

**Available Manganese**

The content of DTPA-Mn at various growth stages in various treatments found to be influenced due to different various rhizosphere soils and its various combinations with sweet orange orchard soil. The maximum DTPA-Mn was recorded at initial stage in treatment $T_5$ (URS) and was gradually decreased till 425 DAT. The lowest DTPA-Mn content was recorded in control (7.74 mg $kg^{-1}$). The rhizosphere soil of Pipal, Banyan and Umber and its hybridization with sweet orange rhizosphere soil showed significantly higher DTPA-Mn content at all growth stages.

**Available -Copper**

DTPA-Cu content in sacred tree rhizosphere soil was 19.63 mg $kg^{-1}$ in URS, 12.84 mg $kg^{-1}$ in BRS and 8.93 mg $kg^{-1}$ in PRS followed by hybridized *Ficus* species rhizosphere soil with sweet orange orchard rhizosphere soil (Table 2). The significantly lower available-copper content was recorded in non rhizosphere soil. Further it was decreased from 8.29 to 5.56 mg $kg^{-1}$ during sweet orange seedling growth period of 137 to 425 DAT.

**Available - Zinc**

Among the various rhizosphere soils (Table 2) *Ficus racemosa* L. rhizosphere soil recorded 6.84 mg $kg^{-1}$ DTPA-Zn showing significantly higher availability of DTPA-Zn over rest of the treatments, followed by *Ficus benghalensis* rhizosphere soil (4.66 mg $kg^{-1}$). In respect of sweet orange growing orchards, non-rhizosphere soil contained 0.1 mg $kg^{-1}$ DTPA-Zn, while rhizosphere soil contained 0.80 mg $kg^{-1}$ DTPA-Zn which was eight times more than the NRS. The control treatment showed significantly lowest availability of DTPA-Zn

**Table 2:** Effect of rhizosphere soil on micronutrient content in sweet orange growing pot culture soil

| Treatment Symbol | Treatment | DTPA-Fe (mg kg$^{-1}$) | | | | DTPA- Mn (mg kg$^{-1}$) | | | | DTPA- Cu (mg kg$^{-1}$) | | | | DTPA- Zn (mg kg$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT | Initial | 137 DAT | 273 DAT | 425 DAT |
| $T_1$ | NRS | 2.81 | 2.31 | 1.77 | 1.08 | 7.74 | 7.42 | 6.91 | 6.32 | 1.57 | 1.41 | 1.19 | 0.98 | 0.21 | 0.19 | 0.17 | 0.13 |
| $T_2$ | NRSW | 5.96 | 5.49 | 4.89 | 3.59 | 15.73 | 14.35 | 13.77 | 12.46 | 2.12 | 1.94 | 1.68 | 1.32 | 0.54 | 0.51 | 0.48 | 0.39 |
| $T_3$ | PRS | 15.19 | 14.68 | 13.85 | 12.75 | 26.28 | 25.87 | 23.24 | 18.31 | 8.93 | 8.71 | 8.53 | 6.34 | 1.98 | 1.92 | 1.72 | 1.63 |
| $T_4$ | BRS | 16.63 | 16.01 | 15.14 | 13.98 | 24.25 | 23.79 | 20.11 | 15.65 | 12.84 | 12.57 | 10.36 | 8.48 | 4.66 | 4.59 | 4.37 | 4.13 |
| $T_5$ | URS | 18.89 | 18.23 | 17.29 | 15.12 | 38.21 | 36.72 | 33.96 | 28.62 | 19.63 | 19.31 | 18.84 | 14.76 | 6.84 | 6.75 | 6.43 | 6.04 |
| $T_6$ | PRS +SRS | 10.91 | 10.39 | 9.70 | 8.87 | 22.24 | 20.81 | 17.26 | 15.85 | 5.90 | 5.61 | 4.24 | 3.44 | 1.23 | 1.16 | 0.99 | 0.92 |
| $T_7$ | BRS+SRS | 12.83 | 12.29 | 11.61 | 9.72 | 18.33 | 17.72 | 23.05 | 13.25 | 8.12 | 7.87 | 5.27 | 4.87 | 2.54 | 2.15 | 2.02 | 1.24 |
| $T_8$ | URS+SRS | 13.51 | 12.88 | 12.11 | 10.14 | 29.18 | 26.76 | 14.75 | 20.41 | 11.68 | 10.29 | 10.18 | 8.46 | 3.93 | 3.61 | 3.36 | 3.15 |
| $T_9$ | SRS | 7.30 | 6.77 | 6.17 | 5.27 | 18.81 | 16.38 | 17.75 | 10.08 | 3.85 | 3.65 | 2.40 | 1.43 | 0.80 | 0.77 | 0.69 | 0.61 |
| | S.Em.± | 0.32 | 0.19 | 0.28 | 0.17 | 0.49 | 0.56 | 0.58 | 0.33 | 0.27 | 0.22 | 0.18 | 0.12 | 0.06 | 0.06 | 0.05 | 0.05 |
| | C.D. at 5(%) | 0.95 | 0.58 | 0.84 | 0.51 | 1.48 | 1.69 | 1.75 | 0.99 | 0.80 | 0.66 | 0.54 | 0.35 | 0.19 | 0.18 | 0.15 | 0.15 |
| | Mean | 11.56 | 11.01 | 10.28 | 8.95 | 22.31 | 21.09 | 18.98 | 15.66 | 8.29 | 7.93 | 6.97 | 5.56 | 2.53 | 2.41 | 2.25 | 2.03 |

## Available Boron

The data presented in Table 3 showed higher available boron content at initial stage of experimentation (1.81 mg kg$^{-1}$).The available boron content found to be decreased to the extent of 1.02 mg kg$^{-1}$, 0.86 mg kg$^{-1}$ and 0.61 mg kg$^{-1}$ at 137, 273 and 425 DAT. The URS treatment recorded maximum available boron followed by BRS, URS+SRS, PRS, BRS +SRS, PRS + SRS and so on. The supremacy of higher available boron status was showed by URS

**Table 3.** Effect of rhizosphere soil on available boron (mg kg$^{-1}$) in soils of sweet orange growing pot culture soil

| Symbol | Treatment name | Available Boron (mg kg$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Initial | 137 DAT | 273 DAT | 425 DAT |
| $T_1$ | NRS | 0.68 | 0.53 | 0.42 | 0.18 |
| $T_2$ | NRSW | 0.79 | 0.64 | 0.47 | 0.29 |
| $T_3$ | PRS | 1.28 | 1.19 | 1.08 | 0.79 |
| $T_4$ | BRS | 1.54 | 1.33 | 1.18 | 0.98 |
| $T_5$ | URS | 1.81 | 1.68 | 1.42 | 1.10 |
| $T_6$ | PRS +SRS | 1.09 | 0.89 | 0.74 | 0.48 |
| $T_7$ | BRS+SRS | 1.12 | 0.95 | 0.80 | 0.60 |
| $T_8$ | URS+SRS | 1.34 | 1.12 | 0.91 | 0.64 |
| $T_9$ | SRS | 1.02 | 0.87 | 0.72 | 0.45 |
| | S.Em.± | 0.03 | 0.03 | 0.02 | 0.01 |
| | C.D. at 5 (%) | 0.08 | 0.08 | 0.06 | 0.03 |
| | Mean | 1.19 | 1.02 | 0.86 | 0.61 |

In the present study the availability of micronutrients viz. Fe, Mn, Zn, Cu and B was exceptionally higher than non rhizosphere bulk soil the results are in agreement with Patil (2013) and Calvaruso *et al.,* (2014). The trace elements concentrations in soil solution were significantly different between the rhizosphere and non rhizosphere soil. These results show that the tree rhizosphere influences the availability of trace elements in these soils. According to, the impact of roots on trace element availability can result from several processes, i.e. accumulation/depletion of ionic species in the rhizosphere, acidification/alkalization of rhizosphere oxidation/ reduction in the rhizosphere and complexation /chelation in the rhizosphere (Graystan, 2013). The dynamics of iron and manganese are very similar to each other and its availability in the rhizosphere is affected by two major factors 1. Redox condition and 2. pH (Mcneal and Oconnor, 1985). Soil Fe is present in oxidized forms $Fe^{3+}$ as a component of the structure of insoluble minerals Goethite (FeOOH) or hematite ($Fe_2O_3$) (Lindsay, 1979). Rhizosphere bacteria can reduce $Fe^{3+}$ to $Fe^{2+}$ the form required by plants. Electrons and protons are available in the rhizosphere and constantly iron is reduced.

## Conclusions

1. The availability of nitrogen, phosphorus, potassium and sulphur was found maximum in the soil treated Umber rhizosphere soil followed by Banyan rhizosphere soil, Pipal rhizosphere soil and combination of *Ficus* species rhizosphere soil at all the growth stages of sweet orange seedlings. Further, the availability of these nutrients decreased during the seedling growth period from initial to 425 Days after Transplanting.
2. The micronutrients viz. of DTPA-Fe, Mn, Cu, Zn and hot water soluble Boron was relatively higher in treatment Umber rhizosphere soil -URS and minimum in Non rhizosphere soil. The rhizosphere soil of Umber, Banyan and Pipal and its hybridization with sweet orange rhizosphere soil showed significantly higher DTPA-extractable micronutrients and hot water soluble Boron content at all growth stages of sweet orange seedlings.

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