International Journal of Chemical Studies

**P-ISSN: 2349–8528**
**E-ISSN: 2321–4902**
IJCS 2018; 6(3): 931-935

Received: 14-03-2018
Accepted: 15-04-2018

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# Effect of zinc biofertilization of soil and its impact on vegetative growth parameters & productivity of sweet orange (*Citrus Sinensis* L.)

**MK Gonte, MB Patil, SJ Syed and RV Nainwad**

**Abstract**
The present investigation entitled "Studies on zinc biofertilization of soil and its impact on growth, quality and productivity of sweet orange (*Citrus sinensis* L. Osbeck.)" was conducted in a well-established sweet orange orchard with 8 years old Nucellar Orange trees planted at 6 x 6 m spacing having uniform growth and productivity at the Sweet Orange Research Station, Badnapur, Dist. - Jalna, during 2016-17. The experiment was laid out in Randomized Block Design (RBD) with ten treatments replicated thrice. The results revealed that, there were significant variations in growth and yield of sweet orange due to application liquid biofertilizers (zinc Solubilizers). The values of vegetative growth parameters height of the trees tem girth number of leaves per branch showed the significant effect by treatments and spread of the tree and number of branches per tree showed the non-significant effect by treatments. The height of tree, stem girth and number of leaves per branch showed most effective in T6 (RNMP+ *Trichoderma viride*) followed by treatment T5 (RNMP + *Pseudomonas striata)* and T8 (RNMP+ *Bacillus megaterium*) and minimum effective in T1 (RNMP). The yield parameters number of fruit per tree and weight of fruit per tree, weight of one fruit and weight of five fruit were noticed maximum in T6 (RNMP+ *Trichoderma viride*) followed by treatment T5 (RNMP + *Pseudomonas striata)* and T8 (RNMP+*Bacillus megaterium*) and minimum effective was noticed in T1 (RNMP). Application of RNMP+*Trichoderma viride* (T6) improved economics in Sweet orange.

**Keywords:** Sweet orange, Biofertilizers, RBD, ZINC, Gorwth, productivity

## 1. Introduction
Sweet orange is considered as most important fruit crop of citrus group with their wholesome nature multifold nutrition and medicinal value have made them so important. Sweet orange (*Citrus sinensis* L. Osbeck) belongs to family *Rutaceae*. Sweet orange is native of Southern China.It is now widely distributed and naturalized in sub tropical zone of India. It is cultivated particularly in Brazil, China, Japan, Turkey and India. In India Andhra Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan and Haryana are main sweet orange growing states. Sweet orange need dry climate and arid weather with distinct summer and winter seasons with low rainfall. It is grown on wide range of soil ranging from clay to light sandy and sensitive to salt. Sweet orange is well grown on medium black, red, alluvial river bank loamy soil of Maharashtra state and Goradu soil of Gujarat. Citrus is third in area and production in India after Mango and Banana. Citrus group comprises of four major types i.e. mandarin, sweet orange, acid lime and lemons. In India, Citrus cultivated on 846.00 thousands ha with the total production of 74.64 lakhs tones and productivity of 8.8 million tons per ha. India is 6th largest producer in Sweet Orange. It contributes to about 49% of the total production in the Country. In Maharashtra area under sweet orange cultivation is 107.00 thousand ha with production of 652.00 thousand MT and productivity 6.1 MT/ha. Commercially Sweet Orange is grown on Khera district of Gujarat and Jalna, Aurangabad, Nanded district of Maharashtra region. (Anonymous, 2016) [1]. Zinc is an essential micronutrient for microorganisms and plants. It is present on the earth's crust in tune of 0.008%. Zinc has an immense role in nutrition of both eukaryotic and prokaryotic organisms as cofactor or metal activator in various enzyme systems (Hughes and Poole, 1991) [3]. Few Zn solubilizing bacterial genera viz. *Thiobacillus thioxidans, Thiobacillus ferroxidans, Acinetobacter, Bacillus, Gluconacetobacter, Pseudomonas* and facultative thermophilic iron oxidizers have been reported as zinc solubilizers (Saravanan *et al*., 2007) [4]. The role of zinc in the nutrition and physiology of both eukaryotic and prokaryotic organisms, especially its

importance for activity of many enzymes is widely studied. Many bacterial enzymes contain zinc in the active centre or in a structurally important site. Bacteria can contribute to metal immobilization by several processes such as precipitation and adsorption as reported by Bapiri *et al.*, (2012) [2]. The organic based zinc nutrition is best since its Zn use efficiency is more. A bacterial based approach was devised to solve the micronutrient deficiency problem. The basic principle behind this approach is decreasing the pH to 5 or below and making zinc soluble and as a consequence the available zinc will get increased in the soil system.

**2. Material and Methods:** Present investigation entitled "Studies on Zn biofertilization of soil and its impact on growth, quality and productivity of sweet orange (*Citrus sinensis* L. Osbeck)" was carried out during the year 2016-17. Selection of trees thirty uniform growing trees of age 8 years were selected randomly. For recording the observations on the various parameters four uniform bearing panicles on the North, South, East, West direction of the tree were selected and tagged with the labels. The details of treatments are given below.

| Treatment No. | Treatment details |
|---|---|
| T1 | RNMP |
| T2 | RNMP+ *Burkholderia cepacia* |
| T3 | RNMP + *Burkholderia cenocepacia* |
| T4 | RNMP + *Pseudomonas fluorescence* |
| T5 | RNMP + *Pseudomonas striata* |
| T6 | RNMP+ *Trichoderma viride* |
| T7 | RNMP+ *Trichoderma harzhianum* |
| T8 | RNMP+ *Bacillus megaterium* |
| T9 | RNMP+ *Pseudomonas extremorientalis* |
| T10 | RNMP+ *Bacillus subtilis* |

**3. Vegetative Growth Parameters**

The height of the tree, spread of the tree (East-West spread) and (North-South spread), stem girth, number of branches per tree, number of leaves per branch as influenced by various treatments of liquid biofertilizers (zinc solubilizers) presented below.

**3.1 Height of the tree (m)**

The heights of the tree influenced by different treatments were recorded periodically at 30, 60, 90, 120, 150 and 180 Days after treatment and are presented in table 1 and depicted in Fig 1. Data on mean height of tree presented in table indicated that there was significant increase in the height of the tree due to treatment from 30 to 180 days.

**Table 1:** Effect of zinc biofertilization of soil on height (m) of the Sweet orange

| Treat. No. | Treatment details | 30 DAT | 60 DAT | 90 DAT | 120 DAT | 150 DAT | 180 DAT |
|---|---|---|---|---|---|---|---|
| T1 | RNMP | 3.22 | 3.36 | 3.40 | 3.48 | 3.62 | 3.68 |
| T2 | RNMP+ *Burkholderia cepacia* | 3.62 | 3.76 | 3.91 | 4.00 | 4.15 | 4.19 |
| T3 | RNMP + *Burkholderia cenocepacia* | 3.46 | 3.58 | 3.70 | 3.75 | 3.79 | 3.85 |
| T4 | RNMP + *Pseudomonas fluorescence* | 3.80 | 4.01 | 4.11 | 4.15 | 4.59 | 4.27 |
| T5 | RNMP + *Pseudomonas striata* | 3.98 | 4.00 | 4.06 | 4.27 | 4.55 | 4.42 |
| T6 | RNMP+ *Trichoderma viride* | 4.23 | 4.39 | 4.45 | 4.54 | 4.61 | 4.65 |
| T7 | RNMP+ *Trichoderma harzianum* | 3.71 | 3.81 | 3.93 | 4.06 | 4.13 | 4.20 |
| T8 | RNMP+ *Bacillus megaterium* | 3.92 | 4.07 | 4.18 | 4.26 | 4.38 | 4.41 |
| T9 | RNMP+ *Pseudomonas extremorientalis* | 3.50 | 3.61 | 3.67 | 3.76 | 3.82 | 3.86 |
| T10 | RNMP+ *Bacillus subtilis* | 3.34 | 3.47 | 3.61 | 3.69 | 3.75 | 3.82 |
| SE ± | | 0.11 | 0.11 | 0.09 | 0.09 | 0.10 | 0.09 |
| C.D. at 5% | | 0.35 | 0.35 | 0.29 | 0.27 | 0.30 | 0.28 |

At 30 days after treatment, maximum tree height (4.23 m) was obtained under the treatment T6 (RNMP+*Trichoderma viride),* followed by the treatment T5 (3.98 m) i.e. RNMP + *Pseudomonas striata* and which were significantly superior over rest of the treatments and statistically at with T8 (3.92 m) i.e. RNMP+*Bacillus megaterium,*. Significantly minimum height was obtained under the treatment T1 (3.22 m) i.e. RNMP. After 60 days after treatment, the similar pattern of increase in the tree height was noticed. The maximum tree height (4.39 m) was noticed under the treatment T6 i.e. RNMP+ *Trichoderma viride*, followed by treatment T8 (4.07 m) i.e. RNMP +*Bacillus megaterium* and treatment (T8) RNMP + *Pseudomonas striata* which was at par with Treatment T8 significantly. The minimum tree height was recorded in the treatment T1 i.e. RNMP (3.36 m) which was statistically at par with the treatment T10 i.e. RNMP+ *Bacillus subtilis* (3.47 m). After 90 days treatment , more tree height (4.45 m) was observed in the treatment T6 i.e. RNMP+ *Trichoderma viride* , followed by the treatments T8 (4.18 m) i.e. RNMP+ *Bacillus megaterium* and which was at par with T5 (4.06 m) i.e. RNMP + *Pseudomonas striata* and The next best treatment was T7 (3.93 m) i.e. RNMP+ *Trichoderma harzianum*. Significantly lowest tree height (3.40 m) was obtained under the treatment T1 i.e. RNMP. At 120 days after the treatment, the maximum tree height (4.54 m) was recorded under the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was significantly superior over the RNMP and rest of the treatments under study. The next best treatment was T5 (4.27 m) i.e. RNMP + *Pseudomonas striata*, which was statistically at par with the treatments T8 (4.26 m) i.e. RNMP+ *Bacillus megaterium*, T4 (4.15 m) i.e. RNMP + *Pseudomonas fluorescence* and T7 (4.06) i.e. RNMP+ *Trichoderma harzianum*. In the remaining treatments also the tree height was significantly more over RNMP. Significantly minimum tree height (3.63 m) was observed under the treatment T1 i.e. RNMP. At 150 days after treatment, the maximum plant height (4.61m) was recorded under the

treatment T6 i.e. RNMP+ *Trichoderma viride*, which was significantly superior over RNMP and rest of the treatments under study. The next best treatment was T5 (4.40 m) i.e. RNMP + *Pseudomonas striata*, which was statistically at par with the treatments T8 (4.38 m) i.e. RNMP+ *Bacillus megaterium* and T4 (4.27 m) i.e. RNMP + *Pseudomonas fluorescence.* In the remaining treatments also the plant height was significantly more over RNMP.Significantly minimum tree height (3.62 m) was recorded under the treatment T1 i.e. RNMP. At 180 days after treatment, the maximum tree height (4.65 m) was recorded by the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was significantly superior over RNMP and rest of the treatments under the study. The next best treatment was T5 (4.42 m) RNMP + *Pseudomonas striata*, which was statistically at par with the treatments T8 (4.41 m) i.e. RNMP+ *Bacillus megaterium*, T4 (4.27 m) i.e. RNMP + *Pseudomonas fluorescence*, T7 (4.20 m) i.e. RNMP+ *Trichoderma harzianum.* In remaining treatments also the tree height was significantly more over RNMP. Significantly minimum tree height (3.68 m) was produced under the treatment T1 i.e. RNMP. It is clearly noted that there was increase in the height of tree with corresponding increase in the RNMP+*Trichoderma viride* (T6), RNMP + *Pseudomonas striata* (T5) and RNMP+ *Bacillus megaterium* (T8). Thus, from Table. 1, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6), RNMP + *Pseudomonas striata* (T5) and RNMP+ *Bacillus megaterium* (T8) proved beneficial in increasing the height of tree over control i.e. RNMP.

### 3.2 Effect of zinc biofertilization of soil on tree spread (m) of sweet orange

The data presented in Table. 2 showed the non-significant effect with application of liquid biofertilizers (zinc Solubilizers) with all treatments.

**Table 2:** Effect of zinc biofertilization of soil on tree spread (m) of sweet orange tree

| Tr. No. | Treatment details | 30 DAT | | 60 DAT | | 90 DAT | | 120 DAT | | 150 DAT | | 180 DAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E-W | N-S | E-W | N-S | E-W | N-S | E-W | N-S | E-W | N-S | E-W | N-S |
| T1 | RNMP | 2.78 | 3.20 | 2.89 | 3.24 | 3.01 | 3.30 | 3.15 | 3.34 | 3.33 | 3.40 | 3.41 | 3.50 |
| T2 | RNMP+ *Burkholderia cepacia* | 3.17 | 3.27 | 3.21 | 3.32 | 3.26 | 3.36 | 3.35 | 3.41 | 3.38 | 3.46 | 3.50 | 3.53 |
| T3 | RNMP + *Burkholderia cenocepacia* | 3.51 | 3.77 | 3.56 | 3.80 | 3.60 | 3.54 | 3.60 | 3.85 | 3.66 | 3.90 | 3.70 | 3.99 |
| T4 | RNMP + *Pseudomonas fluorescence* | 3.37 | 3.68 | 3.40 | 3.44 | 3.45 | 3.60 | 3.52 | 3.63 | 3.49 | 3.63 | 3.56 | 3.71 |
| T5 | RNMP + *Pseudomonas striata* | 3.56 | 3.68 | 3.60 | 3.73 | 3.65 | 3.77 | 3.70 | 3.81 | 3.77 | 3.87 | 3.83 | 3.92 |
| T6 | RNMP+ *Trichoderma viride* | 3.77 | 3.84 | 3.81 | 3.87 | 3.85 | 3.92 | 3.86 | 3.93 | 4.01 | 4.17 | 4.15 | 4.22 |
| T7 | RNMP+*Trichoderma harzhianum* | 3.41 | 3.54 | 3.46 | 3.58 | 3.71 | 3.80 | 3.75 | 3.85 | 3.91 | 4.04 | 3.96 | 4.15 |
| T8 | RNMP+*Bacillus megaterium* | 3.49 | 3.54 | 3.54 | 3.60 | 3.59 | 3.67 | 3.36 | 3.76 | 3.56 | 3.97 | 3.63 | 4.03 |
| T9 | RNMP+ *Pseudomonas extremorientalis* | 2.94 | 3.04 | 2.98 | 3.08 | 3.02 | 3.15 | 3.08 | 3.26 | 3.38 | 3.28 | 3.25 | 3.42 |
| T10 | RNMP+ *Bacillus subtilis* | 3.61 | 3.69 | 3.65 | 3.72 | 3.69 | 3.74 | 3.76 | 3.88 | 3.79 | 3.82 | 3.84 | 3.88 |
| SE ± | | 0.19 | 0.20 | 0.19 | 0.20 | 0.18 | 0.20 | 0.18 | 0.18 | 0.18 | 0.18 | 0.20 | 0.20 |
| C.D. at 5% | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

### 3.3 Stem girth (cm) of the tree

The data pertaining to the effects of liquid biofertilizers with RNMP on stem girth are presented in table 3. It was noticed that stem girth significantly increases. There was increase in the stem girth throughout the period of investigation i.e. 30 days after treatment to 180 days. At 30 days after the treatment T6 i.e. RNMP+ *Trichoderma viride* Increases significantly stem girth (53.66 cm) which was statistically superior over RNMP and all other remaining treatments under study. It was followed by the treatment T5 i.e. RNMP + *Pseudomonas striata* (52.00 cm). The minimum stem girth (42.46 cm) was obtained under the treatment T1 i.e. RNMP. After 60 days after treatment, the similar pattern of increase in the stem girth was noticed. The maximum plant height (53.75 cm) was noticed under the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was statistically at par with the treatment T5 (52.00 cm) i.e. RNMP + *Pseudomonas striata* and which was significantly superior over RNMP and rest of the treatments under study. The minimum stem girth was recorded in the treatment T1 i.e. RNMP (42.53 cm). After 90 days of treatment, more stem girth (53.89 cm) was observed in the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was statistically at par with the treatment T5 (52.10 cm) i.e. RNMP + *Pseudomonas striata* and found significant over rest of the treatments. Significantly minimum stem girth T1 (43.19 cm) was observed under the treatment RNMP. At 120 days after the treatment, the maximum stem girth (53.89 cm) was recorded under the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was significantly superior over the RNMP and rest of the treatments under study. The next best treatment was T5 i.e. RNMP + *Pseudomonas striata* (52.10 cm). In the remaining treatments also the stem girth was significantly more over RNMP. Significantly minimum stem girth (43.20 cm) was observed under the treatment T1 i.e. RNMP. At 150 days after treatment, the maximum stem girth (53.91cm) was recorded under the treatment T6 i.e. RNMP+*Trichoderma viride*, which was significantly superior over RNMP and rest of the treatments under study. The next best treatment was T5 (52.18 cm) i.e. RNMP + *Pseudomonas striata*. In remaining treatments also the stem girth was significantly more over RNMP. Significantly the lowest stem girth (43.28cm) was recorded under the treatment T1 i.e. RNMP. At 180 days after treatment, the maximum stem girth (54.02 cm) was recorded by the treatment T6 i.e. RNMP+ *Trichoderma viride*, which was significantly superior over RNMP and rest of the treatments under the study. The next best treatment was T5 (52.18 cm) i.e. RNMP + *Pseudomonas striata.* In remaining treatments also the stem girth was significantly more over RNMP. Significantly minimum stem girth (43.28 cm) was produced under the treatment T1 i.e. RNMP. It is clearly noted that there was increase in the stem girth with corresponding increase in the RNMP+ *Trichoderma viride* (T6) and RNMP + *Pseudomonas striata* (T5). Thus, from Table. 3, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6) and RNMP + *Pseudomonas striata* (T5) proved beneficial in increasing the stem girth of tree over RNMP.

**Table 3:** Effect of zinc biofertilization of soil on Stem girth of Sweet orange tree

| Treat. No. | Treatment details | 30 DAT | 60 DAT | 90 DAT | 120 DAT | 150 DAT | 180 DAT |
|---|---|---|---|---|---|---|---|
| T1 | RNMP | 42.46 | 42.53 | 43.19 | 43.20 | 43.28 | 43.28 |
| T2 | RNMP+ *Burkholderia cepacia* | 44.13 | 44.30 | 44.37 | 44.40 | 44.40 | 44.41 |
| T3 | RNMP + *Burkholderia cenocepacia* | 43.00 | 43.33 | 43.34 | 43.35 | 43.35 | 43.45 |
| T4 | RNMP + *Pseudomonas fluorescence* | 44.33 | 44.40 | 44.50 | 44.54 | 44.54 | 44.6 |
| T5 | RNMP + *Pseudomonas striata* | 52.00 | 52.00 | 52.10 | 52.10 | 52.18 | 52.18 |
| T6 | RNMP+ *Trichoderma viride* | 53.66 | 53.75 | 53.89 | 53.89 | 53.91 | 54.02 |
| T7 | RNMP+ *Trichoderma harzianum* | 45.66 | 45.76 | 45.81 | 45.82 | 45.82 | 45.85 |
| T8 | RNMP+ *Bacillus megaterium* | 46.66 | 46.83 | 45.84 | 45.84 | 45.85 | 45.85 |
| T9 | RNMP+ *Pseudomonas extremorientalis* | 44.66 | 44.80 | 44.80 | 44.81 | 44.82 | 44.86 |
| T10 | RNMP+ *Bacillus subtilis* | 44.06 | 44.10 | 44.11 | 44.12 | 44.15 | 44.22 |
| SE ± | | 2.19 | 2.11 | 2.08 | 2.09 | 2.09 | 2.09 |
| C.D. at 5% | | 6.25 | 6.28 | 6.19 | 6.21 | 6.21 | 6.23 |

### 3.4 Number of branches per tree

The data presented in Table.4 showed the non-significant effect with application liquid biofertilizers with all treatments.

**Table 4:** Effect of zinc biofertilization of soil and on number of branches tree$^{-1}$ of Sweet orange

| Treatment No. | Treatment details | No of branch tree$^{-1}$ |
|---|---|---|
| T1 | RNMP | 8 |
| T2 | RNMP+ *Burkholderia cepacia* | 7.33 |
| T3 | RNMP + *Burkholderia cenocepacia* | 6.66 |
| T4 | RNMP + *Pseudomonas fluorescence* | 7.66 |
| T5 | RNMP + *Pseudomonas striata* | 7.66 |
| T6 | RNMP+ *Trichoderma viride* | 8.33 |
| T7 | RNMP+ *Trichoderma harzianum* | 7.00 |
| T8 | RNMP+*Bacillus megaterium* | 8.00 |
| T9 | RNMP+ *Pseudomonas extremorientalis* | 7.66 |
| T10 | RNMP+ *Bacillus subtilis* | 7.33 |
| SE ± | | 0.76 |
| C.D. at 5% | | NS |

### 3.5 Effect of zinc biofertilization of soil on number of leaves per branch

The leaves of the tree influenced by different treatments were recorded periodically at 30, 60, 90, 120, 150 and 180 Day and are presented in table 5. Data on number of leaves per branch of tree presented in table indicated that there was significant increase in the number of leaves of the tree due to treatment from 30 to 180 days.

**Table 5:** Effect of zinc biofertilization of soil on number of leaves per branch of Sweet orange tree

| Tr. No. | Treatment details | 30 DAT | 60 DAT | 90 DAT | 120 DAT | 150 DAT | 180 DAT |
|---|---|---|---|---|---|---|---|
| T1 | RNMP | 6039.00 | 6183.00 | 6309.00 | 6439.00 | 6568.66 | 6652.66 |
| T2 | RNMP+ *Burkholderia cepacia* | 6841.33 | 6838.33 | 6906.33 | 6983.33 | 7104.66 | 7860.00 |
| T3 | RNMP + *Burkholderia cenocepacia* | 6619.33 | 6966.66 | 7284.00 | 7038.00 | 7461.66 | 7267.00 |
| T4 | RNMP + *Pseudomonas fluorescence* | 7065.00 | 7422.66 | 7578.66 | 7653.00 | 7770.33 | 7875.00 |
| T5 | RNMP + *Pseudomonas striata* | 7688.00 | 7865.66 | 8003.66 | 8083.33 | 8203.66 | 8315.00 |
| T6 | RNMP+ *Trichoderma viride* | 7968.00 | 8238.00 | 8363.00 | 8450.33 | 8481.00 | 8584.33 |
| T7 | RNMP+ *Trichoderma harzianum* | 6800.33 | 7170.00 | 7137.33 | 7255.66 | 7364.00 | 7506.00 |
| T8 | RNMP+ *Bacillus megaterium* | 7652.33 | 7828.66 | 7934.00 | 8029.00 | 8142.00 | 8265.00 |
| T9 | RNMP+ *Pseudomonas extremorientalis* | 6983.00 | 7120.33 | 7265.33 | 7646.00 | 7755.33 | 7192.66 |
| T10 | RNMP+ *Bacillus subtilis* | 6660.33 | 6750.33 | 6913.66 | 7344.66 | 7172.33 | 7240.00 |
| SE ± | | 292.80 | 298.55 | 312.25 | 310.38 | 307.51 | 341.89 |
| C.D. at 5% | | 869.99 | 887.08 | 927.77 | 922.24 | 913.72 | 1015.85 |

### 4 Yield Parameters

The data presented in Table-6 and depicted in Fig 6 and 7 data on revealed that, there were significant differences with regards to Weight of one fruit (g), Weight of five fruits (g), number of fruits per tree, yield per tree (Kg) due to the application of different liquid biofertilizers (zinc Solubilizers).

### 4.1 Weight of one fruit (g)

The presented in table-6 and deplicated in Fig 6 revealed that, the weight of one fruit varied from (240-350 g) due to application of different treatments of liquid biofertilizers (zinc Solubilizers). The highest weight of one fruit was recorded in the treatment T6 (350 g) i.e. RNMP+*Trichoderma viride* and it was followed by treatment T5 (310 g) i.e. RNMP + *Pseudomonas striata* and T8 (300 g) i.e. RNMP + *Bacillus megaterium* and T9 (300 g) i.e. RNMP + *Pseudomonas extremorientalis*. While, the lowest weight of one fruit was recorded in RNMP T1 (240 g). Thus, from Table. 6, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6), RNMP+ *Pseudomonas striata* (T5) and *RNMP+ Bacillus megaterium* (T8) proved beneficial in increasing the weight of one fruit over RNMP (T1).

**4.2 Weight of five fruit (g)**

The presented in table-6 and deplicated in Fig.7 revealed that, the weight of one fruit varied from (1216.67-1676.66 g) due to application of different treatments of biofertilizers (zinc Solubilizers). The highest weight was recorded in the treatment T6 (1676.66 g) i.e. RNMP+ *Trichoderma viride* and it followed by treatment T3 (1630.00 g) i.e. RNMP + *Burkholderia cenocepacia* and T5 (1583.33 g) i.e. RNMP + *Pseudomonas striata*. While, the lowest yield was recorded in RNMP T1 (1216.67 g). Thus, from Table. 6, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6), RNMP+*Pseudomonas striata* (T5) and RNMP + *Burkholderia cenocepacia* (T3) proved beneficial in increasing the weight of five fruits RNMP (T1).

**4.3 Number of fruits per tree**

The presented in table-6 and deplicated in Fig.8 revealed that, the number of fruits per tree varied from (430.66-537.00) due to application of different treatments of liquid biofertilizers (Zinc Solubilizers). The more number of fruits per tree (537.00) was recorded in treatment T6 i.e. RNMP+ *Trichoderma viride* and it was followed by the treatments T5 and T8 (504.33 and 498.33) i.e. RNMP + *Pseudomonas striata* and RNMP+ *Bacillus megaterium* respectively. The less number of fruits per tree was recorded in RNMP T1 (430.66) i.e. RNMP, followed by treatment T7, T3 and T2 (455.66, 466.66 and 465.00) i.e. RNMP+*Trichoderma harzianum*, RNMP + *Burkholderia cenocepacia* and RNMP+ *Burkholderia cepacia* respectively. Significantly minimum number of fruits (430.66) was produced under the treatment T1 i.e. RNMP. It is clearly noted that there was increase in the number fruits per tree with corresponding increase in the RNMP + (T6), RNMP + *Pseudomonas striata* (T5) and RNMP+ *Bacillus megaterium* (T8). Thus, from Table. 6, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6), RNMP + *Pseudomonas striata* (T5) and RNMP+ *Bacillus megaterium* (T8) proved beneficial in increasing the number of fruits over RNMP (T1).

**4.4 Number of fruits increases over control (%)**

The data revealed that, the highest (24.69%) increases yield over control was recorded in treatment RNMP+ *Trichoderma viride* (T6) followed by (17.10%) RNMP + *Pseudomonas striata* (T5) while lowest yield in (5.80%) was recorded in RNMP + *Trichoderma harzianum* (T7).

**4.5 Yield per tree (kg)**

It is clear that the data presented in Table-6 and Fig. 9, the yield per tree ranged between 103.45-181.31 kg per tree due to various treatments of liquid biofertilizers (zinc Solubilizers).The highest yield was recorded in the treatment T6 (181.31 kg) i.e. RNMP+ *Trichoderma viride* and it was followed by treatment T5 (153.80 kg) i.e. RNMP + *Pseudomonas striata* respectively. While, the lowest yield was recorded in RNMP T1. (103.45 kg), followed by treatments T4 (123.29 kg) respectively. The rest of the treatments were intermediate. Thus, from Table. 6, it is obvious that all the treatments of RNMP+ *Trichoderma viride* (T6), RNMP + *Pseudomonas striata* (T5) and RNMP + *Bacillus megaterium* (T8) proved beneficial in increasing the number of fruits over RNMP (T1).

**4.6 Yield increases over control (%)**

The data revealed that, the highest (75.26%) increases yield over control was recorded in treatment RNMP+ *Trichoderma viride* (T6) followed by RNMP + *Pseudomonas striata* (T5) while lowest yield in % was recorded in RNMP + *Pseudomonas fluorescence* (T4).

**Table 6:** Effect of zinc biofertilization of soil and on yield parameters of Sweet Orange

| Treat. No. | Treatment details | Weight of one fruit (g) | Weight of five fruit (g) | No of fruits/tree | % increase No of fruits/tree over control | Yield/ tree (Kg) | % increases yield/tree (Kg) over control |
|---|---|---|---|---|---|---|---|
| T1 | RNMP | 240 | 1216.67 | 430.66 | - | 103.45 | - |
| T2 | RNMP+ *Burkholderia cepacia* | 290 | 1496.66 | 466.66 | 8.35 | 135.33 | 30.81 |
| T3 | RNMP + *Burkholderia cenocepacia* | 320 | 1630.00 | 465.00 | 7.97 | 148.8 | 43.83 |
| T4 | RNMP + *Pseudomonas fluorescence* | 270 | 1340.00 | 469.00 | 8.90 | 123.29 | 19.17 |
| T5 | RNMP + *Pseudomonas striata* | 310 | 1583.33 | 504.33 | 17.10 | 153.80 | 48.67 |
| T6 | RNMP+ *Trichoderma viride* | 350 | 1676.66 | 537.00 | 24.69 | 181.31 | 75.26 |
| T7 | RNMP+ *Trichoderma harzianum* | 290 | 1240.00 | 455.66 | 5.80 | 131.97 | 27.56 |
| T8 | RNMP+ *Bacillus megaterium* | 300 | 1326.66 | 498.33 | 15.71 | 149.49 | 44.50 |
| T9 | RNMP+*Pseudomonas extremorientalis* | 300 | 1416.66 | 479.93 | 11.44 | 143.97 | 39.16 |
| T10 | RNMP+ *Bacillus subtilis* | 290 | 1430.00 | 462.00 | 7.27 | 133.98 | 29.51 |
| SE ± | | 15.69 | 49.81 | 18.76 | - | 4.22 | - |
| C.D. at 5% | | 46.62 | 148.00 | 55.76 | - | 5.20 | - |

**5. Conclusion**

The results obtained during the course of present investigation are leads to following conclusions:

The application liquid biofertilizers (zinc Solubilizer) i.e.T6 (RNMP+ *Trichoderma viride*) had significantly superior effects on most of the growth characters like height of tree (m), stem girth (cm), number of leaves. Physical parameter of fruit like peel thickness (mm), number of seed per fruit and rind Percent (%), while, lowest was also noted in T6 (RNMP+ *Trichoderma viride*).The significantly superior effects on number of fruits per tree, yield per tree (kg), weight of one fruit (g) and weight of five fruit (g) were seen maximum in T6 (RNMP+ *Trichoderma viride*), T5 (RNMP+ *Pseudomonas striata*) and T8 (*Bacillus megaterium*).

**6. References**


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