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# Effect of Irrigation Schedule and Fertigation Level on Soil Microbial Population of Mandarin (*Citrus reticulata* Blanco.) Orchard cv. Nagpur Mandarin

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**ABSTRACT: Scarcity of water is pervasive on earth across all plant grow ping realm. Water is the major constraint for horticulture production in Rajasthan as well as other parts of the country. At the time of peak summer, no drop of water remains available for crop production. Day by day ground water resources are getting deep due to excessive use of aquifer without much concern for its replenishment. During the peak summer no drop of water remains available for horticulture and agriculture in the region. There is a need of water saving technique. The field experiment was conducted deploying 10 treatments in RBD with four replications covering 160 plants in all during two successive years commencing from March, 2019 to February, 2020 and March, 2020 to February, 2021 at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Rajasthan. The experiment revealed that among various irrigation schedule treatments, application of treatment $I_1$ (100% ETc) was found better in improvement of the soil microbial population in soil (Bacteria 18.17 × $10^6$ CFU/g soil and Fungi 12.62 × $10^4$ CFU/g soil). As regard to individual effect of fertigation, better influence on microbial population (Bacteria 19.33 × $10^6$ CFU/g soil and Fungi 13.78 × $10^4$ CFU/g soil) was found under treatment $F_3$ (60% RDF). Among the interaction of irrigation schedule and fertigation levels, soil microbial population (Bacteria 20.75 × $10^6$ CFU/g soil and Fungi 15.20 × $10^4$ CFU/g soil at 0-15cm depth of soil) had significantly better improvement in treatment $I_1F_3$ (Irrigation Scheduling at 100 % ETc + Fertigation 60 % RDF).**

**Keywords:** Irrigation schedule, Fertigation, Drip irrigation and Mandarin

## INTRODUCTION

Mandarin known as *Citrus reticulata* Blanco is an important fruit in genus citrus. It belongs to the family Rutaceae and sub-family Aurantioideae. The genus citrus includes 162 species and is extensively grown in the tropical and sub-tropical parts of the world (Tanaka, 1977). The majority of the species of citrus are originated in tropical and sub-tropical parts of South East Asia, mainly India and China and in the area among these two countries. The citrus species, mandarin (*Citrus reticulata* Blanco) originated in Indo-China to Southern China (Webber 1967; Davies and Albrigo 1994; Nadabi *et al.*, 2018).

In Jhalawar, mandarin is cultivated under calcareous vertisols (black soil) prevailing in agro-ecology under humid sub-tropical climatic conditions. The Nagpur Mandarin successfully grows between an temperature of 12$^o$C and 40$^o$C. The tree has water requirement of about 800 to 1200 mm per annum under irrigation with optimum rainfall.

Scarcity of water is pervasive on earth across all plant grow ping realm. Water is the major constraint for horticulture production in Rajasthan as well as other parts of the country. At the time of peak summer, no drop of water remains available for crop production. Day by day ground water resources are getting deep due to excessive use of aquifer without much concern for its replenishment. During the peak summer no drop of water remains available for horticulture and agriculture in the region. There is a need of water saving technique. Application of proper dose of water through drip irrigation is expected to result in water saving and likely to hasten plant growth and development (Mellado *et al*., 2005; Hasan *et al*., 2007).

Implementation of fertigation has gained popularity in recent years, mainly in case of large spaced high value crops including fruits. Fertigation is a technique of combined application of fertilizers along with irrigation water effecting saving of fertilizers and water and at the same time enhancing growth, yields and quality of crops and minimizing ground water pollution caused by leaching. Drip fertigation is well organized technology of application of water and fertilizer simultaneously, directly into active root zone at right time in right quantum which ultimately helps in better development of plants. Drip fertigation is beneficial as in this system nutrient use efficiency could be as high as 90 per cent which remains at 40 to 60 per cent in traditional methods (Solaimalai *et al*., 2005). Drip fertigation technology has been well developed, tested, fine-tuned and adapted in large scale field situation and under protected cultivation like poly houses, glass houses, shade net etc. Bandyopadhyay *et al.* (2019) observed that fertigation with no fertilizer doses and irrigation through drip irrigation enhanced soil microbial population in coconut orchard. Besides, the soil microbes can influence the permeability, water holding capacity and tilth of the soil, as has been observed in soils grown to tomato and cocoa in India (Balasubramanian, 2007; Govindan and Nair 2011).

## MATERIAL AND METHODS

The present work was conducted deploying 10 treatments in F-RBD with four replications covering 160 plants in all during two successive years commencing from March, 2019 to February, 2020 and March, 2020 to February, 2021 at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar, Rajasthan. Jhalawar district of Rajasthan is located at 23°4 to 24°52 North-Latitude and 75°29’ to 76°56’East-Longitude. It lies in South-Eastern part of Rajasthan and agro-climatically falls under zone-V (Humid South Eastern Plain). The district receives annual rainfall of about 954 mm. In the winter season temperature dips down up to 1 to 2.5 ºC and during summer season it reaches around 45-48 ºC. The texture of the soil of the experiment field was clay loam (Vertisol/Black soil). The soil was poor in organic carbon. The detailed physic-chemical composition of soil of experimental site is furnished as under:

| Sr. No. | Soil parameters | Physico-chemical composition | | |
|---|---|---|---|---|
| | | **0-15 cm** | **15-30 cm** | **30-45 cm** |
| 1. | pH | 7.51 | 7.40 | 7.31 |
| 2 | EC ($dSm^{-1}$) | 0.40 | 0.37 | 0.34 |
| 3. | Nitrogen ($Kg.ha^{-1}$) | 299 | 294 | 288 |
| 4. | Phosphorus ($Kg.ha^{-1}$) | 19.00 | 16.00 | 12.00 |
| 5. | Potassium ($Kg.ha^{-1}$) | 273 | 267 | 259 |
| 6. | Microbial population | | | |
| | Bacteria ($\times 10^6$CFU/g soil) | 8.00 | 7.00 | 5.00 |
| | Fungi ($\times 10^4$CFU/g soil) | 5.00 | 4.00 | 3.00 |

There were three levels of irrigation *i.e*., 100 per cent ETc ($I_1$), 80 per cent ETc ($I_2$) and 60 per cent ETc ($I_3$), three levels of fertigation, *i.e.*, 100 per cent RDF ($F_1$), 80 per cent RDF ($F_2$) and 60 per cent RDF ($F_3$) and one conventional method (Control: Irrigation at 100% ETc by surface irrigation and 100% RDF as soil application). In the course of investigation, irrigation water was applied every 3rd day during March, 2019 to February, 2021. During the rainy months (first week of July to first week of October) irrigation water was not applied. The fertigation schedule was decided based on standard recommended dose of fertilizer. The required dose of fertilizer for 1 year old plant of mandarin was taken of 90 g N, 90 g P and 90 g K and for two years plant of mandarins is 180 g N, 180 g P and 180 g K (Anon., 2011). The doses of fertilizers were supplemented through water soluble fertilizer NPK-18:18:18 and were supplied during March, July and October at active growth phases of plants during both years of experiment. Thus, at one time, of the total recommended dose of fertilizer (RDF), 1/3rddose was given. Further during each specified month, the $1/3^{rd}$ dose calculated for that particular month was fed through equally distributed irrigation schedule during the specified month splitted further in three equal doses. Water soluble fertilizer as per schedule was dissolved and mixed in fertilizer tank. The mixture of fertilizer water was injected into the drip system through the fertilizer Venturiy. The water requirement was estimated by using following equation. Assume, pan evaporation reading is 10 mm and then volume of to be applied to plant was calculated as under:

$$ETc = ETo \times Kc \times A - Re$$

Where, ETc = Volume of water required in litre per day
ETo = Reference evapotranspiration
Ep = Pan evaporation which has been taken as 10 mm
Kp = Pan co-efficient 0.7 (Kumar *et al*., 2013) for class A pan evaporimeter.

$ETo = Ep \times Kp$
$= 10 \times 0.7$
$= 7$ mm

Kc = Crop co-efficient which is 0.60 (Kc considering, Kc values to be 0.50 in month January, 0.55 in month February to March and November to December, 0.60 in month October and April to May, 0.70 in month of July and August, 0.65 in month June and September, (Kumar *et al.*, 2013).
A = Average canopy area, which is 0.8 $m^2$ in the plants in experimental field.
Re = Effective rainfall 0.00 mm

$ETc = 7 \times 0.6$
$= 4.2$
$WR = 4.2 \times 0.8$
$= 3.36$ litres per day

Likewise, for everyday changing pan evaporation, volume of water (ETc) was calculated for the purpose of experiment.

During plant growth period, irrigation was applied uniformly at 100 per cent ETc, 80 per cent ETc and 60 per cent ETc in particular treatments. Soil microbial population were recorded at the time of commencement and end of the experiment (March, 2019 to February, 2021). The population of bacterial and fungus in soil was determined by soil dilution and plate count method (Pramer and Schmidt, 1964).

## RESULT AND DISCUSSION

The pooled data regarding effect of irrigation schedule and fertigation levels on soil microbial population (CFU) are presented in Table 1 depicted in Fig. 3. The population influenced significantly by various irrigation schedule and fertigation levels at the end of experiment (March, 2019 to February, 2020 and March, 2020 to February, 2021). The treatment $I_1$ (100% ETc) had maximum soil microbial population (Bacteria 18.17 × $10^6$ and Fungi 12.62 × $10^4$ at 0-15cm depth, Bacteria 17.75 × $10^6$ and Fungi 11.62 × $10^4$ at 15-30cm depth and Bacteria 17.15 x $10^6$ and Fungi 9.62 × $10^4$ at 30-45cm depth of soil) and minimum microbial count observed in treatment $I_3$-60% ETc (Bacteria 15.75 × $10^6$ and Fungi 10.20 × $10^4$ at 0-15cm depth, Bacteria 15.34 × $10^6$ and Fungi 9.20 × $10^4$ at 15-30cm depth and Bacteria 14.74 × $10^6$ and Fungi 7.20 × $10^4$ at 30-45cm depth of soil). As regard to fertigation, minimum soil microbial population (Bacteria 14.42 × $10^6$ and Fungi 8.87 × $10^4$ at 0-15cm depth, Bacteria 14.00 × $10^6$ and Fungi 7.87 × $10^4$ at 15-30cm depth and Bacteria 13.40 × $10^6$ and Fungi 5.87 × $10^4$ at 30-45cm depth of soil) was registered in treatment $F_1$ (100% RDF). The maximum increase in available soil microbial population (Bacteria 19.33 × $10^6$ and Fungi 13.78 × $10^4$ at 0-15cm depth, Bacteria 18.92 × $10^6$ and Fungi 12.78 × $10^4$ at 15-30cm depth and Bacteria 18.32 × $10^6$ and Fungi 10.78 × $10^4$ at 30-45cm depth of soil) was found under treatment $F_3$ (60%RDF). As regard to combination of irrigation schedule and fertigation levels treatments, maximum soil microbial population (Bacteria 20.75 × $10^6$ and Fungi 15.20 × $10^4$ at 0-15cm depth, Bacteria 20.34 × $10^6$ and Fungi 14.20 × $10^4$ at 15-30cm depth and Bacteria 19.74 × $10^6$ and Fungi 12.20 × $10^4$ at 30-45cm depth of soil) was observed in treatment $I_1F_3$ (Irrigation Scheduling at 100 % ETc + Fertigation 60 % RDF), followed by treatment $I_2F_3$ (Irrigation Scheduling at 80 % ETc + Fertigation 60 % RDF) in which the values were (Bacteria 19.50 × $10^6$ and Fungi 13.95 × $10^4$ at 0-15cm depth, Bacteria 19.09 × $10^6$ and Fungi 12.95 × $10^4$ at 15-30cm depth and Bacteria 18.49 × $10^6$ and Fungi 10.95 × $10^4$ at 30-45cm depth of soil).

**Table 1: Effect of irrigation schedule and fertigation levels on soil parameters of mandarin (*Citrus reticulate* Blanco.) cv. Nagpur Mandarin during two years growth period (March, 2019 to February 2020, and March, 2020 to February, 2021).**

| Treatment | Soil parameters (Pooled values) | | | | | |
|---|---|---|---|---|---|---|
| | Microbial population (CFU) | | | | | |
| | Bacteria (×$10^6$ CFU/g soil) | | | Fungi (×$10^4$ CFU/g soil) | | |
| | 0-15 cm | 15-30 cm | 30-45 cm | 0-15 cm | 15-30 cm | 30-45 Cm |
| Initial values | 9.00 | 8.00 | 6.25 | 5.50 | 4.50 | 3.50 |
| $I_1$ | 18.17 | 17.75 | 17.15 | 12.62 | 11.62 | 9.62 |
| $I_2$ | 17.42 | 17.00 | 16.40 | 11.87 | 10.87 | 8.87 |
| $I_3$ | 15.75 | 15.34 | 14.74 | 10.20 | 9.20 | 7.20 |
| SE (m) ± | 0.2332 | 0.2211 | 0.2683 | 0.2187 | 0.1768 | 0.2200 |
| CD at 5 % | 0.6808 | 0.6452 | 0.7830 | 0.6384 | 0.5160 | 0.6423 |
| $F_1$ | 14.42 | 14.00 | 13.40 | 8.87 | 7.87 | 5.87 |
| $F_2$ | 17.58 | 17.17 | 16.57 | 12.03 | 11.03 | 9.03 |
| $F_3$ | 19.33 | 18.92 | 18.32 | 13.78 | 12.78 | 10.78 |
| SE (m) ± | 0.2332 | 0.2211 | 0.2683 | 0.2187 | 0.1768 | 0.2200 |
| CD at 5 % | 0.6808 | 0.6452 | 0.7830 | 0.6384 | 0.5160 | 0.6423 |
| $I_1F_1$ | 14.75 | 14.34 | 13.74 | 9.20 | 8.20 | 6.20 |
| $I_1F_2$ | 19.00 | 18.59 | 17.99 | 13.45 | 12.45 | 10.45 |
| $I_1F_3$ | 20.75 | 20.34 | 19.74 | 15.20 | 14.20 | 12.20 |
| $I_2F_1$ | 14.50 | 14.09 | 13.49 | 8.95 | 7.95 | 5.95 |
| $I_2F_2$ | 18.25 | 17.84 | 17.24 | 12.70 | 11.70 | 9.70 |
| $I_2F_3$ | 19.50 | 19.09 | 18.49 | 13.95 | 12.95 | 10.95 |
| $I_3F_1$ | 14.00 | 13.59 | 12.99 | 8.45 | 7.45 | 5.45 |
| $I_3F_2$ | 15.50 | 15.09 | 14.49 | 9.95 | 8.95 | 6.95 |
| $I_3F_3$ | 17.75 | 17.34 | 16.74 | 12.20 | 11.20 | 9.20 |
| $I_0$ $F_0$ (Control) | 13.00 | 12.58 | 11.98 | 7.45 | 6.45 | 4.45 |
| SE (m) ± | 0.4040 | 0.3829 | 0.4646 | 0.3788 | 0.3062 | 0.3811 |
| CD at 5 % | 1.1791 | 1.1176 | 1.3562 | 1.1058 | 0.8937 | 1.1124 |

The minimum soil microbial population (Bacteria 13.00 × $10^6$ and Fungi 7.45 × $10^4$ at 0-15cm depth, Bacteria 12.58 × $10^6$ and Fungi 6.45 × $10^4$ at 15-30cm depth and Bacteria 11.98 × $10^6$ and Fungi 4.45 × $10^4$ at 30-45cm depth of soil) was observed in treatment $I_0F_0$(Control, Irrigation at 100 % ETc by surface irrigation and 100 % RDF as soil application) at the end of experiment (March, 2019 to February, 2021). Maximum microbial population of soil was noticed under the treatment $I_1F_3$ (Irrigation Scheduling at 100 % ETc + Fertigation 60 % RDF) while minimum under the $I_0F_0$ (Control, *i.e.* Irrigation at 100 % ETc by surface irrigation and 100 %

RDF as soil application). The soil microbial population can impact the decomposition of the soil organic matter, ensuing in better availability of the essential nutrients. Higher microbial population of bacteria and fungi in soil with less amount of fertilizer may be due to the speedy decomposition of plant wastes simultaneously in the plant basin as a result of continuous supply of irrigation water through drip irrigation. Presumably, the decomposed plant residue in the plant basin was supportive for the growth microbial population (Hebbar *et al*. 2010; Shobana *et al.* 2012). These compounds maintain the growth of the microbial population and consequently in dense population with less amount of fertigation compared to high fertigation treatments. Besides, the soil microbial population can influence the absorption, WHC and tilth of the soil, as has been reported in soils grown to cocoa and tomato in India (Balasubramanian, 2007; Govindan and Nair, 2011). The soil microbial population had decreasing trend with increasing depth of soil. It may be due to more hardness, less infiltration and less organic matter in the lower layers of soil (Muhammad *et al.*, 2012). Soil organic matter is considered critical component of soil fertility (Ibrahim *et al*., 2011; Sarwar *et al.*, 2010), because it directly influences soil physical structure, water movement and root penetration and indirectly to soil microbial activity (Zabinski *et al.* 2002). Similar explanation for better soil parameters with application of irrigation and fertigation have been cited by Pramanik *et al.* (2020) in banana, Bandyopadhyay *et al.* (2019) in coconut and Balasubramanian, (2007).

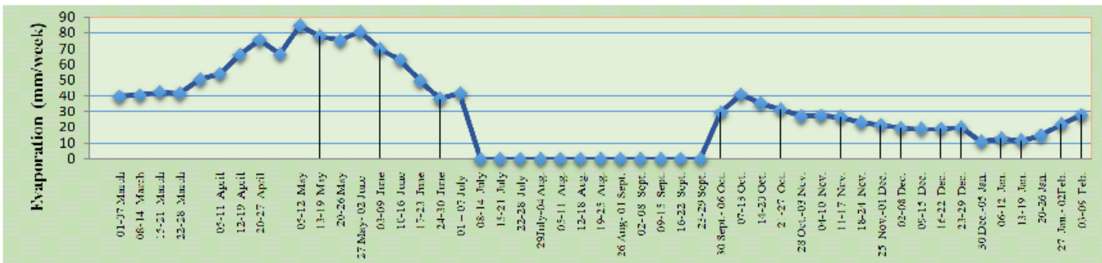


**Fig. 1.** Total evaporation during a particular week for the period of experimentation (March, 2019 to February, 2021).

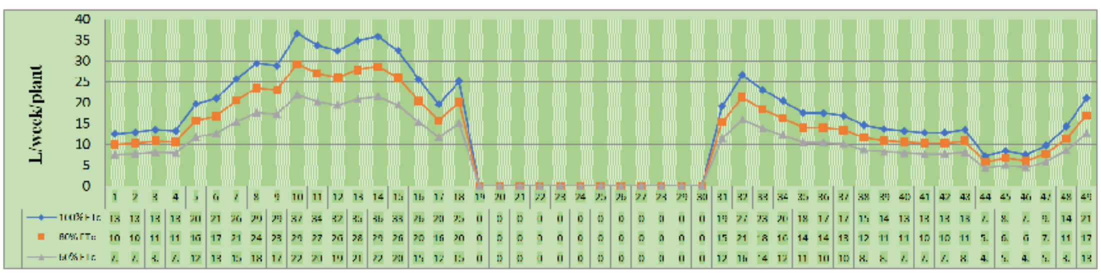


**Fig. 2.** Water application based on evaporation during a particular week for the period of experimentation (March, 2019 to February, 2021).


**Fig. 3.** Effect of irrigation schedule and fertigation levels on soil microbial population (percentage increase) of mandarin (*Citrus reticulata* Blanco.) cv. Nagpur Mandarin during two years growth period (March, 2019 to February 2020, and March, 2020 to February, 2021).

## CONCLUSION

The treatment $I_1$ (100% ETc) was found better in improvement of microbial population in soil (Bacteria 18.17 × $10^6$ CFU/g soil and Fungi 12.62 × $10^4$ CFU/g soil at 0-15cm depth of soil). However, better influence on microbial population (Bacteria 19.33 × $10^6$ CFU/g soil and Fungi 13.78 × $10^4$ CFU/g soil at 0-15cm depth of soil) was found under treatment $F_3$ (60% RDF).As regard to combination of irrigation schedule and fertigation levels treatments, maximum soil microbial population (Bacteria 20.75 × $10^6$ and Fungi 15.20 × $10^4$ at 0-15cm depth of soil) was observed in treatment $I_1F_3$ (Irrigation Scheduling at 100 % ETc + Fertigation 60 % RDF).

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**Conflict of Interest.** None.

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