Chemical Science Review and Letters ISSN 2278-6783

Research Article

# Impact of Nitrogen and Vermicompost Interaction on Photosynthetic Efficiency Parameters of Kinnow Mandarin in Jhalawar District

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## Abstract

A field experiment entitled "Impact of nitrogen and vermicompost interaction on photosynthetic efficiency parameters of kinnow mandarin in Jhalawar district" was conducted at the Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar (Rajasthan) during 2012-13 to study the effect of different levels of nitrogen and vermicompost on photosynthetic efficiency parameters of Kinnow mandarin. The experiment consisted of 16 treatment combinations having four levels of nitrogen i.e. 0, 0.115, 0.230, 0.350 kg/plant and four levels of vermicompost i.e. 0, 10, 15, 20 kg per plant and it was laid out in factorial randomized block design with four replications. The experimental plants were 4 years old and at vegetative growth phage.The result indicate that application of T15 treatment i.e. nitrogen @ 350 g/plant + vermicompost 20 kg/plant was found best with regards to photosynthetic parameters i.e. photosynthesis rate, transpiration rate, stomatal conductance, photosynthetic active radiation, internal $CO_2$ concentration, leaf temperature, relative humidity.

**Keywords:** Kinnow, Nitrogen, Vermicompost, Photosynthesis

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## Introduction

Kinnow (*Citrus nobilis* × *Citrus deliciosa*) is a hybrid between 'King' and 'Willow leaf' mandarin. Kinnow plant has vigorous and drooping growth habit and produces heavy yield under favourable growing conditions. It has attractive fruit colour, size and good eating quality. Its fruits are nutritious, juicy and have bright and deep colour. The fruit is a rich source of minerals and also contains carotene and vitamin C. Kinnow fruit production is intended for fresh fruit market.The total production of oranges in India is 3255.0 thousand tonnes from an area of 324.0 thousand hectares with the productivity of 10.0 MT/ha [1]. In Rajasthan, Kinnow mandarin covers 17.62 thousand hectares area with a total production of 1.46 lac MT/ha [2]. However, Jhalawar district is blessed with Nagpur mandarin where it is grown over 22,500 ha area, 13,000 ha of which are in the fruit bearing stage and the production is 2 lac tonnes [3].In India, the average yield of citrus is about 10 t/ha, which is quiet less than the citrus yield (20-25 t/ha) in other countries like Brazil, Spain, USA, Japan, China and Mexico. The low productivity is probably due to nutritional imbalance, poor orchard management and general negligence of citrus orchard [4].

Nutrition is one of the most important aspects of fruit production and accounts it for 30 per cent of total cost of cultivation. Plants need sufficient mineral nutrients in optimum balance for normal growth and development. There is a continuous removal of nutrients from the soil owing to depletion and imbalanced use of nutrients. Nitrogen is considered as the most important component for supporting plant growth. While nitrogen is a natural element, plants cannot absorb it in this natural form. The nitrogen in the environment is synthesized into fertilizers which are readily available to plants. A proper application of balanced fertilizer promotes thick, green and sustainable orchard. Nitrogen is an essential constituent of protein and chlorophyll and is present in many other compounds of great physiological importance in plant metabolism, such as nucleotides, phosphatides, alkaloids, enzymes, hormones, vitamins etc. [5].

The use of organic fertilizers with inorganic fertilizers as a supplement maintains balance in nutrients and to regulate cropping in farming practices [6]. Keeping in view of all these facts, integration of inorganic fertilizers particularly nitrogen in combination with vermicompost may be helpful for increasing the photosynthesis rate of Kinnow mandarin at pre bearing stage. Better photosynthesis efficiency parameter at pre bearing stage of fruit have positive effect on fruit yield and quality attributes which have economic importance for farmer. Thus, different combination of nitrogen and vermicompost were studied in relation to photosynthesis efficiency parameter of kinnow mandarin.

## Material and Methodology

The experiment was carried out during the year 2012-13 at the Fruit research farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalarapatan, Jhalawar. Factors investigated in this study include effect of different levels of Nitrogen and Vermicompost combination on photosynthesis efficiency parameter of Kinnow mandarin, which includes the following Treatments: **T0**-Control, **T1**-0.115 Kg/plant N (R.D.F.),**T2-**0.230 Kg/plant N, **T3-**0.350 Kg/plant N, **T4-**10 Kg/plant Vermicompost,**T5-**15 kg/plant Vermicompost,**T6-**20 kg/plant Vermicompost, **T7**-0.115 Kg/plant N+10 Kg/plant Vermicompost, **T8**-0.115 Kg/plant N+15 Kg/plant Vermicompost, **T9**-0.115 Kg/plant N+20 kg/plant Vermicompost, **T10-**0.230 Kg/plant N+10 kg/plant Vermicompost, **T11**-0.230 Kg/plant N+15 kg/plant Vermicompost, **T12**-0.230 Kg/plant N+20 kg/plant Vermicompost, **T13**-0.350 Kg/plant N+10 kg/plant Vermicompost, **T14-**0.350 kg/plant N+15 kg/plant Vermicompost, **T15-**0.350 kg/plant N+20 kg/plant Vermicompost. The application of different treatments was done in the month of September, 2012. Nitrogen was applied in two split doses *i.e.* ½ in September + ½ in December. 64 plants of Kinnow mandarin were taken for the experimental study. Measurement of gas exchange characteristics after treatment application of different nitrogen and vermicompost sources were simultaneously taken during the study (8 to 10 am) from October 2012 to March 2013 with respect to sixteen treatments. Observations were recorded on physiologically mature leaves of Kinnow mandarin. Photosynthetic rate (µmolm$^{-2}$s$^{-1}$), Transpiration rate (mmolm$^{-2}$s$^{-1}$), Stomatal conductance (mmolm$^{-2}$s$^{-1}$), Photosynthetic Active Radiation (mmolm$^{-2}$s$^{-1}$), Internal $CO_2$ Concentration (ppm), Vapour Pressure Deficit (mb), Leaf temperature ($^{O}$C) and Relative Humidity(%) were recorded at the interval day of 60 DAT,120DAT,180 DAT (DAT: Day after treatment)using infra-red leaf gas chamber analyzer CIRAS-2 PP system (Portable Photosynthesis system), USA. The boundary layer resistance to vapour was typically 0.8 m$^2$s$^{-1}$mol$^{-1}$. Air was drawn into the instrument from an air probe at the height of 3 m above ground surface. The air pumped into the system was dried using anhydrous calcium sulphate. The gas flow to leaf chamber was maintained at 300 $\pm$2 µmols$^{-1}$. Observations were recorded on environmental variables to see and compare the impact of different treatments on Photosynthetic parameters of Kinnow mandarin from October 2012 to March 2013.

A Panoramic view of experimental site of Kinnow Mandarin

## Result and Discussion

It is very clear from the present results that different levels of nitrogen and vermicompost treatments were significantly superior over control in various plant photosynthesis efficiency parameters after 180 days of application in Kinnow mandarin orchard. Out of all treatment combinations, application of T15 treatment (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) which was statistically significant and superior over other treatments including control with respect of all these parameters. However after 6 months application of treatments, maximum photosynthesis rate(6.97µmolm$^{-2}$s$^{-1}$), photosynthetic active radiation(1850.75 mmolm$^{-2}$s$^{-1}$), stomatal conductance(12.80 mmolm$^{-2}$s$^{-1}$), relative humidity(8.21%), internal $CO_2$ concentration(393.00 ppm), transpiration rate(1.17 mmolm$^{-2}$s$^{-1}$),and water use efficiency(54.45%)was observed under T15 i.e.(Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment which was statistically significant and superior over other treatments and minimum photosynthesis rate(3.87µmolm$^{-2}$s$^{-1}$), photosynthetic active radiation(1607.00 mmolm$^{-2}$s$^{-1}$), stomatal conductance(8.75 mmolm$^{-2}$s$^{-1}$), relative humidity(3.60%), internal $CO_2$ concentration(172.25 ppm), transpiration rate(0.52 mmolm$^{-2}$s$^{-1}$), and water use efficiency(54.45%)was recorded under control.

Similarly the minimum leaf temperature (29.67$^0$C) and vapour pressure deficit (41.05mb), was observed under T15 i.e. (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment which was statistically significant and lower over other treatments and maximum leaf temperature (32.57$^0$C), and vapour pressure deficit (54.17mb) was recorded under control.

Significant positive results were obtained by application of different levels of nitrogen and vermicompost during investigation. It might be due to the fact that application of nitrogen and Vermicompost lead to vigorous vegetative growth and development of the plant and imparts dark green colour of the foliage which favours photosynthetic activity and increased carboxylation efficiency of the plant bringing greater synthesis of carbohydrate in the leaves which in turn favour better development of plants.

The results of the present study indicated that maximum photosynthetic rate (Pn) was there in $T_{15}$ treatment *i.e.* (nitrogen @ 350 g/plant + vermicompost @ 20 kg/plant). This might be attributed to better uptake and utilization of nitrogen along with other macro nutrient especially potassium by Kinnow mandarin plants as compared to other treatments [7].

**Table 1:** Interaction effect of Nitrogen and Vermicompost on photosynthetic Rate and Photosynthetic Active Radiation

| **Treatment** | **Photosynthetic Rate (µmolm$^{-2}$s$^{-1}$)** | | | **Photosynthetic Active Radiation (mmolm$^{-2}$s$^{-1}$)** | | |
|---|---|---|---|---|---|---|
| | **60 DAT** | **120 DAT** | **180 DAT** | **60 DAT** | **120 DAT** | **180 DAT** |
| **$T_0$** | 3.35 | 3.72 | 3.87 | 1416.75 | 1457.50 | 1607.00 |
| **$T_1$** | 3.40 | 4.80 | 5.00 | 1451.50 | 1566.50 | 1647.00 |
| **$T_2$** | 4.25 | 4.95 | 5.15 | 1520.00 | 1567.75 | 1656.25 |
| **$T_3$** | 5.82 | 4.95 | 5.17 | 1649.75 | 1664.75 | 1691.25 |
| **$T_4$** | 4.45 | 5.30 | 5.55 | 1651.50 | 1676.00 | 1711.75 |
| **$T_5$** | 4.77 | 5.42 | 5.67 | 1684.50 | 1699.50 | 1720.75 |
| **$T_6$** | 5.67 | 5.55 | 5.77 | 1717.50 | 1710.25 | 1734.00 |
| **$T_7$** | 5.45 | 5.90 | 6.15 | 1757.25 | 1735.75 | 1745.75 |
| **$T_8$** | 5.25 | 5.75 | 6.00 | 1770.50 | 1744.25 | 1768.50 |
| **$T_9$** | 5.65 | 5.30 | 5.55 | 1788.00 | 1773.75 | 1797.25 |
| **$T_{10}$** | 5.72 | 5.70 | 5.95 | 1806.25 | 1786.75 | 1819.25 |
| **$T_{11}$** | 5.95 | 5.70 | 5.95 | 1822.75 | 1801.25 | 1848.50 |
| **$T_{12}$** | 6.00 | 5.95 | 6.20 | 1834.25 | 1815.75 | 1848.00 |
| **$T_{13}$** | 5.77 | 5.72 | 6.02 | 1854.75 | 1825.50 | 1835.00 |
| **$T_{14}$** | 6.02 | 5.95 | 6.25 | 1903.25 | 1845.25 | 1844.00 |
| **$T_{15}$** | **7.05** | **6.55** | **6.97** | **1932.00** | **1863.75** | **1850.75** |
| **SEm ±** | 0.21 | 0.15 | 0.16 | 8.32 | 3.09 | 6.61 |
| **C.D. at 5 (N×V)** | 0.43 | 0.31 | 0.33 | 16.76 | 6.23 | 13.33 |

The photosynthetic rate (Pn) was found maximum in $T_{15}$ treatment over all other treatments might be due to ample intensity of photosynthetic active radiation, increased leaf area, better stomatal conductance with high relative humidity percentage of leaf and better relative water content of Kinnow leaves as a result of better uptake and utilization of applied nitrogen. Translocation and partitioning of assimilated carbon are major determinants of plant growth and development. Photosynthetic rate (Pn) per unit leaf area measured for the entire canopy was found maximum during the entire growth period and better assimilation of carbohydrates as a result of improved nutrition by Kinnow rhizosphere [8]. There was a progressive reduction in leaf temperature with increasing levels of nitrogen which subsequently favoured better photosynthetic rate under $T_{15}$ treatment [9].

Environmental controls on stomatal conductance (gs) studies indicates a strong link between stomatal conductance and carbon gain. The reason for this might be the higher internal $CO_2$ concentration, high photosynthetic active radiation (PAR), high relative humidity (RH) percentage of leaves, low vapour pressure deficit (VPD) as observed under treatment $T_{15}$[10].

**Table 2:** Interaction effect of Nitrogen and Vermicompost on stomatal conductance and Leaf Temperature

| **Treatment** | **Stomatal Conductance (mmolm$^{-2}$s$^{-1}$)** | | | **Leaf Temperature ($^{o}$C)** | | |
|---|---|---|---|---|---|---|
| | 60 DAT | 120 DAT | 180 DAT | 60 DAT | 120 DAT | 180 DAT |
| **$T_0$** | 8.50 | 9.00 | 8.75 | **34.57** | **18.65** | **32.57** |
| **$T_1$** | 8.50 | 11.00 | 11.50 | 32.98 | 18.00 | 31.15 |
| **$T_2$** | 10.25 | 11.75 | 12.00 | 31.37 | 18.25 | 31.27 |
| **$T_3$** | 12.50 | 11.75 | 11.75 | 32.32 | 17.82 | 31.30 |
| **$T_4$** | 10.50 | 12.50 | 12.25 | 30.92 | 18.20 | 31.05 |
| **$T_5$** | 10.50 | 12.50 | 12.25 | 33.12 | 18.52 | 30.65 |
| **$T_6$** | 12.75 | 12.75 | 12.75 | 34.30 | 18.02 | 30.82 |
| **$T_7$** | 12.50 | 12.75 | 12.50 | 32.15 | 17.02 | 30.80 |
| **$T_8$** | 12.25 | **13.00** | 12.50 | 34.27 | 18.02 | 30.85 |
| **$T_9$** | 12.75 | 12.25 | 12.50 | 31.17 | 17.75 | 30.72 |
| **$T_{10}$** | 12.75 | 12.75 | 12.75 | 32.15 | 17.17 | 30.90 |
| **$T_{11}$** | **13.00** | 12.50 | 12.50 | 34.52 | 16.75 | 30.70 |
| **$T_{12}$** | 12.50 | 12.75 | 12.50 | 33.80 | 16.55 | 30.55 |
| **$T_{13}$** | 12.50 | 12.25 | 12.75 | 31.50 | 17.10 | 30.32 |
| **$T_{14}$** | 12.50 | 12.75 | 12.75 | 30.28 | 16.65 | 29.70 |
| **$T_{15}$** | 12.25 | 12.25 | 12.80 | 30.15 | 16.52 | 29.67 |
| **SEm ±** | 0.43 | 0.37 | 0.36 | 0.70 | 0.27 | 0.16 |
| **C.D. at 5 (N×V)** | 0.88 | 0.76 | 0.73 | 1.41 | 0.54 | 0.32 |

**Table 3:** Interaction effect of Nitrogen and Vermicompost on Relative Humidity and Internal $CO_2$ Concentration

| **Treatment** | **Relative Humidity (%)** | | | **Internal $CO_2$Conc. (ppm)** | | |
|---|---|---|---|---|---|---|
| | **60 DAT** | **120 DAT** | **180 DAT** | **60 DAT** | **120 DAT** | **180 DAT** |
| **$T_0$** | 2.38 | 3.40 | 3.60 | 105.00 | 130.75 | 172.25 |
| **$T_1$** | 2.49 | 3.78 | 3.90 | 117.75 | 143.00 | 175.25 |
| **$T_2$** | 2.63 | 4.03 | 4.11 | 119.00 | 155.25 | 183.00 |
| **$T_3$** | 2.89 | 4.20 | 4.26 | 126.50 | 174.25 | 204.75 |
| **$T_4$** | 2.93 | 4.32 | 4.39 | 133.00 | 183.25 | 206.75 |
| **$T_5$** | 2.98 | 4.65 | 4.69 | 143.25 | 192.75 | 215.75 |
| **$T_6$** | 3.05 | 4.78 | 4.84 | 158.75 | 204.75 | 230.25 |
| **$T_7$** | 3.16 | 4.85 | 5.01 | 175.25 | 200.50 | 233.50 |
| **$T_8$** | 3.25 | 5.26 | 5.32 | 190.75 | 223.75 | 235.25 |
| **$T_9$** | 3.45 | 5.71 | 5.83 | 204.00 | 238.75 | 258.75 |
| **$T_{10}$** | 4.05 | 5.77 | 5.97 | 224.00 | 258.25 | 272.50 |
| **$T_{11}$** | 4.29 | 5.82 | 6.20 | 239.50 | 278.25 | 282.25 |
| **$T_{12}$** | 4.48 | 6.01 | 6.53 | 241.25 | 292.25 | 304.50 |
| **$T_{13}$** | 4.68 | 6.22 | 6.64 | 261.00 | 312.50 | 337.00 |
| **$T_{14}$** | 4.82 | 6.39 | 7.55 | 273.50 | 322.75 | 361.00 |
| **$T_{15}$** | **5.73** | **6.87** | **8.21** | **296.75** | **377.25** | **393.00** |
| **SEm ±** | 0.03 | 0.03 | 0.07 | 4.07 | 4.35 | 5.66 |
| **C.D. at 5 (N×V)** | 0.73 | 0.06 | 0.14 | 8.20 | 8.76 | 11.41 |

There is a high correlation between photosynthesis rate and stomatal conductance in Kiwifruit cultivars [11]. It has been reported that stomatal regulation may be the first line of defensive mechanism of citrus to with stand the water deficit conditions.

Photosynthetic efficiency of fruit plants depends on photosynthetic active radiation during the cumulative day hours of the year which determines plant growth and productivity. High assimilation rate of citrus are accompanied by high rates of transpiration and extreme sensitivity to moisture conditions [12, 13].

The effect of environment control on stomatal conductance (gs) and carbon assimilation efficiency and ultimately plant growth, vapour pressure deficit between leaf and air is governed by stomatal conductance and inverse relationship exists between stomatal conductance and vapour pressure deficit. High vapour pressure deficit indicates low stomatal conductance which causes stomatal closure as a feedback response to mechanism of transpiration and water loss from the leaf rather than as a direct response to humidity [14, 15].

The higher relative humidity percentage of Kinnow leaves might be attributed to increased water use efficiency, increased nutrient uptake, better electrolytic composition of leaves with improve nutrition which in turn resulted in improved photosynthetic rate [16].

The higher transpiration rate exhibits correlation with high relative humidity percentage of leaves which indicates better utilization and uptake of water and nutrients provided by application of nitrogen to plants so as to lower down the leaf surface temperature for minimizing the damage to photosynthetic apparatus for gaining carboxylation efficiency of Kinnow mandarin plants. The transpiration rate seems to be not closely linked to solar irradiation but rather to leaf temperature [17].

The leaf temperature variation range (30.06 to 31.57$^{o}$C) in Kinnow mandarin leaves during March 2013. It may be due to fluctuation in environmental conditions as a result of photosynthetic active radiation incidence on leaf surface. The present investigations revealed oscillating fluctuations in photosynthetic rate (Pn) coupled with variations in leaf temperature in Kinnow mandarin under different treatments during the entire study period under field condition [15].

Improvement in above parameters might be due to the fact that $T_{15}$ treatment contains higher doses of nitrogen and vermicompost, so it may have synergistic effect with respect to soil microclimate and mineral nutrient status. The better result obtained under $T_{15}$ treatment pertaining to photosynthetic rate (Pn), internal $CO_2$ concentration (ci), relative humidity percentage of leaves, transpiration rate, photosynthetic active radiation (PAR) and water use efficiency. This might be attributed to the fact that availability of nitrogen through (vermicompost 20 kg + urea 350 g) during the vegetative stage of Kinnow plants is helpful in catalyzing specific metabolic processes based on proteins leading to increase in growth and development attributes of Kinnow mandarin under Vertisols of Jhalawar [18].

**Table 4:** Interaction effect of Nitrogen and Vermicompost on Transpiration Rate and Vapour Pressure Deficit

| **Treatment** | **Transpiration Rate (mmolm$^{-2}$s$^{-1}$)** | | | **Vapour Pressure Deficit (mb)** | | |
|---|---|---|---|---|---|---|
| | **60 DAT** | **120 DAT** | **180 DAT** | **60 DAT** | **120 DAT** | **180 DAT** |
| **$T_0$** | 0.30 | 0.35 | 0.52 | **81.07** | **31.30** | **54.17** |
| **$T_1$** | 0.37 | 0.42 | 0.55 | 72.30 | 24.55 | 48.90 |
| **$T_2$** | 0.55 | 0.37 | 0.52 | 65.07 | 25.12 | 49.30 |
| **$T_3$** | 0.80 | 0.60 | 0.67 | 63.87 | 26.05 | 49.42 |
| **$T_4$** | 0.65 | 0.52 | 0.62 | 67.02 | 26.22 | 44.55 |
| **$T_5$** | 0.60 | 0.57 | 0.67 | 66.07 | 26.27 | 44.32 |
| **$T_6$** | 0.65 | 0.55 | 0.67 | 60.42 | 23.75 | 41.55 |
| **$T_7$** | 0.62 | 0.62 | 0.72 | 64.40 | 23.30 | 45.25 |
| **$T_8$** | 0.70 | 0.72 | 0.77 | 57.17 | 24.05 | 48.47 |
| **$T_9$** | 0.80 | 0.75 | 0.82 | 59.10 | 26.12 | 48.15 |
| **$T_{10}$** | 0.67 | 0.85 | 0.92 | 57.25 | 26.60 | 44.25 |
| **$T_{11}$** | 0.70 | 0.85 | 0.95 | 57.87 | 25.80 | 45.70 |
| **$T_{12}$** | 0.75 | 0.85 | 0.92 | 52.72 | 24.15 | 41.45 |
| **$T_{13}$** | 0.82 | 0.87 | 0.95 | 53.35 | 25.12 | 44.47 |
| **$T_{14}$** | 0.87 | 0.82 | 0.97 | 50.62 | 23.52 | 43.75 |
| **$T_{15}$** | **1.22** | **1.05** | **1.17** | 49.27 | 23.77 | 41.05 |
| **SEm ±** | 0.07 | 0.05 | 0.05 | 2.27 | 1.38 | 1.73 |
| **C.D. at 5 (N×V)** | 0.15 | 0.11 | 0.10 | 4.57 | 2.79 | 3.49 |

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Publication History
Received 28$^{th}$ Mar 2017
Revised 14$^{th}$ Apr 2017
Accepted 15$^{th}$ Apr 2017
Online 30$^{th}$ Apr 2017