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CONCURRENT CHANGE IN PHOTOSYNTHETIC PARAMETERS IN KINNOW LEAVES UNDER INTEGRATED NUTRIENT APPLICATION

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ABSTRACT : Seasonal changes in photosynthetic characteristics, relative water content, canopy volume, leaf nutrient content in Kinnow leaves in response to integrated nutrient sources were investigated in Jhalawar district of South Eastern Rajasthan state of India during 2012-13. Interaction effect of nitrogen and vermicompost were significantly superior over other treatments in terms of better photosynthetic efficiency parameters of Kinnow mandarin plants during gestation period of 3 years age *viz.* photosynthesis rate, transpiration rate, stomatal conductance, photosynthetic active radiation, internal CO_2 concentration, vapour pressure deficit, leaf temperature, relative humidity. Out of all treatment combinations, T15 (nitrogen @ 350 g/plant + vermicompost @ 20 kg/plant) proved significantly superior over most of treatment combinations including control in photosynthetic efficiency parameters of Kinnow mandarin plants. The photosynthetic efficiency of Kinnow mandarin plants was found maximum under T_{15} (6.97) treatment. The better stomatal conductance, transpiration rate, relative humidity percentage of leaves, internal CO_2 concentration and leaf temperature attained optimal values at higher PAR. The application of 350 g nitrogen along with 20 kg vermicompost per plant in two split doses in Kinnow mandarin at gestation phase may improve the plant growth, developmental and photosynthetic efficiency parameters which are pre-requisite for strong framework and higher yield along with improvement in the soil health. In order to define P_n of the tree, it is necessary to consider not only photosynthetic response of the single leaf but also the overall canopy structure (leaf area index, total leaf area, leaf orientation towards radiation flux) which varies considerably according to environmental conditions. The canopy structure influences the overall P_n of the tree. Further studies on the carbon balance in relation to nutrition may contribute to growth and developmental improvement in the plants.

Keywords : *Photosynthesis rate, transpiration rate, stomatal conductance, photosynthetic active radiation, CO_2 concentration*

Various factors influence fruit tree performance but amenable growth is primarily related to the ability of the tree to produce photosynthates over a broad range of environmental conditions. Therefore, photosynthesis during the growing season has been the key factor in the growth and development of the plants (Ceulemans and Saugier, 2; Bhatnagar *et al.* 1). Nutrition is one of the most important aspects of fruit production and it alone accounts 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. C_3 plants can assimilate CO_2 during the year whenever environmental conditions are favourable (Waring, 12). Adequate amounts of nitrogen (N) are necessary to achieve maximum rates of CO_2 assimilation, commercially acceptable growth and fruit yields (Davies and Albrigo, 3; Syvertsen, 11). 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. Leaf N concentration can range from 2% to 6% of dry weight (Jones, 6; Munson, 9) and is usually strongly correlated with photosynthetic capacity and yield (Evans, 5). Dark green leaves, high photosynthetic activity and vigorous vegetative growth are characteristics of plant with adequate N supply. Conversely, inadequate N supply can lead to chlorosis and stunted growth.

The indiscriminate use of inorganic fertilizers for several years without incorporating organic additives has resulted in a totally deteriorating farming scenario in the country and also in elemental imbalance at soil and plant levels leading to accentuated accumulation of harmful substances in plant environments. Vermicompost increases the efficiency of chemical fertilizers. It works on the principle of maintenance and

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improvement of soil fertility for sustainable productivity on long term basis. The importance and usefulness of organic manure in soil sustainability has been emphasized and judicious use of inorganic fertilizer along with organic sources has been suggested. (Sanewski, 10).

Kinnow mandarin is generally a heavy feeder and very nutrient responsive crop. It requires sufficient and adequate nutrition for proper growth and development phase of the plant. Ordinarily, the element which Kinnow plants need constant replenishment are mainly nitrogen, phosphorous and potassium as these are used up in considerable quantities (Khokhar *et al.,* 7). Keeping in view all these facts, integration of inorganic fertilizers particularly nitrogen in combination with vermicompost may be helpful in increasing the growth and development of Kinnow mandarin at pre bearing stage. So far no attempt has been conducted on these aspects under Jhalawar agro climatic condition of Rajasthan which is pre dominantly Nagpur mandarin growing belt. The study will be useful in view point of manipulating the dependent growth and yield parameters via managing the integrated nutrient application.

MATERIALS AND METHODS

The present study was carried out in orchard of Kinnow mandarin at Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar (Rajasthan), India during October, 2012 to March 2013. For experimental study 64 plants of Kinnow mandarin were put under investigation related to photosynthetic parameters as per objectives of the study. Measurement of gas exchange characteristics were done after treatment application of different sources of nitrogen and vermicompost. There were 16 treatment combinations, *viz.,* T_0 : Control, T_1 : 0.115 Kg/plant N (R.D.F.), T_2 : 0.230 Kg/plant N, T_3 : 0.350 Kg/plant N, T_4 10 Kg/plant Vermicompost, T_5 : 15 kg/plant Vermicompost, T_6 : 20 kg/plant Vermicompost, T_7 : 0.115 Kg/plant N+10 Kg/plant VC, T_8 : 0.115 Kg/plant N + 15 Kg/plant VC, T_9 : 0.115 Kg/plant N + 20 kg/plant VC, T_{10} : 0.230 Kg/plant N +10 kg/plant VC , T_{11} : 0.230 Kg/plant N + 15 kg/plant VC, T_{12} : 0.230 Kg/plant N+ 20 kg/plant VC, T_{13} : 0.350 Kg/plant N + 10 kg/plant VC, T_{14} : 0.350 kg/plant N + 15 kg/plant VC, and T_{15} : 0.350 kg/plant N + 20 kg/plant VC with three replications. 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.

Plant environmental factors were recorded during the study (8.00 to 10.00 am) from October 2012 till March 2013 with respect to sixteen treatments. Observations were recorded on physiologically mature leaves of Kinnow mandarin with three leaves/unit replications. Photosynthetic rate ($\mu molm^{-2}s^{-1}$), Transpiration rate ($\mu molm^{-2}s^{-1}$), Stomatal conductance ($\mu molm^{-2}s^{-1}$), Photosynthetic Active Radiation ($\mu molm^{-2}s^{-1}$), Internal CO_2 Concentration (ppm), Vapour Pressure Deficit (mb), Leaf temperature (°C) and Relative Humidity(%) were recorded using infra red leaf gas chamber analyzer CIRAS-2 PP system (Portable Photosynthesis system), USA. The boundary layer resistance to vapour was typically ($0.8 m^2s^{-1}mol^{-1}$). 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 $300 \pm 2 \mu molm^{-2}s^{-1}$. Observations were recorded on selected clear days during 2 week monthwise to see photosynthetic variables and compare the impact of different treatments of integrated nutrient management on growth and development of Kinnow mandarin from October 2012 till March 2013. The data obtained during the course of experimentation were subjected to statistical analysis using Indostat Statistical Software. The significance of the treatments was tested through F-test at 5 per cent level of significance. The critical difference was calculated to assess the significance of difference among the different treatments.

RESULTS AND DISCUSSION

It is very clear from the experimental results that interaction effect of nitrogen and vermicompost were significantly superior over other treatments in terms of better photosynthetic efficiency parameters viz. photosynthesis rate, transpiration rate, stomatal conductance, photosynthetic active radiation, internal CO_2 concentration, vapour pressure deficit, leaf temperature, relative humidity and water use efficiency. Out of all treatment combinations, T_{15} *i.e.* (nitrogen @ 350 g/plant + vermicompost @ 20 kg/plant), proved significantly superior over most of treatment combinations including control in photosynthetic efficiency parameters. The data pertaining to photosynthesis rate (*Pn*) in leaves as affected by interaction effect of nitrogen and vermicompost are presented in Table 1. The photosynthesis rate got influenced significantly by different interaction treatments. However, after 6 months of treatments

application period the maximum photosynthesis rate (6.97 $\mu molm^{-2}s^{-1}$) was observed under T_{15} *i.e.* N_3V_3 (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) observed under T_{15} *i.e.* N_3V_3 (Nitrogen @ 350 g/plant + vermicompost @ 20 kg/plant) treatment, which was at par over other treatments *i.e.* T_4 to T_{13}, T_2 and

Table 1: Effect of nitrogen and vermicompost on photosynthetic variables of Kinnow mandarin.

Treatments	180 Days after treatment					
	Pn ($\mu molm^{-2}s^{-1}$)	gs ($mmolm^{-2}s^{-1}$)	PAR ($mmolm^{-2}s^{-1}$)	E ($mmolm^{-2}s^{-1}$)	RH (%)leaf	Ci (ppm)
T_0	3.87	8.75	1607.00	0.52	3.60	172.25
T_1	5.00	11.50	1647.00	0.55	3.90	175.25
T_2	5.15	12.00	1656.25	0.52	4.11	183.00
T_3	5.17	11.75	1691.25	0.67	4.26	204.75
T_4	5.55	12.25	1711.75	0.62	4.39	206.75
T_5	5.67	12.25	1720.75	0.67	4.69	215.75
T_6	5.77	12.75	1734.00	0.67	4.84	230.25
T_7	6.15	12.50	1745.75	0.72	5.01	233.50
T_8	6.00	12.50	1768.50	0.77	5.32	235.25
T_9	5.55	12.50	1797.25	0.82	5.83	258.75
T_{10}	5.95	12.75	1819.25	0.92	5.97	272.50
T_{11}	5.95	12.50	1848.50	0.95	6.20	282.25
T_{12}	6.20	12.50	1848.00	0.92	6.53	304.50
T_{13}	6.02	12.75	1835.00	0.95	6.64	337.00
T_{14}	6.25	12.75	1844.00	0.97	7.55	361.00
T_{15}	6.97	12.80	1850.75	1.17	8.21	393.00
C.D. (0.05)	0.33	0.73	13.33	0.10	0.14	11.41

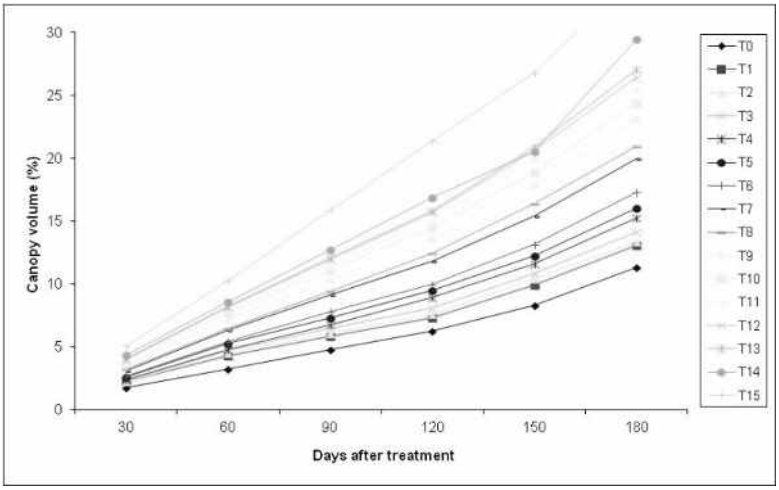

Fig. 1: Effect of nitrogen and vermicompost on per cent increase of canopy volume of Kinnow mandarin.

treatment which was statistically significant and superior over other treatments.

The stomatal conductance was significantly influenced by different interaction treatments. However, after 6 months of treatments application, the maximum stomatal conductance (12.80 $mmolm^{-2}s^{-1}$) was minimum stomatal conductance (8.75 $mmolm^{-2}s^{-1}$) was recorded under control. The photosynthetic active radiation was significantly influenced by different interaction treatments with the advancement of growth period from 30 to 180 days. However, after 6 months of treatments application period the maximum photosynthetic active radiation (1850.75 $mmolm^{-2}s^{-1}$)

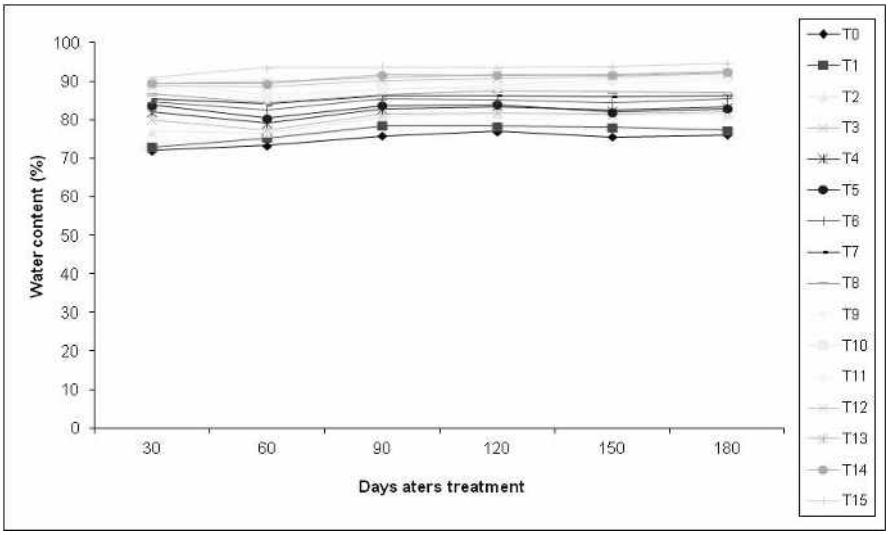

Fig. 2: Effect of nitrogen and vermicompost on relative water content (%) of Kinnow mandarin.

was observed under T_{15} *i.e.* N_3V_3 (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment, which was at par to T_{11} and T_{12} and significantly superior over other treatments. Minimum photosynthetic active radiation (1607.00 $mmolm^{-2}$ s^{-1}) was recorded under control. The transpiration rate got influenced significantly by different interaction treatments. However, after 6 month of treatments application, the maximum transpiration rate (1.17 m $molm^{-2}s^{-1}$) was observed under T_{15} (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment which was significantly higher over other treatments. The minimum rate of transpiration (0.52 $mmolm^{-2}s^{-1}$) was recorded in control treatment. The relative humidity was significantly influenced by different interaction treatments. However, after 6 month of treatments, the maximum relative humidity percentage (8.21%) was observed under T_{15} (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment, which was significantly superior over other treatments. The control treatment had minimum increase in relative humidity percentage (3.60%). The internal CO_2 concentration was found significantly influenced by different interaction treatments. However, after 6 month of treatments application period, the maximum internal CO_2 concentration (393.00 ppm) was observed under T_{15} *i.e.* N_3V_3 (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment, which was statistically significant and higher over other treatments. The minimum internal CO_2 concentration (172.25 ppm) was recorded in control. Dudi *et al.* (4) reported the beneficial effect of nitrogen in Kinnow mandarin as a growth promoter and found significant improvement in growth attributes due to enhanced synthesis and accumulation of protein, amino acids and enzymes which are responsible for cell division, cell elongation and ultimate growth of plants during juvenile phase. Similar investigation was reported by Morgan (8) on the response of young citrus plants in Florida subjected to nitrogen fertilization.

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 photosynthetic parameters like photosynthetic rate (*Pn*), internal CO_2 concentration (*ci*), relative humidity percentage of leaves, transpiration rate, photosynthetic active radiation (PAR) and water use efficiency in T_{15} 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 plants under Vertisols of Jhalawar. These findings are strongly supported by Evans (5) in C_3 plants. Photosynthetic rate (Pn) per unit leaf area measured for the entire canopy was found maximum and showed wide variations during the entire growth period.

The per cent increase in canopy volume got significantly influenced by different interaction treatments (Fig. 1). However, after 6 months of treatments application, the maximum per cent increase in canopy volume 34.58% was observed under T_{15} *i.e.* N_3V_3 (Nitrogen @ 350g/plant + Vermicompost @ 20kg/plant) treatment which was statistically significant and superior over other treatments and minimum per

cent increase in canopy volume (11.30%) was recorded under control. Improvement in above parameters may be due to the synergistic effect of higher doses of nitrogen and vermicompost. The application of nitrogen resulted in vigorous vegetative growth of the plant and imparted dark green colour to the foliage which might favoured greater assimilation and greater accumulation of carbohydrate in the leaves promoting the formation of amino acids, nucleoproteins, chlorophyll, alkaloids and amides. These complex compounds are responsible for building up of new tissues and are associated with the catalytic activity of a number of metabolic processes which is turn invigorates better development of plants. The periodical variation in relative water content percentage with the advancement of growth period due to application of vermicompost treatments have been presented in Fig. 2. The critical examination of data reveals that there was variation in the relative water content percentage of Kinnow leaves at all the days of observation from 30 to 180 days after application of different treatments. Further, after 180 days after treatment the maximum increase in relative water content (88.53%) was observed at vermicompost @ 20 kg per plant treatment which was found at par to V_2 treatment, and the minimum relative water content (84.52%) was recorded under control.

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