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# Effect of organic manure and nitrogen on growth yield and quality of kinnow mandarin in sandy soils of hot arid region

**P. C. Garhwal[1]*, P. K. Yadav[2], B. D. Sharma[3], R. S. Singh[3] and A. S. Ramniw[4]**

[1]Department of Horticulture, College of Agriculture, Junagadh Agricultural University Motibag, Junagadh-362001, Gujarat, India.
[2]Department of Horticulture, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University (SKRAU), Bikaner – 334006, India.
[3]Central Institute for Arid Horticulture (CIAH), Bikaner 334 006, Rajasthan, India.
[4]Krishi Vigyan Kendra (KVK), Central Arid Zone Research Institute (CAZRI), Bhuj – 370105, India.

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**The findings of present investigation revealed that the application of 80 kg farm yard manure (FYM) per plant significantly increased trunk diameter (9.47%), fruit yield (25.22 kg/tree), number of fruits (212.75 fruits/tree), average fruit weight (118.22 g), fruit diameter (5.96 cm), fruit length (5.58 cm), volume of fruit (129.71 cc), peel weight (32.95 g), weight of sacs (85.27 g), juice percentage (48.30%), TSS (12.11 °B), ascorbic acid (26.37 mg/100 g edible portion), total sugar (6.63%), reducing sugar (2.92%), non-reducing sugar (3.71%), juice acidity (0.79%) (significantly minimum), phosphorus soil at 15 to 30 cm depth (12.50%), soil potassium at 0 to 15, 15 to 30 and 30 to 60 cm depths (0.74, 2.27 and 0.75%, respectively), leaf nitrogen (28.17%), leaf potassium (6.28%), leaf zinc (27.88%), leaf iron (5.47%) and minimum 29.92 days to 75% flowering, 52.58 days to fruit set at initial stage and 6.33% fruit drop at maturity. Whereas, application of FYM 60 kg per plant gave maximum B:C ratio (2.30) and net return (38472.31 Rs/ha). The application of 750 g nitrogen per plant gave significant maximum trunk diameter (8.99%), average weight (118.19 g), diameter (6.06 cm) and length of fruit (5.53 cm), peel weight (33.38 g), weight of sacs (84.80 g), volume of fruit (132.31 cc), titrable acidity (0.83%), leaf nitrogen (25.25%), leaf zinc (24.37%), leaf iron (3.46%) and minimum 55.60 days to fruit set at initial stage and 6.79% fruit drop at maturity. While the application of 500 g nitrogen per plant increased number of fruits (204.20 per plant), yield (23.19 kg per plant, TSS (11.37 °B), ascorbic acid (25.66 mg/100 g edible portion), total sugar (6.30%), reducing sugar (2.83%), non-reducing sugar (3.48%), B:C ratio (2.55), net return (39212.93 Rs./ha) and minimum 31.33 days to 75% flowering. The combined application of 80 kg FYM and 750 g nitrogen per plant led to significant increase in plant height (15.20%), spread (N-S, 18.03%; E-W, 18.99%), canopy volume (81.81%), soil nitrogen at different depths (0 to 15 cm, 41.78%; 15 to 30 cm, 51.36% and 30 to 60 cm, 27.71%) over initial level.**

**Key words:** Farm yard manure (FYM), nitrogen, kinnow mandarin, soil and leaf analysis, hot arid region, economical treatments, sandy soils, fruit yield.

## INTRODUCTION

Citrus is the leading fruit crop of the world. It belongs to the family Rutaceae and sub-family Aurantoideace. A large number of citrus species are widely grown in India. Kinnow is an economical important subtropical fruit grown almost all over the arid and semi-arid regions of India, where irrigation facilities are available. Among fruit crops, Kinnow mandarin is an important crop of hot arid region of Rajasthan. In Rajasthan, total area under fruit crops is 46.5 thousand ha with production of 716.8 thousand MT. For kinnow cultivation, Sriganganagar District is on prime position with 15.2 000 ha area and 27.2 000 MT production followed by Hanumangarh and Bikaner districts of North-west Rajasthan (Anonymous, 2013).

Nowadays, its production as well as quality is deteriorating day by day because farmers do not know the nutritional value of fruit orchards; and also because the soil of hot arid regions is not fertile; it has low carbon and nitrogen contents, which are essential for growth and development of plants. To increase the fruit production in terms of quantity and quality, farmers have to meet the international standards in order to compete in the global market.

Farm yard manure (FYM) provides essential nutrients along with organic matter to the plant rhizosphere. FYM also enhances soil porosity and water holding capacity of the soil. It also limits the losses caused by leaching and maintains balanced nutrient status of the soil. However, nitrogen is the most important essential plant nutrient which plays a great role in increasing vegetative growth and fruit production of the plant. Nitrogen causes early vigorous vegetative growth and green colour, which triggers the physiological activities of the plant. Sharma and Chopra (2000) observed that nitrogen played an important role in increasing the growth and yield of sweet orange.

Thus, there is ample scope for increasing the growth and production parameters by using FYM and nitrogen, especially by standardizing the economic doses. Hence, this work was carried out to study the effect of FYM and nitrogen levels on growth, yield and quality of Kinnow mandarin in sandy soils of hot arid region.

## MATERIALS AND METHODS

The experiment was carried out at the Research Farm, Central Institute for Arid Horticulture, Bikaner and Laboratory, Department of Horticulture, College of Agriculture, SKRAU-Bikaner (Rajasthan) from February to December 2008. Seven years old uniform and healthy Kinnow trees were used; they were spaced at 6 m apart. There were 20 treatment combinations consisting of five levels of FYM (0, 20, 40, 60 and 80 kg per plant) and four levels of nitrogen (0, 250, 500 and 750 g per plant). This was done to find out their effect on soil and plant nutrient and to standardize the best economical dose. The experiment was laid out in factorial randomized block design with three replications. Full dose of FYM and half dose of nitrogen were applied in the second week of February through basal dose and the remaining half dose of nitrogen was applied in the second week of July in 2008. The nitrogen was applied though urea. Urea contains 46% nitrogen, whereas FYM contains 0.50% nitrogen, 0.25% phosphorus and 0.50% potassium. The orchard soil contains 86.41, 22.91 and 234.00 kg/ha nitrogen, phosphorus and potassium, respectively. The uniform doses of phosphorus (250 g/plant), potassium (100 g/plant) and zinc (25 g/plant) were applied through basal dose per plant.

Growth parameters in terms of plant height, spread (N-S and E-W), trunk diameter, canopy volume, soil nutrient status related to nitrogen, phosphorus and potassium at three consecutive depths (0 to 15, 15 to 30 and 30 to 60 cm) and analysis of leaves in relation to nitrogen, phosphorus, potassium, zinc and Iron of Kinnow plants were measured two times. That is, before imposing treatment (February 2008) and after completion of experiment (December 2008). The percent increase in last observation was calculated on the basis of initial observation. Finally, results are presented as percent increase over the initial one. Yield parameter in terms of fruit yield was noted at various intervals of harvesting. Number of fruits was counted in November and it was again confirmed at the time of harvesting (end of December). Average weight, diameter, length of fruit, peel weight, weight of sacs, number of seeds, juice percentage and volume of fruit were recorded by taking five representative fruits from each tree and were averaged. Growth and development parameter of fruits like percentage of fruit drop at maturity was counted and divided by total number of fruits and then multiplied by 100. The dates of fruit set at initial stage and flowering were recorded by visual observation. They were expressed as number of days required to attain the particular stage on the day the treatment was applied, that is, 8$^{th}$ February, 2008.

Qualitative attributes like TSS was determined with a hand refractometer. Ascorbic acid was estimated by titration method. Acidity was estimated according to the method suggested by official and tentative methods of analysis. Total sugar was estimated by colorimetric method. Reducing sugar was measured by aresenomolybdate reagent colour development method. Non-reducing sugar was calculated by reducing sugar from total sugar.

The available soil nitrogen was determined by Alkaline Potassium Permanganate Method. Available soil phosphorous was extracted using 0.5M $NaHCO_3$ solution and thereafter determined by Dickmon and Bray method. Available soil and leaves potassium was determined by Flame photometer. Estimation of leaf nitrogen was done with wet colorimetric method. Phosphorus in plant samples was analyzed with wet digestion of triacid mixture using Vanado molybdo-phosphric yellow colour method on spectrophotometer. Estimation of iron and zinc in plant was determined by Atomic Absorption Spectrophotometer.

In order to evaluate the economic feasibility of the treatments, net returns and B:C ratio were worked out on the basis of prevailing market prices so that most remunerative treatment could be recommended.

### Climate and weather conditions

Bikaner District extends from 27°15' to 29.5° north latitudes and 71°54' to 74°12' east longitudes. Bikaner has arid climate with an annual average rainfall of about 260 mm. More than 80% rainfall is received during South-west monsoon season. During summer, the maximum temperature is as high as 48°C, while in the winter it falls to 0°C and sometimes sub-zero. This region is prone to high wind velocity and soil erosion. Soil drifting due to high speed winds leads to soil erosion. This is the major problem in summer. The weekly mean weather parameters for the period of the experimentation

*Corresponding author. E-mail: premhorti75@gmail.com

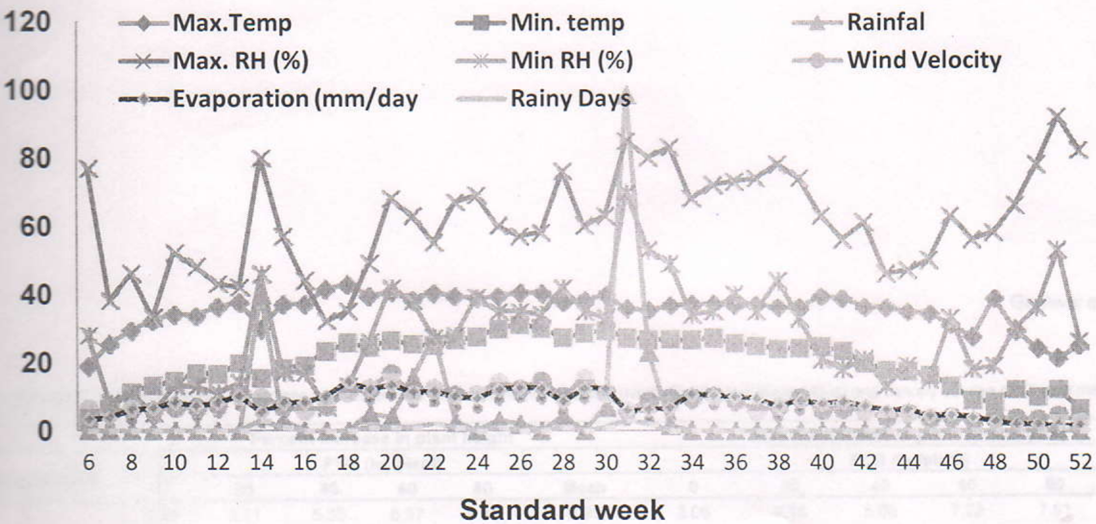


**Figure 1.** Mean weekly meteorological data recorded during the experiment.

were recorded from the Meteorological Observatory of Agricultural Research Station, Beechwal, Bikaner (Figure 1).

## RESULTS AND DISCUSSION

### Growth parameters

The data in Tables 1 and 2 show that application of 80 kg FYM per plant led to significant percentage increase in plant height (12.48%), plant spread (North-South, 13.60%; East-west; 14.71%), canopy volume (58.57%) and trunk diameter (9.47%). This might be due to improved nutritional status and physical properties of the soil caused by the addition of FYM. This made the plant to uptake water and mineral nutrients better, resulting in its increased growth rate. Similarly, significant growth of Kinnow mandarin by the application of FYM has been earlier reported by Dudi et al. (2003).

The data on the effect of nitrogen revealed that the application of 750 g nitrogen per plant led to significant percent increase in plant height (13.05%), plant spread (North-South, 13.54%; East-West, 14.67 %), canopy volume (57.16%) and trunk diameter (8.99%). Application of nitrogen resulted in vigorous vegetative growth of the plant and gave the dark green colour of the foliage. This favoured the photosynthetic activity of the plants and greater synthesis of carbohydrate, which led to the formation of amino acids, nucleo-proteins, chlorophyll, alkaloids and amides. These complex compounds are responsible for building up of new tissues and are associated with a number of metabolic processes, which in turn favour better development of plants. The increase in growth as a result of nitrogen application is obvious. Similarly, increase in vegetative growth of fruit plants by the application of nitrogen has also been reported earlier by Kaul and Bhatnagar (2006) in Kinnow mandarin and Dhomane et al. (2011) in guava.

The combined application of 80 kg FYM and 750 g nitrogen per plant significantly led to maximum percentage increase over the initial one. It is seen in plant height (15.20%), plant spread (North-South, 18.03%; East-West, 18.99%) and canopy volume (81.81%). This might be due to the fact that combined application of nitrogen and FYM enhances leaf expansion and its dark green colour, which favours photosynthesis and respiration; hence, growth is enhanced by application of nitrogen and balanced nutrition provided by FYM. FYM improves physico-chemical properties of soil, which provides better conditions for plant growth and development. The findings are in line with the results obtained in Kinnow (Dudi et al., 2003; Kaul and Bhatanagar, 2006). Data also revealed that plant spread was more in E-W direction compared to N-S direction. This might be due to the fact that the foliage receives sunlight directly.

### Yield characters

The data presented in Table 2 revealed that fruit yield (25.22 kg/tree), number of fruits (212.75 fruits/tree), average weight (118.22 g), diameter (5.96 cm), length of fruit (5.58 cm), volume of fruit (129.71 cc), peel weight (32.95 g), weight of sacs (85.27 g) and juice percentage (48.83%) significantly increased in plants receiving 80 Kg FYM followed by 60 kg FYM. This may be due to increased vegetative and reproductive growth of plant and better nutrient supply as a result of the application of FYM. It does not only add organic matter and macro and

Table 1. Effect of FYM and nitrogen levels on per cent increase in plant height, plant spread (North-South) and (East- West) and canopy volume of Kinnow mandarin.

| Nitrogen (g/plant) | Percent increase in plant height | | | | | | Percent increase in plant spread (N-S) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FYM (kg/plant) | | | | | | FYM (kg/plant) | | | | | |
| | 0 | 20 | 40 | 60 | 80 | Mean | 0 | 20 | 40 | 60 | 80 | Mean |
| 0 | 3.08 | 3.71 | 5.33 | 8.07 | 9.45 | 5.93 | 3.05 | 4.18 | 5.06 | 7.22 | 7.91 | 5.49 |
| 250 | 6.04 | 8.44 | 8.54 | 10.35 | 11.67 | 9.01 | 5.6 | 7.50 | 9.09 | 11.24 | 12.38 | 9.16 |
| 500 | 8.84 | 10.07 | 9.74 | 11.42 | 13.61 | 10.74 | 8.98 | 10.68 | 10.75 | 12.46 | 16.08 | 11.79 |
| 750 | 9.59 | 11.31 | 14.02 | 15.14 | 15.2 | 13.05 | 9.91 | 11.43 | 13.26 | 15.07 | 18.03 | 13.54 |
| Mean | 6.89 | 8.38 | 9.41 | 11.25 | 12.48 | | 6.89 | 8.45 | 9.54 | 11.5 | 13.6 | |

| | Nitrogen | FYM | Nitrogen x FYM | Nitrogen | FYM | Nitrogen x FYM |
|---|---|---|---|---|---|---|
| S.Em. ± | 0.07 | 0.08 | 0.16 | 0.17 | 0.19 | 0.39 |
| CD at 5% | 0.21 | 0.23 | 0.46 | 0.50 | 0.55 | 1.11 |

| Nitrogen (g/plant) | Percent increase in Plant spread (E- W) | | | | | | Percent increase in canopy volume | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FYM (kg/plant) | | | | | | FYM (kg/plant) | | | | | |
| | 0 | 20 | 40 | 60 | 80 | Mean | 0 | 20 | 40 | 60 | 80 | Mean |
| 0 | 3.38 | 4.46 | 5.80 | 6.67 | 6.75 | 5.41 | 10.25 | 14.08 | 18.11 | 23.82 | 25.31 | 18.31 |
| 250 | 6.12 | 8.18 | 10.45 | 15.16 | 15.16 | 10.52 | 19.72 | 27.49 | 35.55 | 45.39 | 54.84 | 36.60 |
| 500 | 8.85 | 11.73 | 12.78 | 17.94 | 17.94 | 12.98 | 31.78 | 41.84 | 44.79 | 54.03 | 72.34 | 48.96 |
| 750 | 10.88 | 12.95 | 14.80 | 18.9 | 18.99 | 14.67 | 38.20 | 46.53 | 55.98 | 63.29 | 81.81 | 57.16 |
| Mean | 7.31 | 9.33 | 10.96 | 12.16 | 14.71 | | 24.99 | 32.49 | 38.61 | 46.63 | 58.57 | |

| | Nitrogen | FYM | Nitrogen x FYM | Nitrogen | FYM | Nitrogen x FYM |
|---|---|---|---|---|---|---|
| S.Em. ± | 0.11 | 0.12 | 0.24 | 0.56 | 0.63 | 1.26 |
| CD at 5% | 0.31 | 0.35 | 0.70 | 1.62 | 1.81 | 3.62 |

micro nutrients to soil, but also improves the physico-chemical properties of soil; and hence provides better conditions for plants' growth and development (Dudi et al., 2004). Similar results were earlier obtained by Hiwale et al. (2010) in sapota and Kashyap et al. (2012) in pomegranate. Average number of seeds per fruit was found statistically non – significant in various combined treatments of FYM and nitrogen. It is evident from the data in Table 2 that significant maximum fruit yield (23.19 kg/tree), number of fruits (204.20 fruits/tree) and juice percentage (48.83%) were observed in plants receiving 500 g nitrogen. Whereas, other characters such as average weight (118.19 g), diameter (6.06 cm), length (5.53 cm) volume (132.31 cc), peel weight (33.38 g) and weight of sacs (84.80 g) of fruit increased significantly by the application of 750 g nitrogen per plant. It is due to the fact that increases in nitrogen doses at 750 g per plant causes excessive and imbalance vegetative growth. This is caused by the diversion of reserved food material to vegetative growth instead of reproductive growth (Dudi et al., 2004 in kinnow). It is in accordance with the findings of Dhomane et al. (2011) in guava and Kashyap et al. (2012) in pomegranate. Nitrogen leads to increased

Table 2. Effect of FYM and nitrogen levels on trunk diameter, fruit yield, number of fruits, average weight, diameter and length, peel weight, weight of sacs, no. of seeds and volume of Kinnow mandarin fruits.

| Treatment symbol | % increase in trunk diameter | Fruit yield kg plant$^{-1}$ | No. of fruits plant$^{-1}$ | Av. weight of fruit (g) | Diameter of fruit (cm) | Length of fruit (cm) | Peel weight of fruit (g) | weight of sacs fruit$^{-1}$ (g) | Av. No. of seeds fruit$^{-1}$ (g) | Juice percent | Volume of fruit (CC) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen (g/plant) | | | | | | | | | | | |
| $N_0$ | 3.61 | 17.81 | 181.40 | 93.95 | 5.33 | 5.00 | 26.84 | 67.11 | 11.05 | 42.99 | 104.15 |
| $N_{250}$ | 5.43 | 19.74 | 192.00 | 102.13 | 5.60 | 5.15 | 29.25 | 72.89 | 11.30 | 46.03 | 114.32 |
| $N_{500}$ | 7.19 | 23.19 | 204.20 | 112.79 | 5.95 | 5.40 | 31.51 | 81.28 | 11.47 | 48.83 | 124.95 |
| $N_{750}$ | 8.99 | 23.42 | 197.00 | 118.19 | 6.06 | 5.53 | 33.38 | 84.80 | 11.81 | 47.44 | 132.31 |
| S.Em.± | 0.16 | 0.15 | 0.98 | 0.50 | 0.02 | 0.02 | 0.21 | 0.57 | 0.35 | 0.20 | 0.63 |
| C.D 5% | 0.47 | 0.43 | 2.82 | 1.43 | 0.07 | 0.06 | 0.61 | 1.62 | NS | 0.57 | 1.79 |
| FYM (kg/plant) | | | | | | | | | | | |
| $FYM_0$ | 3.76 | 15.97 | 169.75 | 93.72 | 5.44 | 5.00 | 26.45 | 67.27 | 12.16 | 44.16 | 105.27 |
| $FYM_{20}$ | 4.70 | 18.46 | 184.75 | 99.48 | 5.66 | 5.07 | 29.14 | 70.35 | 11.56 | 45.28 | 114.54 |
| $FYM_{40}$ | 5.92 | 20.98 | 193.50 | 108.05 | 5.76 | 5.26 | 30.89 | 77.16 | 11.36 | 46.34 | 119.97 |
| $FYM_{60}$ | 7.67 | 23.78 | 207.50 | 114.35 | 5.86 | 5.46 | 31.80 | 82.55 | 11.22 | 47.53 | 125.18 |
| $FYM_{80}$ | 9.47 | 25.22 | 212.75 | 118.22 | 5.96 | 5.58 | 32.95 | 85.27 | 10.73 | 48.30 | 129.71 |
| S.Em. ± | 0.18 | 0.17 | 1.10 | 0.56 | 0.03 | 0.02 | 0.24 | 0.63 | 0.39 | 0.22 | 0.70 |
| C.D 5% | 0.52 | 0.48 | 3.15 | 1.60 | 0.07 | 0.06 | 0.69 | 1.81 | NS | 0.64 | 2.00 |

average weight, length, diameter, volume, peel weight and weight of sacs of kinnow fruits. This is due to the fact that nitrogen increases the efficiency of metabolic process of the plants; and thus encourages the growth of the plant and consequently increases the size and weight of the fruit. Another probable cause could be greater mobility of nutrients to the developing fruits which act as strong metabolic sink; examples are pomegranate (Prasad and Mali, 2000), Kinnow (Dudi et al., 2004) and guava (Kashyap et al., 2012). The reduction in juice content caused by high doses of nitrogen might be due to the thickness of the peel; example is sweet orange (Sharma and Chopra, 2000). Carranca et al. (1992) reported that the production of sweet oranges and mandarins flower and fruit were high by the application of the highest level of nitrogen but the total yield was maximum by the application of medium level of nitrogen. These results are in accordance with the findings of Prasad and Mali (2000) in pomegranate, Dudi et al. (2004) in Kinnow mandarin, Kaul and Bhatnagar (2006) in kinnow, Hiwale et al. (2010) in sapota and Kashyap et al. (2012) in pomegranate.

## Fruit growth and development

The data in Table 3 show that the application of 80 kg FYM per plant led to significant decrease in 29.92 days to 75% flowering, 55.58 days to fruit set at initial stage and 6.33% fruit drop at maturity, over the control. This is because FYM not only adds organic matter and macro and micro nutrients to soil, but also improves the physico–chemical properties of soil; and hence causes nutritional balance of the soil as well as the plant. Thus, the improved plant growth and development caused by nutritional balance reduces the days taken to have 75% flowering and the days taken to have fruit set at initial stage and fruit drop at maturity stage.

It is also clarified from the data in Table 3 that application of 500 g nitrogen per plant significantly

Table 3. Effect of FYM and nitrogen levels on total soluble solids (TSS), titrable acidity, ascorbic acid, total sugar, reducing sugar, non-reducing sugar, days to 75% flowering, days to fruit set at marble stage, fruit drop at maturity, B:C ratio and net returns of Kinnow mandarin.

| Treatment symbol | TSS (°B) | Titrable acidity (%) | Asco. acid (mg/100 g) | Total sugar (%) | Reducing sugar (%) | Non-reducing sugar (%) | Days to 75% flowering | Days to fruit set at marble stage | Fruit drop at maturity (%) | B:C ratio | Net returns (Rs/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen (g/plant) | | | | | | | | | | | |
| $N_0$ | 9.78 | 0.78 | 23.50 | 5.61 | 2.51 | 3.10 | 33.80 | 58.93 | 7.67 | 2.01 | 24024.94 |
| $N_{250}$ | 10.56 | 0.80 | 24.42 | 5.95 | 2.65 | 3.30 | 33.07 | 58.00 | 7.37 | 2.24 | 30387.23 |
| $N_{500}$ | 11.37 | 0.81 | 25.66 | 6.30 | 2.83 | 3.48 | 31.33 | 57.07 | 7.03 | 2.55 | 39212.93 |
| $N_{750}$ | 11.10 | 0.83 | 25.06 | 6.08 | 2.74 | 3.34 | 32.20 | 55.60 | 6.79 | 2.50 | 39093.07 |
| S.Em ± | 0.08 | 0.0047 | 0.17 | 0.09 | 0.07 | 0.07 | 0.24 | 0.26 | 0.14 | --- | 413.92 |
| CD 5% | 0.23 | 0.013 | 0.49 | 0.25 | 0.20 | 0.21 | 0.69 | 0.75 | 0.41 | --- | 1185.39 |
| FYM (kg/plant) | | | | | | | | | | | |
| $FYM_0$ | 9.37 | 0.82 | 23.00 | 5.40 | 2.39 | 3.00 | 35.42 | 61.42 | 7.94 | 2.29 | 25079.85 |
| $FYM_{20}$ | 10.02 | 0.81 | 23.81 | 5.64 | 2.58 | 3.05 | 33.58 | 59.75 | 7.66 | 2.31 | 29224.29 |
| $FYM_{40}$ | 10.62 | 0.80 | 24.59 | 5.95 | 2.69 | 3.27 | 32.42 | 57.83 | 7.35 | 2.34 | 33450.57 |
| $FYM_{60}$ | 11.40 | 0.80 | 25.51 | 6.32 | 2.83 | 3.49 | 31.67 | 55.42 | 6.81 | 2.39 | 38472.31 |
| $FYM_{80}$ | 12.11 | 0.79 | 26.37 | 6.63 | 2.92 | 3.71 | 29.92 | 52.58 | 6.33 | 2.30 | 39670.69 |
| S.Em ± | 0.09 | 0.0052 | 0.19 | 0.10 | 0.08 | 0.08 | 0.27 | 0.29 | 0.16 | --- | 462.78 |
| CD 5% | 0.26 | 0.015 | 0.55 | 0.28 | 0.23 | 0.23 | 0.77 | 0.84 | 0.46 | --- | 1325.30 |

curtailed days taken to have 75% flowering (31.33 days). By increasing nitrogen levels to 750 g/plant further, the days were recorded more (32.30). This might be due to the fact that application of 750 g nitrogen per plant causes the diversion of reserved food material to vegetative growth instead of reproductive growth; it also causes nutritional imbalance for flower production. Thus, adequate dose of nitrogen may be required for flower production. Dayal et al (2006) reported that flower production could be regulated by the nitrogen status in grape. Sharma and Chopra (2000) reported that nitrogen is considered to be of prime importance in the production of leaves, flowers and fruits in Blood Red sweet orange.

However, days taken to have fruit set at initial stage and fruit drop percentage at maturity stage were minimum 55.60 and 6.79 by the application of 750 g nitrogen per plant, over previous levels. The data revealed that days taken to have fruit set at initial stage significantly decreased with increasing levels of nitrogen. This is because nitrogen as an important constituent of nucleo-protiens, amino acids and amino sugars is responsible for cell division and cell elongation. The fruit drop percentage at maturity stage significantly decreased over control by the application of 750 g nitrogen. Nitrogen applications usually enhance micronutrients uptake and utilization (Gupta, 1999). Increased nitrogen rates resulted in more absorption of water and minerals from the soil. This results in the maintenance of nutritional and water requirement of the plant which reduce the fruit drop. Singh et al. (2003) reported the increase in fruit set and decrease in fruit drop as a result of nitrogen application in sapota. This might be due to increase in auxin content. Sharma et al. (2003) reported that the increased doses of nitrogen in phalsa significantly reduced fruit drop.

### Quality attributes

The data in Table 3 revealed that the application of 80 kg FYM per plant resulted in significant increase in TSS (12.11 °B), ascorbic acid (26.37 mg/100 g edible portion), total sugar (6.63%), reducing sugar (2.92%), non-reducing sugar (3.71%), but significant decrease in juice acidity (0.79%). This might be due to good nutrient status, improved plant conditions, efficient functioning of leaf area and increased photosynthetic activity. These results are in conformity with the results obtained by Sharma et al. (2003) in pomegranate and Singh and Banik (2011) in mango.

It was further observed that significant increase in TSS (11.37 °B) was recorded by the application of 500 g nitrogen per plant. This is because adequate dose of nitrogen stimulates the functioning of number of enzymes in the physiological process which may have increased the total soluble solid content of the fruits. The highest ascorbic acid content (25.66 mg/100 g edible portion) was found significant by the application of 500 g nitrogen per plant. This might be due to the catalytic activity of several enzymes which participate in the biosynthesis of ascorbic acid and precursor. The sugars (total, reducing and non-reducing) (6.30, 2.83 and 3.48%) increased significantly by the application of 500 g nitrogen per plant.

The highest mean values for sugars with the application of nitrogen could be attributed to the involvement of nitrogen in various energy sources like amino acids and amino sugars. Application of 750 g nitrogen per plant decreased the TSS, ascorbic acid, sugars (total, reducing and non-reducing). This is because when it reaches the toxicity level, it decreases other enzymes and nutrient molecules which help in the synthesis of these quality attributes. These results are in conformity with the results obtained by Prasad and Mali (2000) in pomegranate, Kaul and Bhatanagar (2006) in Kinnow and Kashyap et al. (2012) in pomegranate.

The acidity of fruit juice (0.83%) significantly increased by the application of the highest dose of nitrogen (750 g per plant). This is due to increased synthesis and translocation of organic acids in the fruits as cited by Prasad and Mali (2000) in pomegranate. Similar findings were earlier reported by Sharma et al. (2013) in guava.

## Soil analysis

An analysis was carried out on the soil's three distinct layers of nitrogen content: 0 to 15, 15 to 30 and 30 to 60 cm. Data in Table 4 revealed that nitrogen content increased significantly with increased levels of FYM. The maximum increase in nitrogen content (37.88, 46.23 and 25.44%) was found in 0 to 15, 15 to 30 and 30 to 60 cm soil depths, respectively by the application of 80 kg FYM per plant followed by 60 kg FYM per plant. But, it was minimum in control.

The data on soil nitrogen content at different soil depths showed that soil nitrogen content increased significantly with continuous increase in the levels of nitrogen. The maximum increase in nitrogen content (36.11, 46.03 and 25.73%) was found in 0 to 15, 15 to 30 and 30 to 60 cm soil depths, respectively by the application of 750 g nitrogen per plant followed by 500 g nitrogen.

The interaction between FYM and nitrogen significantly increased soil nitrogen content percentage over initial level. Maximum increase of 41.78, 51.36 and 27.71% was found in 0 to 15, 15 to 30 and 30 to 60 cm soil depths, respectively by the combined application of 750 g nitrogen and 80 kg FYM per plant followed by 750 g nitrogen and 60 kg FYM per plant treatment.

It is evident from Table 5 that percent increase in phosphorus content of soil was not significantly influenced by FYM application at 0 to 15 and 30 to 60 cm soil depths. However, a general trend of increase in phosphorus content was observed with increasing levels of FYM. At 15 to 30 cm soil depth, the phosphorus content (12.50%) was significantly increased by the application of 80 kg FYM per plant.

The data on potassium content in Table 5 showed that maximum increase in potassium (0.74, 2.27 and 0.75%) was observed at 0 to 15, 15 to 30 and 30 to 60 cm soil depths, respectively by the application of 80 kg FYM per plant, followed by 60 kg FYM. However, minimum increase was recorded in control. The data on soil phosphorus and potassium were not significantly influenced by the application of nitrogen at different soil depths (0 to 15, 15 to 30 and 30 to 60 cm).

The nitrogen content in soil at different depths increased with increasing doses of nitrogen and FYM in combination and separately due to increased concentration of supplied sources (FYM and Urea) and mobility character of nitrogen in soil. Therefore, higher percent increase of nitrogen was observed at different depths. The application of 80 kg FYM in soil significantly increased the potassium content of soil at different depths, but phosphorus content increased significantly only at 15 to 30 cm soil depth. This is because this depth has residual effect of FYM, which increases the level of phosphorus. But phosphorus content decreased at 0 to 15 and 30 to 60 cm depth compared to nitrogen and potassium content. This is because FYM has very low quantity of phosphorus (0.25%) compared to nitrogen and potassium (0.50%), respectively. The maximum increase of nitrogen, phosphorus and potassium was observed at 15 to 30 cm soil depth because FYM and urea (only for nitrogen) were applied at this depth. Therefore, residual effects of supply sources could enhance the concentration of these nutrients. Similar results were also found by Sharma et al. (2003) in pomegranate and Sharma et al. (2009) in pomegranate variety Jalore seedless.

## Leaf analysis

The data presented in Table 5 showed that leaf nitrogen (28.17%), potassium (6.28%), zinc (27.88%) and iron (5.47%) significantly increased by the application of 80 kg FYM per plant against lower levels of FYM. This might be due to improved soil texture, structure and moisture level which facilitate the absorption of mineral nutrition

**Table 4.** Effect of FYM and nitrogen levels on percent increase in nitrogen content at different depths of Kinnow orchard soil.

| Nitrogen (g/plant) | At 0-15 cm soil depth | | | | | | At 15-30 cm soil depth | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FYM (kg/plant) | | | | | | FYM (kg/plant) | | | | | |
| | 0 | 20 | 40 | 60 | 80 | Mean | 0 | 20 | 40 | 60 | 80 | Mean |
| 0 | -1.51 | 26.43 | 28.08 | 30.83 | 33.67 | 23.50 | -1.81 | 34.02 | 36.34 | 39.04 | 41.26 | 29.77 |
| 250 | 27.62 | 28.67 | 31.71 | 33.80 | 36.68 | 31.70 | 36.49 | 36.34 | 39.05 | 42.77 | 44.56 | 39.84 |
| 500 | 28.79 | 31.16 | 34.09 | 36.08 | 39.41 | 33.90 | 38.83 | 38.75 | 42.59 | 46.90 | 47.73 | 42.96 |
| 750 | 29.38 | 33.30 | 36.79 | 39.29 | 41.78 | 36.11 | 41.08 | 41.17 | 45.96 | 50.57 | 51.36 | 46.03 |
| Mean | 21.07 | 29.89 | 32.67 | 35.00 | 37.88 | | 28.65 | 37.57 | 40.99 | 44.82 | 46.23 | |

| | Nitrogen (0-15 cm) | FYM (0-15 cm) | Nitrogen x FYM (0-15 cm) | Nitrogen (15-30 cm) | FYM (15-30 cm) | Nitrogen x FYM (15-30 cm) |
|---|---|---|---|---|---|---|
| S.Em. ± | 0.39 | 0.43 | 0.87 | 0.35 | 0.39 | 0.78 |
| CD at 5% | 1.11 | 1.25 | 2.49 | 1.00 | 1.12 | 2.24 |

| Nitrogen (g/plant) | At 30-60 cm soil depth | | | | | |
|---|---|---|---|---|---|---|
| | FYM (kg/plant) | | | | | |
| | 0 | 20 | 40 | 60 | 80 | Mean |
| 0 | 1.98 | 20.49 | 21.36 | 22.15 | 23.28 | 17.85 |
| 250 | 21.49 | 22.04 | 22.56 | 23.63 | 24.67 | 22.88 |
| 500 | 22.58 | 23.60 | 24.03 | 25.03 | 26.08 | 24.26 |
| 750 | 23.91 | 25.02 | 25.43 | 26.56 | 27.71 | 25.73 |
| Mean | 17.49 | 22.78 | 23.35 | 24.34 | 25.44 | |

| | Nitrogen | FYM | Nitrogen x FYM |
|---|---|---|---|
| S.Em. ± | 0.25 | 0.28 | 0.56 |
| CD at 5% | 0.71 | 0.80 | 1.60 |

from the soil. Secondly, farm yard manure being a good source of all nutrients certainly improves nutrient contents.

The phosphorus content of leaves was found non- significant with the application of FYM. This is due to the low content of FYM in the soil and its immobility. Similar results were obtained by Sharma et al. (2003) in pomegranate.

It is also evident from the data that the leaf nitrogen (25.25%), zinc (24.37%) and iron (3.46%) increased significantly by the application of 750 g nitrogen per plant, against that of control. The leaf nitrogen increased with urea application due to nitrogenous fertilizer. Zinc and iron contents increased with nitrogen application. This is because nitrogen application usually enhances micronutrients uptake and utilization (Gupta, 1999); secondly, increased nitrogen rates resulted in more absorption of water and minerals from the soil, which enhanced the zinc and iron contents in leaves.

These results are in accordance with the findings of Singh et al. (2003) in sapota. Phosphorus and potassium content of leaves decreased with increasing levels of nitrogen. Similar results were earlier found by Intrigliolo and Intelisano (1997) in lemon tree.

**Table 5.** Effect of FYM and nitrogen levels on percent increase in soil phosphorus and potassium content at different depths, leaves nitrogen, phosphorus and potassium contents Kinnow mandarin orchard.

| Treatment symbol | Phosphorus at different soil depths (cm) | | | Potassium at different soil depths (cm) | | | Percent increase in leaves contents | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-15 | 15-30 | 30-60 | 0-15 | 15-30 | 30-60 | Nitrogen | Phosphorus | Potassium | Zinc | Iron |
| **Nitrogen (g/plant)** | | | | | | | | | | | |
| $N_0$ | 3.26 | 10.36 | 2.18 | 0.54 | 1.80 | 0.55 | 9.06 | 20.24 | 5.14 | 23.50 | 2.47 |
| $N_{250}$ | 3.29 | 10.27 | 2.20 | 0.53 | 1.80 | 0.54 | 14.34 | 19.73 | 4.81 | 23.79 | 2.76 |
| $N_{500}$ | 3.31 | 10.25 | 2.22 | 0.53 | 1.79 | 0.54 | 19.73 | 19.19 | 4.61 | 24.09 | 3.11 |
| $N_{750}$ | 3.32 | 10.41 | 2.20 | 0.53 | 1.80 | 0.55 | 25.25 | 18.66 | 4.30 | 24.37 | 3.46 |
| S.Em.± | 0.15 | 0.13 | 0.07 | 0.0007 | 0.0018 | 0.0010 | 0.55 | 0.41 | 0.21 | 0.05 | 0.02 |
| CD 5% | NS | NS | NS | NS | NS | NS | 1.58 | NS | NS | 0.16 | 0.06 |
| **FYM (kg/plant)** | | | | | | | | | | | |
| $FYM_0$ | 2.93 | 7.34 | 2.04 | 0.28 | 1.32 | 0.34 | 6.27 | 18.95 | 2.92 | 19.67 | 0.30 |
| $FYM_{20}$ | 3.16 | 9.31 | 2.12 | 0.48 | 1.58 | 0.47 | 11.70 | 19.21 | 4.12 | 22.02 | 1.31 |
| $FYM_{40}$ | 3.30 | 10.61 | 2.21 | 0.53 | 1.78 | 0.53 | 16.57 | 19.50 | 4.83 | 24.03 | 3.01 |
| $FYM_{60}$ | 3.53 | 11.46 | 2.29 | 0.63 | 2.03 | 0.65 | 22.77 | 19.74 | 5.42 | 26.08 | 4.37 |
| $FYM_{80}$ | 3.56 | 12.50 | 2.34 | 0.74 | 2.27 | 0.75 | 28.17 | 19.91 | 6.28 | 27.88 | 5.74 |
| S.Em. ± | 0.17 | 0.15 | 0.08 | 0.0008 | 0.0020 | 0.0011 | 0.62 | 0.46 | 0.24 | 0.06 | 0.02 |
| CD 5 % | NS | 0.43 | NS | 0.0023 | 0.0058 | 0.0032 | 1.76 | NS | 0.68 | 0.17 | 0.06 |

## Economics

The data on benefit- cost ratio (Table 3) revealed that maximum B : C ratio of 2.39 and 2.55 was recorded in the plants receiving 60 kg FYM and 500 g nitrogen per plant followed by lower levels. The data on net returns (Table 3 and Figure 2) show that significant maximum net returns of 39670.69 and 39212.93 Rs./ha were recorded in the plants receiving 80 kg FYM and 500 g nitrogen per plant; and it was also found at par with the application of FYM. That is, 60 Kg per plant (38472.31 Rs./ha) over lower levels of FYM. The minimum net return was recorded in untreated plants.

The highest B : C ratio and net returns were obtained with the application of 500 g nitrogen per plant. Whereas in FYM application, the maximum B : C ratio was recorded in the application of 60 kg FYM; maximum net returns were found in the application of 80 kg FYM per plant. The increase in net returns from 60 to 80 kg FYM was not significant; therefore, application of 60 kg FYM per plant is the best economical dose. Similar economical returns have been reported by Luhach et al. (2007) in mango and Luhach et al. (2007) in guava.

## Conclusion

It can be concluded that application of 60 kg FYM and 500 g nitrogen per plant is the best doses among all the treatment combinations for Kinnow mandarin fruit crop. Hence, these doses of FYM and nitrogen are recommended particularly in sandy soils of hot arid region in North – west Rajasthan. However, these results are only indicative and require further experimentation to

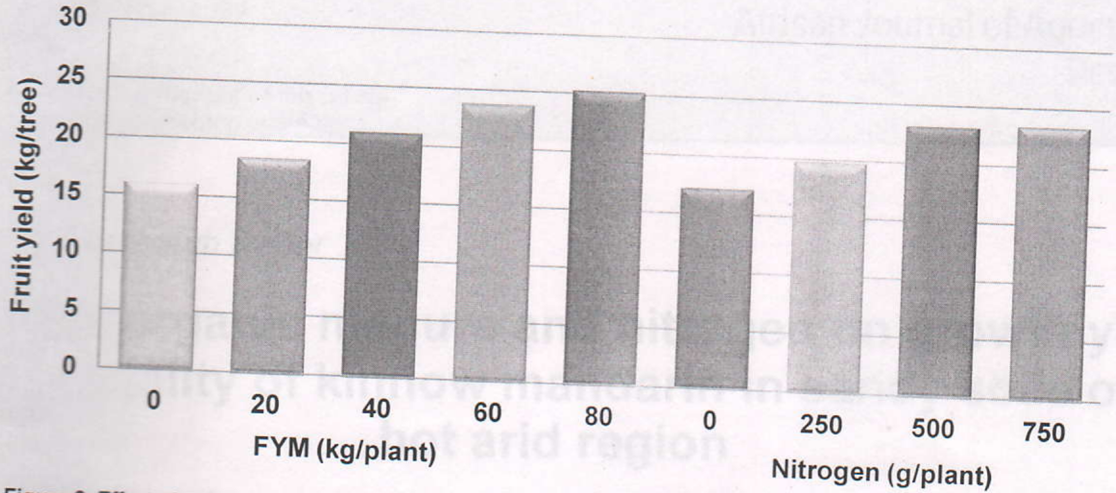


**Figure 2.** Effect of FYM and Nitrogen levels on fruit yield of Kinnow mandarin.

arrive at a final conclusion.

### Conflict of Interest

The authors have not declared any conflict of interest.

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