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RESEARCH ARTICLE

EFFECT OF INTEGRATED USE OF NUTRIENTS ON GROWTH, YIELD AND FRUIT QUALITY OF SWEET ORANGE

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ABSTRACT

A trial was conducted to study the effect of integrated use of nutrients on growth, yield and qulity of sweet orange cv. Mosambi at regional research station, Jhargram of Bidhan Chandra Krishi Viswavidyalaya. Growth in terms of canopy height, basal girth and canopy volume were significantly improved with application of nutrients and maximum growth was observed in plants received with ($N_{200}P_{75}K_{150}$g + neem cake 2.0kg)/ plant / year followed by ($N_{200}P_{75}K_{150}$g + neem cake 2.0kg + VAM)/plant/year. Highest average fruit yield (9.0kg/plant) was obtained with application of 200g nitrogen, 75g phosphorus and 150g potassium in combination with 2.0kg of neem cak as compared with control (3.0kg/plant). The fruit quality in terms of total soluble solids, total sugar, TSS: acid ratio and vitamin C content of fruits were obtained from plants received with ($N_{200}P_{75}K_{150}$g + neem cake 2.0kg). The highest fruit yield was associated with the foliar N.P.K concentration of 2.30, 0.12 and 1.30 percent respectively.

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INTRODUCTION

Nutrition in citrus plays an important role for maintaining vigour, productivity and quality fruit production for longer period. Improper and inadequate nutrition is one of the major causes of citrus decline in India (Chadha *et al.,* 1970). The sweet orange, particularly the cultivar Mosambi was found to perform well under rainfed condition producing best quality fruits (Ghosh and Chattopadhyay, 1998). Continuous fertilization has failed to sustain the yield expectancy on a long term basis due to depletion of soil carbon and consequently, multiple nutrient deficiencies have emerged irrespective of soil type (Srivastava and Singh, 2009). The menace of multiple nutrient deficiencies has further been triggered through increase in air temperature via changes in microbial communities and activities within the rhizosphere in the light of climate change (Wu and Srivastava, 2012). The response of fertilization in improving the growth, yield and fruit quality of different citrus fruits is well recognized under different agro climatic regions of the country (Ram *et al.,* 1997). Maximum fruit yield coupled with an adequate tree volume of sweet orange is attainable through combined use of organics plus inorganic or bio-fertilizers (Marathe and Bharambe, 2007). It is now well understood that continuous use of chemical fertilizers causes serious damage to the soil health. Besides, the production of chemical fertilizers consumes high energy, which comes from the fossil fuel. However, to supplement chemical fertilizers through organic sources of nutrients for maintaining high level of production for longer period is impractical because the organic sources provide little amount of essential nutrients and required in bulk amount which may not be available in sufficient quantities in our country. On the other hand, use of bio-fertilizers may increase the yield and quality of crops when used in combination with organic manures and inorganic fertilizers in a balanced proportion (Mohandas, 1999).Use of biofertilizers for crop production is gaining momentum as they are environmentally safe when compared to chemical fertilizers in banana (Soorianathasundaram *et al.,* 2000). Azospirillium and VAM (Vesicular Arbuscular Mycorhizae) are gaining popularity as bio-fertilizers for fixing atmospheric nitrogen, better mobilization of fixed phosphorus and better availability of these compounds to the plants. The high efficiency of Azospirillium for fixing nitrogen and better mobilization of fixed phosphorus by VAM even at high temperature can make these highly suited for Mosambi (Singh *et al.,* 2000). The adequate fertilization, regular application of nutrients or alternatively use of nutrient enriched organic

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manures and biofertilizers in integrated nutrient management results in quality citrus production (Srivastava, 2012). For promotion and maintenance of soil fertility in sustaining crop productivity through optimizing all possible sources of nutrients like organic, inorganic and biological in an integrated manner to each farming situation in its ecological, soil and economic possibilities, integrated plant nutrient supply is the best approach. The objective of the present experiment is judicious use of nutrients for obtaining better growth and higher yield of quality fruits in sweet orange without leaving any applied nutrient unused under a given ecosystem.

MATERIALS AND METHODS

The investigation was conducted at the Regional Research Station of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. The experimental sites were located at 22.5^0N latitude and 87^0 E longitudes with an altitude of 78.8 m above the mean seal level. The experimental site is a drought prone semi-arid zone with an average annual rainfall of 1100-1500 mm of which 80 per cent rainfall occur during July to September. The soil of the experimental site was analysed in the laboratory following standard method. The type of soil in the experimental site was red and laterite.

Experimental details

Age of the plant : 7 year
Variety: Mosambi
Rootstock used : Rough lemon
Treatments : 12 (twelve)
Treatment combinations
T_1 = Full NPK, T_2 = Full neem cake, T_3 = Full NPK + Full neem cake
T_4 = Full NPK + Half neem cake, T_5 = Half NPK + Full neem cake
T_6 = Half NPK + Half neem cake , T_7 = VAM culture
$T_8 = T_3$ + VAM, $T_9 = T_4$ + VAM, $T_{10} = T_5$ + VAM, $T_{11} = T_6$ + VAM
T_{12} = Control

Where, Full NPK = N_{400} P_{150} K_{300} g/plant/year
Half NPK = N_{200} P_{75} K_{150} g/plant/year
Full neem cake = 2.0 kg/plant/year
Half neem cake = 1.0 kg/plant/year
Design: Randomized Block Design
Replication: 4 (Four)
Number of plants/replication: 4 (Four)
Planting distance : 5m x 5m

Time of application of chemical fertilizer: in 2 splits, once in second week of June and another in first week of September.

Time of application of neemcake: Single application during second week of June.

Application of VAM

VAM (Vesicular Arbuscular Mycorhizae) was applied 21 days after application of chemical fertilizers in June.

Method of application of neem cake and inorganic fertilizers

Neem cake and inorganic fertilizers were applied in a circular trench of 30 cm wide between a radial distance of 105 and 135 cm from the trunk. In each year, 60 g VAM culture spp. *Glomus fasciculatum,* obtained from the Nodule Research Laboratory of Bidhan Chandra Krishi Viswavidyalaya at Mohanpur, was thoroughly mixed with 3 kg of cowdung manure and applied evenly around each plant in the circular trench where neem cake and inorganic fertilizers were applied 21 days ahead. The inorganic nutrients *viz.,* N, P and K were applied in the form of urea (46 % N), Rock Phosphate (24 % P_2O_5) and Muriate of Potash (60% K_2O). No irrigation was done during the period of investigation. The experimental field was kept free from weeds by removing them manually as and when required. All the dried, diseased and unwanted twigs are removed from the plants as and when seen. After removal of dried and diseased twigs, the cut end was painted with blitox paste. To prevent termite attack, soil application of thimet @ 5 g/plant around the base of the plant was applied. For controlling lemon butterfly the plants were sprayed with Carbaryl @ 1.5 g/l and Monocrotophos @ 1.0 ml/l alternatively at 21 days interval during April-May and August-September. For controlling fungal diseases like gummosis, 1per cent bordeaux mixture followed by Carbendazim @ 1g/l were applied at 21 days interval during April-May and August-September. Micronutrients (Zn, B, Fe and Mn) were applied in the form of foliar spray for maintaining the general health of trees, besides controlling alternate bearing. The micronutrients were applied @ 4 g of $ZnSO_4$, 1.5 g of $FeSO_4$, 1.5 g of $MnSO_4$, 2 g of Borax per litre water twice during March and November. The pH of the spray solution was adjusted by adding required amount of lime and sticker was added in the spray solution. Observations were recorded on plant height, basal girth and canopy volume at 4 months interval and expressed as percentage of promotion. The canopy volume of the plant was measured at 4 months interval and was calculated by adopting the formula as described by Westwood *et al*. (1963) and has been expressed as percentage of promotion *i.e.* canopy volume = $4/3\ a^2b$,

Where, a = height/2, b= average spread of canopy volume in the East-West and North-South direction.

Total number of fruits per plant were counted before harvesting. The fruit yield per plant was calculated by multiplying the fruit number with average weight of fruit and was expressed in kg. Ten fruits were taken from each plant randomly at mature stage and average weight was expressed in gram (g). Fruit length and diameter was calculated by vernier calliper. Total soluble solids of fruit were estimated with the help of a hand refractometer based on the principle of total refraction. Acidity of the fruit juice was estimated by titrating against standard alkali (0.1 N NaOH) solution (A.O.A.C., 1984) using phenopthalein as an indicator and was expressed as percentage in terms of citric acid. Total sugar content of the fruit was determined by titrimetic procedures. Firstly the non-reducing sugar content of juice of the fruit sample was converted into reducing sugar by acid hydrolysis. After convertion, the sugar of the aqueous solution were determined by titrating against the freshly made mixture containing Fehling's solution A and B and using methylene blue as an indicator (A.O.A.C., 1984).Ascorbic acid content of the fruit was estimated by using 2, 6-dichlorophenol indophenol dye which is reduced by ascorbic acid to a colourless form (Ranganna, 1977). TSS/acid ratio was calculated by dividing TSS with their corresponding acidity. For foliar analysis, basal leaves of 6 month old were collected twice from current season's growth emerged in March and September respectively. The sample size was 50 leaves. Leaf nitrogen content was estimated following Kjeldahl method (Jackson, 1973). The phosphorus was estimated colorimetrically by using vandomolybdate yellow colour method of Koeing and Johnson (1942).

The potassium content was determined by flame photometer (Jackson, 1973). For detection of vesicular arbuscularmycorhizae in the innoculated sweet orange root, root segments were heated at 90^0C for about half an hour to make the roots very clear with the vascular cylinder distinctly visible by removing the cytoplasm and most of the nucleii. As the roots were pigmented there was need for dispigmenting the roots with alkaline H_2O_2 solution at 20^0C until bleached. The root bits were then acidified with dilute HCl and stained with 0.05 per cent trypan blue lactophenol (Phillips and Hayman, 1970). Population count of VAM was made at the Nodule Research Laboratory, Bidhan Chandra KrishiViswavidyalaya, West Bengal, India. Statistical analysis of the data was obtained by the analysis of variance method (Panse and Sukhatme, 1978). Angular transformation of data on percentage was done as per Snedecor (1959). The significance of difference of different sources of variation was tested by error mean square by Fisher-Snedecor's 'T' test at probability levels of 0.05.

RESULTS AND DISCUSSION

The growth of sweet orange plant in respect of height, basal girth and canopy volume were maximum in plants which received half dose of NPK + full dose of neem cake (T_5) followed by half dose of NPK + full dose of neem cake + VAM (T_{10}). Lowest plant growth in respect of canopy height, basal girth and canopy volume was observed from the control plants (T_{12}). Singh *et al*. (2000) also revealed an improvement in plant growth in terms of height, trunk diameter and canopy volume with the application of chemical fertilizers and biofertilizers in sweet orange. Ibe *et al.* (2011) found that the complementary use of organic and inorganic fertilizers holds the key to sustainable citrus production and improved plant height and spread through a sound fertility management strategy. The increase in the height and trunk diameter could be attributed to the stimulative activity of microflora in the rhizosphere leading to the increased nutrient availability and hence vigorous plant growth. These results are in agreement with the findings of Chandrababu and Shanmugam (1983) who had reported an increase in the stem height and trunk diameter of different citrus species with VAM. The increase in plant growth with the application of nitrogen may be explained from the fact that the nitrogen is the major constituent of many compound of great physiological importance in the metabolism such as amino acids, proteins, nucleic acids, porphyrins, enzymes and co-enzymes (Agarwala and Sharma, 1976). It was also reported that protein and chlorophyll synthesis were markedly improved with the application of higher dose of N (Wadleigh, 1957). Like nitrogen, phosphorus plays an important role as a structural component of cell. It is a constituent of the sugar phosphates- ADP, ATP etc., nucleic acids, nucleoproteins, purine and pyrimidine nucleotides (Agarwala and Sharma, 1976). Phosphorus also plays an important role in energy transformation and metabolic processes of plant.

Table 1. Effect of integrated nutrient management on canopy volume of sweet orange cv. Mosambi (expressed as percentage of promotion and measured at 4 months interval)

Treatments	1st Year			2nd Year			Total percentage of promotion	
	March-April	July-August	November-December	March-April	July-August	November-December		
$T_1 = N_{400}P_{150}K_{300}$ g/plant/year	5.5 (13.56)	12.1 (20.36)	6.8 (15.12)	5.2 (13.18)	25.4 (30.26)	14.3 (22.22)	80.9	(64.09)
T_2 = Neem cake 2.0 kg/plant/year	7.1 (15.45)	10.6 (12.00)	6.3 (14.54)	7.1 (15.45)	15.8 (23.42)	10.6 (19.00)	60.8	(51.24)
$T_3 = N_{400}P_{150}K_{300}$ g + Neem cake 2.0 kg/plant/year	7.7 (16.11)	8.4 (16.85)	6.1 (14.30)	7.7 (16.11)	16.8 (24.20)	9.7 (18.15)	51.6	(45.92)
$T_4 = N_{400}P_{150}K_{300}$ g + Neem cake 1.0 kg/plant/year	4.6 (12.38)	14.0 (21.97)	12.3 (20.53)	6.8 (15.12)	12.4 (20.62)	11.0 (19.37)	68.7	(55.98)
$T_5 = N_{200}P_{75}K_{150}$ g + Neem cake 2.0 kg/plant/year	18.4 (25.40)	27.5 (31.63)	28.4 (32.20)	7.4 (15.79)	35.5 (36.57)	23.5 (29.00)	99.8	(87.44)
$T_6 = N_{200}P_{75}K_{150}$ g + Neem cake 1.0 kg/plant/year	7.6 (16.00)	8.6 (17.05)	9.2 (17.66)	4.8 (12.66)	23.3 (28.86)	8.6 (17.05)	55.0	(47.87)
T_7 = VAM culture	4.1 (11.68)	6.6 (14.89)	9.2 (17.66)	4.2 (11.83)	20.2 (26.71)	6.7 (15.00)	66.0	(54.33)
$T_8 = T_3$ + VAM	9.7 (18.15)	13.6 (21.64)	7.7 (16.11)	5.6 (13.69)	27.4 (31.56)	10.1 (18.53)	84.7	(66.97)
$T_9 = T_4$ + VAM	2.3 (8.72)	4.3 (11.97)	3.8 (11.24)	3.9 (11.39)	26.6 (31.05)	11.9 (20.18)	52.8	(46.61)
$T_{10} = T_5$ + VAM	10.2 (18.63)	19.6 (26.28)	15.1 (22.87)	6.8 (15.12)	29.9 (33.15)	14.9 (22.71)	93.2	(74.88)
$T_{11} = T_6$ + VAM	3.6 (10.94)	6.6 (14.89)	3.7 (11.24)	3.6 (10.94)	18.7 (25.62)	5.9 (14.06)	67.8	(55.43)
T_{12} = Control	1.6 (7.27)	3.1 (10.14)	3.4 (10.63)	2.3 (8.72)	12.0 (20.27)	5.1 (13.05)	29.1	(32.65)
C. D. at 5%	4.64	3.58	7.75	6.24	8.36	7.95	16.99	

Figures in parenthesis are angular transformed values.

Table 2. Effect of integrated nutrient management on Yield, TSS : acid ratio and vitamin-C content of sweet orange cv. Mosambi

Treatments	Yield per plant (kg)			TSS : acid ratio			Vitamin-C (mg/100 ml juice)		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
$T_1 = N_{400}P_{150}K_{300}$ g/plant/year	4.6	6.0	5.3	21.1	18.6	19.8	52.8	48.8	50.8
T_2 = Neem cake 2.0 kg/plant/year	9.6	7.5	8.6	20.5	18.6	19.5	52.2	50.0	51.1
$T_3 = N_{400}P_{150}K_{300}$ g + Neem cake 2.0 kg/plant/year	8.7	6.2	7.5	17.1	18.7	17.7	54.6	51.6	53.1
$T_4 = N_{400}P_{150}K_{300}$ g + Neem cake 1.0 kg/plant/year	7.6	4.5	6.1	16.8	18.3	17.6	52.8	49.6	51.2
$T_5 = N_{200}P_{75}K_{150}$ g + Neem cake 2.0 kg/plant/year	11.0	6.9	9.0	32.0	30.0	31.0	60.2	57.8	59.0
$T_6 = N_{200}P_{75}K_{150}$ g + Neem cake 1.0 kg/plant/year	9.1	5.6	7.4	29.4	27.2	28.2	60.6	56.6	58.6
T_7 = VAM culture	4.0	1.9	3.0	20.0	18.1	19.1	53.2	51.6	52.4
$T_8 = T_3$ + VAM	8.0	5.0	6.5	18.7	20.5	19.6	55.8	52.4	54.1
$T_9 = T_4$ + VAM	7.2	5.8	6.5	18.6	18.2	18.4	54.0	50.6	52.3
$T_{10} = T_5$ + VAM	10.9	6.9	8.9	26.3	25.4	25.8	60.2	57.4	58.8
$T_{11} = T_6$ + VAM	9.3	4.7	7.0	24.1	24.3	24.2	60.2	57.0	58.6
T_{12} = Control	5.4	0.5	3.0	17.9	16.7	17.3	49.4	46.6	48.0
C. D. at 5%	0.45	0.26	0.32	1.41	1.22	1.49	1.87	1.51	3.13

Table 3. Effect of integrated nutrient management on foliar N, P, K content and VAM population per centimeter of root in sweet orange cv. Mosambi

Treatment	Foliar N (%)			Foliar P(%)			Foliar K(%)			Number of VAM/cm of root		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
$T_1 = N_{400}P_{150}K_{300}$ g/plant/year	2.4	2.6	2.5	0.11	0.14	0.13	1.6	2.2	1.9	70	80	75
T_2 = Neem cake 2.0 kg/plant/year	2.0	2.4	2.2	0.09	0.10	0.10	1.8	2.5	2.2	80	90	85
$T_3 = N_{400}P_{150}K_{300}$ g + Neem cake 2.0 kg/plant/year	2.3	2.4	2.4	0.13	0.16	0.15	1.6	2.3	2.0	70	80	75
$T_4 = N_{400}P_{150}K_{300}$ g + Neem cake 1.0 kg/plant/year	2.0	2.4	2.2	0.12	0.15	0.13	1.4	2.6	2.0	70	70	70
$T_5 = N_{200}P_{75}K_{150}$ g + Neem cake 2.0 kg/plant/year	2.5	2.9	2.7	0.16	0.17	0.17	1.6	3.0	2.3	70	90	80
$T_6 = N_{200}P_{75}K_{150}$ g + Neem cake 1.0 kg/plant/year	1.9	2.3	2.1	0.11	0.14	0.13	1.6	2.3	2.0	70	90	80
T_7 = VAM culture	2.0	2.2	2.1	0.14	0.16	0.15	1.5	2.1	1.8	70	90	80
$T_8 = T_3$ + VAM	2.3	2.4	2.4	0.10	0.12	0.11	1.6	2.1	1.9	90	90	90
$T_9 = T_4$ + VAM	2.2	2.3	2.3	0.11	0.13	0.13	1.7	2.5	2.1	90	100	95
$T_{10} = T_5$ + VAM	2.3	2.8	2.6	0.15	0.16	0.16	1.9	2.5	2.2	80	100	90
$T_{11} = T_6$ + VAM	2.2	2.6	2.4	0.12	0.16	0.14	1.7	2.1	1.9	90	90	90
T_{12} = Control	1.9	2.1	2.0	0.10	0.12	0.11	1.7	2.0	1.9	70	80	75
C. D. at 5%	0.21	0.14	0.18	N.S.	N.S.	0.05	0.23	0.41	0.37	N.S.	N.S.	N.S.

N.S. = Non significant

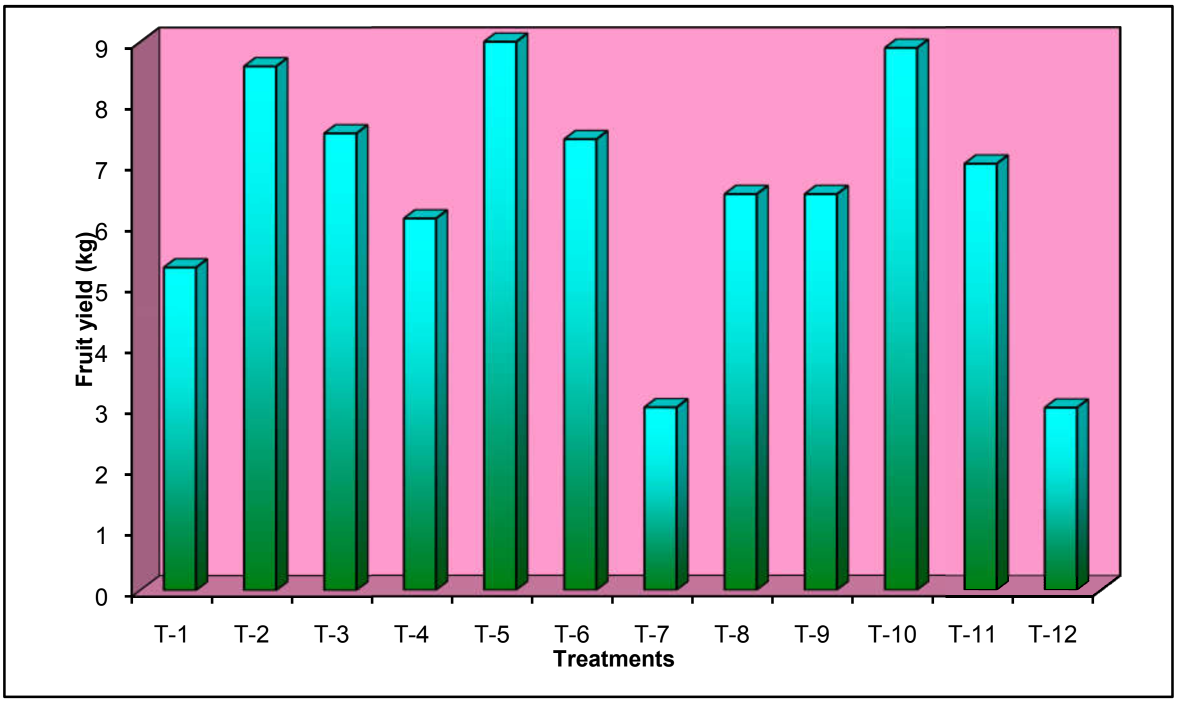

Fig.1. Effect of integrated nutrient management on fruit yield per plant (kg) in sweet orange cv. Mosambi

The potassium, another nutrient known for its important role in the maintenance of cellular organization by regulating the permeability of cellular membranes and keeping the protoplasm in a proper degree of hydration by stabilizing emulsions of highly colloidal particles (Agarwala and Sharma, 1976). It plays an important role in the formation or synthesis of amino acids and proteins from ammonium ions which are absorbed from the soil. It is also considered essential in the photosynthetic activity of leaves. In addition to its role as an activator in protein metabolism, potassium also can act as an activator for several enzymes involved in carbohydrate metabolism (Devlin and Witham, 1986). Beneficial effect of applied nutrients in promoting growth was also noted by Ghosh (1990) in Mosambi sweet orange and Borah *et al.* (2001) in Khasi mandarin. The increased uptake of N and P is expected to increase the rate of biosynthesis of various metabolites and physiological processes in the plant system leading to increased rate of growth. Improvement in growth parameters of citrus species by N application had also been reported earlier by Reese and Koo (1975); Kumar *et al.* (1993) and Ingle *et al.* (2001). Fruit yield and quality of citrus trees depends largely on nitrogen (N) and potassium (K) fertilization (Cantarella *et al*., 2003 and Alva *et al*., 2006). Fruit size increased with K supply, which was associated with increased leaf K concentration (Quaggio *et al.,* 2011).

It was interesting to note that neem cake alone or in combination with the inorganic fertilizers resulted an improvement in fruit production in sweet orange cv. Mosambi. Highest average fruit yield (9.0 kg/plant) was recorded from the plants received with half dose of NPK + full dose of neem cake (T_5) as compared with lowest yield (3.0kg/plant) from the control plants (T_{12}). Effectiveness of neem cake along with the half dose of NPK in improving the fruit yield may be explained from the fact that the organic matter helps to retain urea in the soil (Mitsui *et al*.1960 and Chin and Kroontje, 1963) and in making the phosphate and potash available to the plants (Roychowdhuri, 1976). Beneficial effect of neem cake and inorganic fertilizers in improving the yield was also noted by Borah *et al.* (2001) in Khasi mandarin and Ingle *et al.* (2001) in acid lime. Similar findings are also reported in Kinnow mandarin by earlier work of Muhammad and Manzoor (2010). Tiwari *et al.* (1999) also observed in sweet orange that yield potentiality of inorganic fertilizers with organic manure like neem cake was better than fertilizers or manures alone in respect of agronomic growth parameters *viz.* height, canopy diameter, total canopy volume along with yield. It was also observed that the highest level of nutrients ($N_{400}P_{150}K_{300}$ g/plant/year) when applied singly or in combination with neem cake and VAM were not effective in further improvement in fruit production. The reasons may be due to growing of the crop under rainfed condition and the red laterite soil type. Response of lower levels of NPK to improve the yield in sweet orange has practical utility in this zone, where more than 60 per cent farmers have marginal holdings (Anon., 1989) that are unable and unwilling to apply higher doses of fertilizer particularly for the fruit crops. It was also noted that application of neem cake alone (T_2) was not effective to increase the yield. The weight and size of the fruits were improved with the application of inorganic fertilizers either in full or half dose with neem cake. However, no significant differences were observed among the different treatments. Fruit quality was improved with the application of inorganic fertilizers and neem cake. Highest juice recovery percentage, more total soluble solids, less acidity with maximum TSS: acid ratio was recorded from the fruits of the plant which received half dose of NPK + full dose of neem cake (T_5). The vitamin C content of the fruit was also measured highest from the same treatment (T_5). Increase in juice content, TSS and ascorbic acid content and decrease in acidity with the application of neem cake and NPK was also noted by Borah *et al*. (2001) in Khasi mandarin and Ingle *et al.* (2001) in acid lime. All the fruit quality parameters were significantly influenced by the combined application of organic and inorganic source of nutrients. Ghosh and Besra (1997) and Rakba *et al.* (1995) also reported improved fruit quality by the application of organic matter + ½ dose of NPK in sweet orange. The better fruit number, size and good quality fruits with T_5 may probably be due to better growth and development of plants with this treatment. Thus, the above results indicate the suitability of combined application of higher dose of organic and lower dose of inorganic fertilizers for improving growth, yield and fruit quality of sweet orange cv. Mosambi.

It indicated the suitability of organic fertilizer (neem cake) in combination with chemical fertilizers (NPK) for better growth, yield and fruit quality. It will help in bringing down the cost of chemical fertilizers and better building of soil fertility by maintaining physical condition of the soil.Application of VAM in different treatments gave no significant improvement either in fruit production or fruit quality, which may be due to the inherent presence of Vesicular Arbuscular Mycorhizae in the rhizosphere of the plant of the present area of study. However, application of VAM in combination with half dose of NPK + full dose of neem cake (T_{10}) resulted second highest yield of quality fruits in sweet orange cv. Mosambi. Foliar N, P and K content were estimated to be more in all the treatments than the control plants (T_{12}). However, no significant difference among the various treatments was observed. Highest fruit yield was associated with 2.5 per cent N, 0.16 per cent P and 1.6 per cent K during first year and 2.9 per cent N, 0.17 per cent P and 3.0 per cent K during second year of observation with treatment T_5 closely followed by treatment T_{10}. The same trend was also observed from the average data. Calabretta *et al*. (2004) also reported that leaf content of P and K was higher in the organically managed orange trees.

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