Site-Specific Nutrient Management in 'Mosambi' Sweet Orange

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Site-specific nutrient management (SSNM) increased the yield and improved the quality of sweet orange when compared with fertiliser treatments based on existing recommendations or farm practice. This, along with the higher net economic return with SSNM, makes the case for large-scale adoption of SSNM to help reduce the gap between the actual and potential productivity of 'Mosambi' sweet orange orchards.

Citrus fruits are grown in an area of 7.12 lakh ha in India with a production of 59.77 lakh t and a productivity of 8.3 t/ha. Among the citrus fruits in India, sweet orange is the second most important fruit, occupying an area of 1.26 lakh ha with a production of 21.1 lakh t and a productivity of 16.7 t/ha. The commercially grown varieties of sweet oranges in India are: 'Jaffa', 'Valencia', 'Hamlin', and 'Malta' in Punjab, Himachal Pradesh, and Rajasthan; 'Sathgudi' orange in Andhra Pradesh; and 'Mosambi' in the Marathwada region of Maharashtra.

The productivity of sweet orange in India is significantly lower than in some of the frontline citrus growing countries like Brazil, USA, Spain, and Italy (30 to 35 t/ha). Similarly, the average productivity of 'Mosambi' sweet orange orchards (14.9 t/ha) is comparatively lower among the different sweet orange varieties. One of the main reasons for low sweet orange orchard productivity in the soils of Marathwada region is multiple nutrient deficiencies. The soils of this region are mostly derived from basaltic parent material and are commonly deficient in multiple nutrients, including N, P, Fe, Mn, and Zn (Srivastava and Singh, 2004). That is why the conventional nutrient management strategy based mainly on macronutrient application in citrus orchards has not been very successful in raising the productivity level (Srivastava et al., 2006). Soil test-based site-specific nutrient management (SSNM) offers a tangible option to address these nutritional constraints and to harness the productivity potential of specific orchard sites.

We conducted a field experiment for 3 years (2006-07 to 2008-09) at Narkhed Tehsil in Nagpur, Maharashtra, to evaluate whether soil test-based SSNM improves 'Mosambi' productivity, fruit quality, and economics of production. An 8-year-old 'Mosambi' sweet orange orchard was used with scion of sweet orange (*Citrus sinensis* Osbeck) budded on rough lemon rootstock (*Citrus jambhiri* Lush). The plant-to-plant and row-to-row distance was 6 m each, which results in a plant population of 278 trees/ha . The site had an alkaline, calcareous soil (Typic Haplustert) with available N, P, K, Fe, Mn, and Zn contents of 231, 25, 417, 25, 18 and 2.20 kg/ha, respectively. The climate of 'Mosambi' growing belts in the Marathwada region is characterised by hot and dry pre-monsoon summer months (March to May), followed by well expressed monsoon months (June to September). The mean summer (April, May, and June) to mean winter (December, January, and February) temperatures vary from 42^{o} to 38 ^{o}C. The average annual rainfall of the region is 800 mm, of which 80 to 90% is received during monsoon months. For the experiment, we designed 17 different fertiliser treatments as outlined in **Table 1**. These fertiliser treatments were designed based on: a) the standard analysis of soil macronutrient, secondary nutrient, and micronutrient status of the experimental soil prior to the start of the experiment, and b) fertiliser recommendations designed to evaluate if up to 300% of the recommended doses can improve yield and/or fruit quality. In each of the experimental years, fertiliser application was split into three equal doses coinciding with the emergence of new flush in the months of April, August, and October. Different fruit quality parameters viz., TSS was determined using hand refractometer, juice content volumetrically, and acidity tritrimetrically as per commonly followed procedures.

Abbreviations and notes: FFP = farmers' fertiliser practice; RDF = recommended doses of fertilisers; SSNM = site-specific nutrient management; TSS = Total soluble solids; N = nitrogen; P = phosphorus; K = potassium; Fe = iron; Mn = manganese; Zn = zinc; lakh = 100,000; Ca = calcium; CD = Critical Difference, equivalent to Least Significant Difference.

Immature sweet oranges in Nagpur, Maharashtra.

Yield Response

Fruit yield is a good index of orchard productivity. A significantly higher 'Mosambi' yield was obtained with SSNM as compared to RDF and FFP **(Table 1)**. This indicates the potential of SSNM to reduce the gap between actual and potential productivity of 'Mosambi' sweet orange orchards.

The RDF, FFP, and SSNM treatments all had similar N:P:K ratios, and the only change was in the levels of N, P, and K applied with SSNM using double the amounts of macronutrients **(Table 1)**. This indicates that in crops where the traditional macronutrient ratio approach to guiding fertiliser application is well established, SSNM does not try to change the approach. Instead, it tries to include the effect of other related factors (like

Table 1. Response of different treatments on growth and yield of 'Mosambi' sweet orange (pooled data of 3 years).

Treatments[1]	Fruit yield, kg/tree	-------- Quality -------- Juice, %	TSS, %	Acidity, %
$T_1 = N_0$-P_{200}-K_{300}-M_1	37.9	47.2	8.5	0.46
$T_2 = N_{400}$-P_0-K_0-M_1	37.7	45.1	8.3	0.41
$T_3 = N_0$-P_0 -K_{300}-M_1	36.2	45.8	8.3	0.46
$T_4 = N_{400}$-P_{200}-K_0-M_1	42.0	46.5	8.3	0.40
$T_5 = N_{400}$-P_{200}-K_{300}-M_1 (RDF)	44.4	48.3	8.9	0.44
$T_6 = N_{400}$-P_{200}-K_{300}-M_2	46.4	47.7	8.6	0.46
$T_7 = N_{400}$-P_{200}-K_{300}-M_0 (FFP)	40.2	46.9	8.3	0.48
$T_8 = N_{800}$-P_{400}-K_{600}-M_1 (SSNM)	61.4	50.9	9.5	0.44
$T_9 = N_{800}$-P_{400}-K_{900}-M_1	58.8	49.6	9.3	0.51
$T_{10} = N_{800}$-P_{400}-K_{1200}-M_1	57.9	49.9	9.3	0.61
$T_{11} = N_{800}$-P_{400}-K_{1200}-M_2	56.7	49.8	9.2	0.57
$T_{12} = N_{1200}$-P_{400}-K_{300}-M_1	53.6	47.9	8.7	0.47
$T_{13} = N_{1200}$-P_{400}-K_{600}-M_1	54.2	48.9	8.8	0.49
$T_{14} = N_{1200}$-P_{400}-K_{900}-M_1	51.2	49.7	8.9	0.58
$T_{15} = N_{1200}$-P_{400}-K_{1200}-M_1	50.8	50.5	8.8	0.63
$T_{16} = N_{1200}$-P_{400}-K_{300}-M_0	48.3	46.7	8.4	0.53
$T_{17} = N_{1200}$-P_{400}-K_{300}-M_1S_1	48.7	48.3	8.8	0.47
CD (p = 0.05)	1.98	1.2	0.27	0.031

[1]Subscripts after N, P, and K indicate rates applied, kg/ha
M_0 = no micronutrients
M_1 = micronutrients consisting of 250 g each of $FeSO_4$, $MnSO_4$, and $ZnSO_4$/tree
M_2 = micronutrients consisting of 500 g each of $FeSO_4$, $MnSO_4$, and $ZnSO_4$/tree
S_1 = $CaSO_4$ and $MgSO_4$ each at 250 g/tree

levels, etc.) to better nutrient management decisions. Also, as the established macronutrient ratio was altered (T_8 vs T_9 and T_{10}), we observed a significant decline in 'Mosambi' yield.

Micronutrient application had a significantly positive effect on 'Mosambi' yield (FFP vs RDF treatments) under the experimental conditions **(Table 1)**. Their effect was more pronounced at lower levels of N, P, and K (T_5 vs T_6 vs T_7) than at higher levels (T_{10} vs T_{11}). However, the application of secondary nutrients, i.e., Ca and Mg, caused yield declines (T_{12} vs T_{17}). This was probably due to the increased competition for plant uptake between these nutrients and K.

We observed a variety of nutrient deficiencies in nutrient omission plots as a cumulative effect of 3 years of experimentation. For example, N deficiency was observed where no N was applied for three successive years (T_1), K deficiency was observed in the form of small fruit size where no K was applied (T_2), and Fe, Mn, and Zn deficiencies were observed where no micronutrient application was done in the 3 years of experimentation (T_7). These deficiencies were confirmed using leaf analysis, and indicated that there is a continuous mining of nutrients in 'Mosambi' sweet orange orchards. And unless we supplement the nutrients using a SSNM strategy, attaining potential productivity of these orchards is almost impossible.

Table 2. Analysis of economic returns from SSNM versus RDF and FFP.

Treatment	Cost[1], 000' Rs/ha	Benefit[2], 000' Rs/ha	Net returns, 000' Rs/ha
T_7 (FFP)	16.5	110.8	94.3
T_5 (RDF)	21.7	121.9	100.2
T_8 (SSNM)	32.5	169.0	136.5

[1]Includes operational charges consisting of two weedings, basin cleaning, and labour charges for fertiliser application (Rs.10,000/ha) plus the cost of fertilisers including urea (Rs.8/kg), SSP (Rs.7/kg), KCl (Rs.8/kg), gypsum (Rs.2/kg), $FeSO_4$ (Rs.15/kg), $MnSO_4$ (Rs.30/kg), and $ZnSO_4$ (Rs.30/kg).
[2]As per existing farm rate (Rs.10,000/t).

Fruit Quality Response

Juice content, TSS, and juice acidity are the three most important parameters used to determine orange quality. And just like the yield response, SSNM had a significant positive impact on these parameters as compared to RDF and FFP treatments **(Table 1)**.

Omission of K (T_4) from the RDF (T_5) significantly reduced juice percentage and TSS, suggesting a strong influence of K on quality parameters of sweet orange **(Table 1)**. However, even when we applied more K but disturbed the balanced ratio of macronutrients (T_8 vs T_9 and T_{10}), the juice content again declined significantly. Additionally, higher K rates increased juice acidity, regardless of the level of NP input.

Inclusion of micronutrients produced a significantly favorable response on juice and TSS (T_7 vs T_5 and T_{16} vs T_{12}). Inclusion of secondary nutrients increased juice yields significantly, but did not have a significant effect on TSS **(Table 1)**.

Economics of Nutrient Management Approaches

Just like its favorable response on 'Mosambi' yield and quality, SSNM provided a comparatively higher net return than either RDF or FFP **(Table 2)**. The cost of cultivation increased marginally with SSNM compared with RDF and FFP, but this increase was offset by a remarkable increase in net benefit, realised mainly through increased 'Mosambi' yields.

The results of this study clearly show the need to a) maintain a balance between macronutrients and micronutrients in deciding need-based, optimum fertiliser doses and b) revise the current fertiliser recommendation system to realise full productivity potential on a given soil type. BC INDIA

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References

Srivastava, A.K. and Shyam Singh. 2004. Comm. Soil Sci. & Pl. Anal. 35(17/18):2537-2550.
Srivastava, A.K., Shyam Singh, and K.N. Tiwari. 2006. Better Crops 90(2): 22-24.