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BRAZIL

Nitrogen and Potassium Fertilization Impacts Fruit Yield and Quality of Citrus

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Market destination determines the most beneficial nutrition program in citrus production. Recent studies in Brazil indicate the need to review current fertilizer recommendations for citrus trees based on soil and leaf analysis, as proposed in newly formed recommendations.

Brazil produces 15 million metric tons (M t) of sweet oranges per year, or 30% of the world's production. The strength of local production is due to a large global juice export market. Around 80% is delivered within the country's major citrus-producing state of São Paulo to more than 10 processing plants. In addition to citrus for juice, 2 to 3 M t of oranges, tangerines, and acid limes are produced annually which supply domestic and export fresh citrus fruit markets. The importance of these strong niche markets points to an equally strong need to properly manage for improved yield, quality, and postharvest qualities.

Nutrient management plays a key role for optimal production of quality fruits intended for either the frozen concentrated orange juice (FCOJ) or fresh fruit markets. By definition, the establishment of best management practices should also reduce cost of production and minimize any potential adverse impact that citrus cropping may have on the environment.

Fruit yield of citrus trees is largely regulated by nitrogen (N) supply because it affects photosynthesis and carbohydrate production, specific leaf weight, and carbon allocation to tree parts. Although optimal N availability results in green foliage color and increased crop yields, excess N can lead to luxury consumption by the tree, negative impacts on fruit size and composition, and reduced commercial value for harvested products. Fine-tuning of N fertilization recommendations based on leaf analysis is critical to maintain a proper N balance. Potassium (K) plays an important role in maintaining cell turgor and extensibility. Many studies have demonstrated the marked effects of K supply on fruit size and rind thickness.

External characteristics, such as fruit size and rind coarseness, are most important for citrus destined for fresh markets.

Research from Brazil

Results of recent field experiments conducted with Pêra and Valencia sweet oranges demonstrate that individual fruit mass will decrease with increased N rate (**Table 1**). This

Table 1. Selected data observed on fertilization experiments conducted with sweet orange trees.

Nutrient rate, kg/ha	Fruit yield, t/ha	Fruit mass, g	TSS, °Brix	Juice content, %	Box/ton juice[1], #	TSS/area, kg/ha
Nitrogen						
30	43.0	230	10.8	51.4	285	2,411
240	47.8	219	11.0	52.0	275	2,724
Potassium						
25	33.0	159	11.5	56.2	254	2,344
223	38.8	176	11.0	55.7	264	2,466

[1] Number of boxes (40.8 kg of fruits) required for production of concentrated juice (66 °Brix).
Source: Quaggio et al., submitted for publication.

characteristic was also inversely related with total fruit yield since higher N rates increased the fruit set of citrus trees, thus producing a greater number of smaller-sized fruits per unit volume of canopy.

The effects of K fertilization on orange yield are strongly related to the availability of exchangeable soil K. A linear response was observed at an experimental site with a low soil K availability of 1.2 $mmol_c\ dm^{-3}$ exchangeable-K at 0 to 20 cm depth layer, where an 18% increase in fruit yield occurred as K rate increased from 25 to 223 kg/ha (**Table 1**). At another site, where exchangeable-K was considered high at 2.9 $mmol_c\ dm^{-3}$, average fruit yield has not varied significantly with K supply over the last four seasons (data not shown).

Most literature agrees that citrus fruit becomes larger and coarser with increasing K application rate. This might explain observed reductions in juice and total soluble solids (TSS) content of fruits (**Table 1**), constituents considered important for the FCOJ market, but a detriment to the fresh fruit market.

Fruit yield may also be negatively impacted by excess. An experiment conducted in a commercial Murcott tangor (Honey Tangerine) grove found that fruit yield (average for six harvests) was reduced by 53% as K application rate increased from 25 to 225 kg/ha. Trees that received the highest K rate had excessive defoliation and decreased calcium (Ca) and magnesium (Mg) contents in the spring flush of leaves

Lower N and higher K application rates are usually best if fruit is intended for fresh market, while higher N and lower K rates may be more appropriate for frozen concentrated orange juice market destinations.

Figure 1. Calcium and Mg concentrations in leaves of Murcott trees planted on a sandy loam oxisol 6 years after a yearly schedule of K application. Source: Mattos, Jr. et al., 2004.

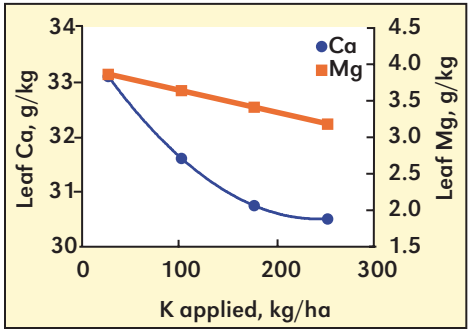

Table 2. Fertilizer recommendations for citrus in Brazil based on expected yield, soil analysis, and fruit quality.

Yield	Leaf N, g/kg			Soil P (resin), mg dm^{-3}				Soil exch. K, $mmol_c\ dm^{-3}$			
target, t/ha	<23	23-27	>27	<6	6-12	13-30	>30	<0.8	0.8-1.5	1.6-3.0	>3.0
	---------- $N/P_2O_5/K_2O$, kg/ha ----------										
FCOJ production											
<16	90	70	60	50	40	20	0	60	40	30	0
17 - 20	100	80	70	70	50	30	0	70	50	40	0
21 - 30	140	120	90	90	70	40	0	90	70	50	0
31 - 40	190	160	130	130	100	50	0	120	100	70	0
41 - 50	240	200	160	160	120	60	0	160	120	90	0
>50	260	220	180	180	140	70	0	180	140	100	0
Fresh fruit											
<15	80	60	40	60	50	30	0	100	80	60	0
16 - 20	100	80	60	80	70	40	0	140	120	100	60
21 - 30	120	100	80	120	90	50	0	160	140	120	80
31 - 40	160	140	100	140	110	60	0	200	180	160	100
>40	180	160	120	160	120	80	0	220	220	180	120

Source: Quaggio et al., in press.

collected from fruiting terminals (**Figure 1**). Excess soil K levels are frequently found in citrus orchards where traditional fertilizer formulas are applied without consulting a soil test.

Therefore, best management nutritional programs will depend on the market destination. In general, the external fruit characteristics, such as size and rind coarseness, are most important for fruit destined for fresh markets. These characteristics are normally obtained with lower N and higher K application rates than those used for fruits produced for FCOJ processing (**Table 2**). Of course, soil testing and leaf analyses play an important role in defining fruit quality parameters for citrus trees. These studies have pointed out the need to review the current recommendation of fertilizers for citrus trees based on soil and leaf analyses, as is proposed in the newly formed table of recommendations. BC

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