Nitrogen Fertilization and Plant Nutrient Status Monitoring – the Basis for High Yields and Quality of Broccoli in Potassium-Rich Vertisols of Central Mexico

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Central Mexico grows more than 27,000 ha of broccoli and with up to two growing seasons per year provides most of Mexico's broccoli for export to Canada, Japan, and the U.S.

High yielding, high quality broccoli production requires careful nutrient management, but current information is lacking for today's new varieties and drip irrigation production systems. No information is available on nutrient availability in the Vertisols of Central Mexico. In response to a lack of current information, researchers studied the effect of nitrogen (N) fertilization on yield, nutrient accumulation, and demand by broccoli over the growing season in this region. The study also determined normal plant levels of N, phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in broccoli during the growing season.

Broccoli requires careful attention to nutrient management for top yields and quality.

Three field experiments were conducted in central Mexico from 1996 through 1998 on clay loam to clay soils near Celaya, Gto. These soils contained 2.0 to 2.2 percent organic matter, 11 to 20 parts per million (ppm) soil test P, and 600 to 900 ppm soil test K with a pH of 7.4 to 7.6

In 1996 to 1997, varying rates of N (0 to 400 kg/ha) were applied at three times during the growing season: 20 percent at planting, 40 percent 30 days after planting, and 40 percent 45 days after planting. Recommended amounts of P_2O_5 (80 kg/ha) and K_2O (300 kg/ha) were applied at planting. During the third year, N and K were injected into the drip irrigation system as determined by the demand curve, but P was applied at planting. Treatments with plus and minus P and K were also included with a level of N considered optimum for crop yield.

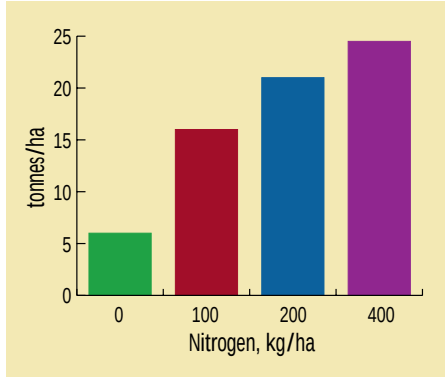

Figure 1. Marketable yield of broccoli under fertigation during 1998 in response to N treatments.

Results for marketable yield for 1998 are shown in **Figure 1**. There was a significant response to N above the level of 290 kg/ha. Maximum yield of 24.5 tonnes/ha was obtained with the treatment of 400 kg/ha of N. Similar trends were observed during 1996 and 1997. In other studies, the maximum reported yields ranged from 10 to 15 tonnes/ha (Rincon *et al.*, 1997; Doerge and Thompson, 1997). The above authors reported an optimum N level of 250 kg/ha to attain a yield of 9.5 tonnes/ha. In our study, the optimum N rate was much higher as was yield, probably the result of more favorable growing conditions and high Ca- and K-rich soils. There was no response to applied P or K, since soil tests were high (Olsen-P ranged from 11 to 20 ppm, and exchangeable K was greater than 600 ppm).

Plants were analyzed at several growth stages to develop sufficiency levels for N and normal nutrient concentrations for P, K, Ca, and Mg. Results for the most recent fully expanded leaves are shown in **Table 1**. Total N ranged from 5.5 to 6.5 percent from the early growth stages until first bud, but was reduced to 5.5 to 6 percent at heading and to 4 to 5 percent during the pre-harvest stage. Lower sufficiency values at heading have been reported by others (Reuter and Robinson, 1986; Jones *et al.*, 1991). Concentrations of P, K, Ca, and Mg also declined as plants matured, but by time of heading the values were within the range commonly reported in the literature.

Normal levels for nitrate-N (NO_3-N), phosphate-P (PO_4-P), and K in the midrib are presented in **Table 2**. Values for NO_3-N are similar to those reported by Doerge and Thompson (1997) and by Gardner and Roth (1989). Normal ranges for PO_4-P were slightly reduced at the end of the growing season, but the values for K were reduced by half from the beginning of the season to pre-harvest.

Table 1. Sufficiency levels for total N, NO_3-N, and normal levels for P, K and Mg in the most recently fully expanded leaf in broccoli (data average ranges of three years).

Growth stage	Total N	NO_3-N	P	K	Ca	Mg
			%			
4-6 leaves	5.5 - 6.5	0.80 - 1.10	0.50 - 0.80	3.50 - 6.50	2.00 - 3.50	0.40 - 0.50
10-12 leaves	5.5 - 6.5	0.60 - 0.80	0.50 - 0.80	3.50 - 6.50	2.00 - 3.50	0.25 - 0.50
First buds	5.5 - 6.5	0.35 - 0.60	0.45 - 0.80	3.00 - 5.00	1.00 - 3.50	0.20 - 0.45
Heading	5.5 - 6.0	0.30 - 0.50	0.45 - 0.80	3.00 - 4.50	1.00 - 2.50	0.20 - 0.30
Pre-harvest	4.0 - 5.0	0.25 - 0.40	0.45 - 0.70	3.00 - 3.50	1.00 - 2.50	0.18 - 0.25

Table 2. Sufficiency levels for NO_3-N and normal levels for PO_4-P and K in the dry midrib of the most recently fully expanded leaf in broccoli.

Growth stage	NO_3-N	PO_4-P	K
	%		
4-6 leaves	1.50 - 2.00	0.45 - 0.55	6.50 - 9.20
10-12 leaves	0.80 - 1.80	0.35 - 0.50	6.50 - 9.00
First buds	0.55 - 1.30	0.30 - 0.50	3.50 - 5.50
Heading	0.50 - 0.80	0.30 - 0.45	3.00 - 5.00
Pre-harvest	0.25 - 0.40	0.30 - 0.40	2.80 - 4.00

Table 3. Sufficiency levels for NO_3-N and normal levels for PO_4-P and K in the petiole press sap of the most recently fully expanded leaf in broccoli.

Growth stage	NO_3-N	PO_4-P	K
	mg/L		
4-6 leaves	1,500 - 2,000	130 - 200	4,000 - 6,500
10-12 leaves	1,000 - 1,900	120 - 200	3,000 - 6,000
First buds	800 - 1,500	100 - 120	2,500 - 5,500
Heading	700 - 1,000	100 - 120	2,500 - 4,000
Pre-harvest	300 - 600	80 - 120	2,200 - 4,000

Values are also presented for press sap of the midrib in **Table 3**. Nitrate-N values are slightly higher at the beginning of the season than those proposed by Kubota et al. (1997), but similar from mid to the end of the season. Literature reports showing normal levels for P and K are very limited and the data in **Table 3** are only for general guidance. The lack of crop response to these nutrients does not allow accurate determination of critical values in these experiments.

Most literature references report only nutrient concentrations at heading or in mature plants. This does not allow correction of deficiencies during the growing season. Data from early growth stages should prove useful in diagnosis of nutrient deficiency problems in time to allow correction during the growing season. **BCI**

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