Corn Fertilization in the North Central Pampas: CREA Experiments South of Santa Fe

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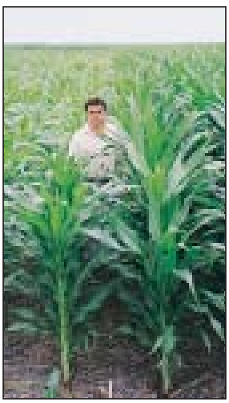
On-farm research conducted in southern Sante Fe and Cordoba provinces is explaining crop responsiveness to applied nutrients. Expectations for corn yield gains resulting from macronutrients and micronutrients are outlined. A preliminary critical soil sulfate-sulfur (SO_4^{2-}-S) value for the region's corn crop is suggested.

Nutrient management in corn has been evaluated in different soils of the Pampas, and nitrogen (N) and phosphorus (P) fertilization recommendations have been developed (Berardo et al., 2001; González Montaner and Di Napoli, 1997a,b; Sainz Rozas et al., 2000; Ruiz et al., 2001). Corn N fertilization is determined according to soil nitrate-N (NO_3^--N) availability at planting (Ruiz et al., 2001), whereas P fertilization is based on soil and crop criteria developed in the southern area of the Pampas (Berardo et al., 2001). There is a lack of criteria for S fertilization in the region. However, in recent years, S deficiencies and responses to S fertilization have been observed in corn and other annual crops in the northern area (Cordone et al., 2001).



At La Marta, Miguel Boxler stands between the check plot (left) and the NPS plot.

For the Regional Consortium of Agricultural Experimentation (CREA) region south of Santa Fe, the area planted to corn accounts for approximately 39,800 ha of the 184,500 ha in annual crops every year. The CREA region south of Santa Fe is comprised of 12 groups of 10 to 15 farmers, located in southern Santa Fe and Cordoba provinces, with the goal of developing and exchanging experiences and information on soil and crop management, farm business management, and product marketing. A network of fertilization trials was established in the 2000/01 growing season to: 1) evaluate corn response to applied N, P, S, and other nutrients such as potassium (K), magnesium (Mg), boron (B), copper (Cu), and zinc (Zn); 2) validate N and P fertilization recommendation methods; and 3) evaluate the soil SO_4^{2-}-S test for S fertilization recommendation.

Eight on-farm trials were conducted by different CREA groups in 2000/01. Test soils were Argiudolls (eastern area) and Hapludolls (western area). All sites were under no-tillage management. Corn *cv.* Monsanto

Treatment	Application rates, kg/ha
Control	——
PS	20 kg P + 19 kg S
NS	100 kg N + 19 kg S
NP	100 kg N + 20 kg P
NPS	100 kg N + 20 kg P + 19 kg S
Complete	NPS + 18 kg K + 10 kg Mg + 1 kg B + 2 kg Cu + 4 kg Zn

Table 1. Fertilizer treatments applied to CREA on-farm trials, 2000-01.

DK 696 MG was planted between September 18 and October 13 at a 70 cm row spacing. Fertilizer treatments (kg/ha) were assigned to a randomized complete block with three replications (**Table 1**). All fertilizers were banded below and to the side of the seed at planting. At maturity, grain yield (14.5% moisture content) was determined by harvesting an area of 180 to 360 m^2.

Soil samples were taken from each experimental site prior to planting to determine soil organic matter, pH, Bray P-1, exchangeable calcium (Ca), Mg, K, and micronutrient concentrations [Cu, Zn, iron (Fe), and manganese (Mn)] at 0 to 20 cm depth; and NO_3^--N, SO_4^{2-}-S, and borate-B ($H_2BO_3^-$-B) at 0 to 20, 20 to 40, and 40 to 60 cm depth. Soil NO_3^--N concentration at 0 to 30 cm was also determined at V5-6 (Ritchie and Hanway, 1982) in the PS treatment. Chlorophyll meter readings (Minolta SPAD 502) were determined at V5-6 and R1 in treatments PS and NPS.

Results

Soil analysis. Soil organic matter levels and pH were within the normal ranges for soils of the region (data not shown). Nitrate-N availability at planting was generally low (< 150 kg/ha NO_3^--N, 0 to 60 cm), except at San Antonio where levels were 304 kg/ha. Bray P-1 concentrations were low [< 15 parts per million (ppm) P] at Balducchi, San Antonio, La Marta, and El Pilarcito, medium (15 to 25 ppm P) at La Blanca and Santo Domingo, and high (> 25 ppm P) at San Alfredo and Lambaré. Sulfate-S availability (0 to 20 cm depth) was low (<10 ppm) at four sites, and medium (10 to 15 ppm) at four sites. Concentrations of other nutrients were considered adequate for corn production according to international references.

Soil NO_3^--N concentrations at V5-6 (0 to 30 cm) were very low (< 12 ppm) at all sites because of plant growth and high precipitation between planting and V5-6 that leached the majority of NO_3^- from the 0 to 30 cm layer.

Corn grain yields and response to fertilizers. Abundant precipitation in October, November, and January reduced incidences of moisture stress and helped to produce high corn yields. Control yields varied from 5,630 kg/ha (Balducchi) to 9,680 kg/ha (Lambaré), while maximum yields from the fertilized treatments varied from 8,090 kg/ha (San Antonio) to 12,300 kg/ha (San Alfredo) (**Table 2**). All sites, except San Antonio, showed statistically significant differences in corn yields among treatments. The low yields and lack of response at San Antonio is not readily explainable, but are partly attributed to high soil NO_3^--N availability at planting (which improved the control yield) and soil degradation due to compaction.

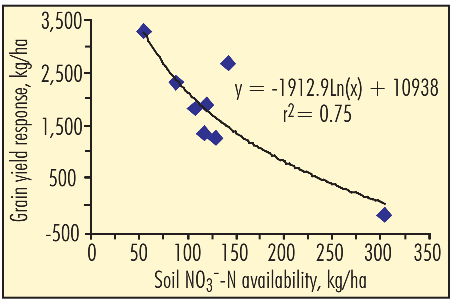
Table 2. Corn grain yields for the six fertilization treatments in the eight experimental sites.

Treatments	La Blanca	Balducchi	San Antonio	Lambaré	Santo Domingo	La Marta	El Pilarcito	San Alfredo
	Corn grain yields, kg/ha							
Control	7,070 b[1]	5,630 b	7,690	9,680 c	7,840 b	9,080 c	6,350 c	8,280 d
PS	8,110 ab	6,090 b	7,970	10,600 b	7,560 b	10,300 bc	6,380 c	8,780 d
NS	9,000 a	7,970 a	8,090	11,800 a	9,410 a	11,100 ab	8,820 b	9,960 c
NP	8,910 a	8,090 a	7,850	11,900 a	9,410 a	12,000 a	8,760 b	10,800 bc
NPS	9,360 a	8,400 a	7,740	12,000 a	9,450 a	12,100 a	9,680 ab	11,500 ab
Complete	9,180 a	8,370 a	7,880	11,700 a	9,630 a	11,200 ab	10,000 a	12,300 a
LSD, 5%	1,450[2]	1,200	ns[3]	806	548	1,200	1,060	1,130

[1] Grain yields followed by different letters in a same column are significantly different at the 5% probability level. [2]Differences significant at the 10% probability level. [3] ns = No significant differences.

Corn yield response to N (NPS vs. PS) was significant at six of the eight sites, whereas the P response (NPS vs. NS) was significant at only one site (San Alfredo). Four sites showed tendencies to P response (La Marta, El Pilarcito, Balducchi, and La Blanca), and to S response (NPS vs. NP; El Pilarcito, San Alfredo, La Blanca, and Balducchi). There were no significant differences between the NPS and complete treatments, indicating that the availability of soil K, Mg, B, Cu, and Zn was sufficient for these grain yields when moisture was generally sufficient throughout the growing season.

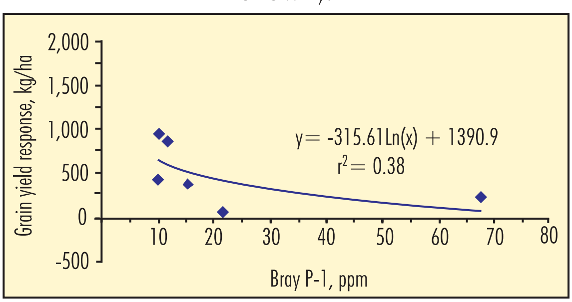
Figure 1. Corn yield response to N as a function of soil NO_3^--N availability at planting, 0 to 60 cm depth.



Relationships among soil and plant variables and response to fertilizer. Nitrogen response was significantly related to soil NO_3^--N availability at the 0 to 60 cm depth (**Figure 1**). Previous research in northern Buenos Aires and southern Santa Fe provinces estimate the critical level to be 150 kg/ha NO_3^--N for corn grain yields of 9,000 kg/ha (Ruiz et al., 2001). The N response equation derived from these data (**Figure 1**) indicates an N response of 1,350 kg corn/ha for 150 kg N/ha of available soil NO_3^- -N. The high N response may partly explain the high grain yields obtained. It should be cautioned, however, that a lack of test soils between 129 and 300 kg soil NO_3^--N/ha may be over emphasizing the influence of the site with the highest N fertility.

No relationship was found between N response and soil NO_3^--N concentration at V5-6, or chlorophyll meter readings at V5-6 (data not shown).

Figure 2. Corn yield response to P as a function of soil Bray P-1 at planting, 0 to 20 cm depth. The points belonging to the sites San Alfredo and San Antonio were omitted.



Grain yield response to P fertilizer was related to Bray P-1 levels except at San Alfredo and San Antonio (**Figure 2**). At San Alfredo, there was a high P response although the soil was high in available soil P (28 ppm Bray P-1). It is possible that the site's general low soil P status was not detected due to variability caused by previously applied P fertilizer bands under no-tillage.

The four sites with a tendency for S response had soil SO_4^{2-}-S levels lower than 10 ppm at 0 to 20 cm (**Figure 3**). This level may serve as a preliminary critical S level to decide S fertilizer requirements in the region. Soil SO_4^{2-}-S determination to the 60 cm depth did not improve the estimation of a critical level.

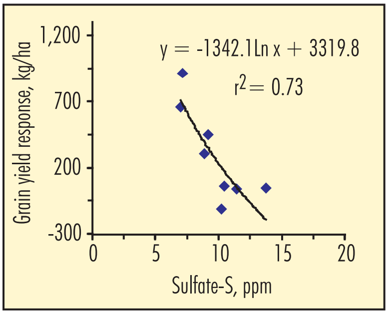


Figure 3. Corn yield response to S as a function of soil SO_4^{2-}-S concentration at planting, 0 to 20 cm depth.

Conclusions

Responses to N were significant in six of eight sites and were related to soil NO_3^--N availability at planting. Phosphorus response was significant at only one site and it was related to Bray P-1 levels. Responses to S were not significant, but a preliminary critical level of 10 ppm SO_4^{2-}-S is suggested. Application of K, Mg, B, Cu, and Zn did not affect grain yields at any site. **BCI**

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