Direct and Residual Effects of Balanced Fertilization in Field Crops of the Pampas of Argentina

Fernando Garcia[1], Miguel Boxler[2], Jorge Minteguiaga[2], Hugo Blanco[2], Raul Houssay[2], German Deza Marin[3], and Angel Berardo[4]
[1]PPI-PPIC Southern Cone, fgarcia@ppi-ppic.org, [2]CREA Southern Santa Fe, [3]Agroservicios Pampeanos (ASP), and [4]Laboratorio Fertilab- INTA-FCA Balcarce

Crop production in the Pampas region of Argentina is generally affected by nitrogen (N) and phosphorus (P) deficiencies. In recent years, sulfur (S) has also been reported as a limiting nutrient for field crops. A long-term fertilization study was established in eleven farmer's fields of the CREA Region of Southern Santa Fe (southern Santa Fe and southern Cordoba provinces, Argentina) with the following objectives: i) to determine direct and residual crop responses to the application of N, P, S, and other nutrients (potassium, magnesium, boron, copper, and zinc); ii) to evaluate diagnostic methodologies for N, P, and S fertilization of corn, wheat and soybean; and iii) to evaluate the effects of nutrient management on soil properties. This paper presents the results of the first five years of the study.

Experiments were started in 2000/01 under corn. After the first year, the experiments were divided in two groups: Five sites continued under a corn-wheat/soybean (C-W/S) rotation, and six sites under a corn-soybean-wheat/soybean (C-S-W/S) rotation. Soils at the different sites are classified as Typic Argiudolls or Typic Hapludolls. Fields were under continuous annual cropping for 50-60 years and under continuous no-tillage management for at least 5 years prior to 2000/01.

Treatments included: 1) Check, 2) PS, 3) NS, 4) NP, 5) NPS, and 6) Complete (NPS plus other nutrients: potassium, magnesium, boron, copper and zinc). Treatments were repeated every year on the same plots to evaluate direct and residual fertilization effects. Nutrient rates were equivalent to nutrient removal by grain to keep the soil nutrient balance close to its original condition.

For corn, in 23 site/years, responses were significant in 21, 8, 6, and 5 site/years for N, P, S, and NPS, respectively. For wheat, responses were significant in 5 of the 16 site/years for N, 11 site/years for P, 3 site/years for S, and 2 site/years for other nutrients. For full season soybean, in 11 site/years, responses were significant in 1, 3, 2, and 3 site/years for N, P, S, and NPS, respectively. For double cropped soybean, responses were significant in 1 of the 16 site/years for N, 3 site/years for P, 10 site/years for S, and 4 site/years for NPS.

Nutrient use efficiencies (NUE, kg grain yield increase per kg of nutrient added) were 10.4-24.8, 0.1-8.3, and 0.1-1.2 kg grain kg^{-1} N for corn, wheat, and double cropped soybean, respectively; 3.3-46.5, 6.5-36.2, 2.3-11.5, and 2.1-4.2 kg grain kg^{-1} P for corn, wheat, full season soybean, and double cropped soybean; and 5.2-60.5, 2.8-13.4, 0-10.1, and 14.7-27.2 kg grain kg^{-1} S for corn, wheat, full season soybean, and double cropped soybean. High values of partial factor productivity (PFP, kg grain yield per kg of nutrient added) for N, 68-102 kg corn kg^{-1} N, and 22-38 kg wheat kg^{-1} N, indicate high N efficiency use compared to data reported in other cropping systems. Frequency of responses and yield differences increased along the five seasons of evaluation as a consequence of residual effects that resulted in soil fertility buildup.

Nitrogen response in corn and wheat was significantly related to soil nitrate-N availability at planting (0-60 cm), and P response was related to soil Bray 1 P for corn, wheat, and full season soybean. Responses to S were related to sulfate-S concentration (0-20 cm) at planting for corn, and full season soybean, but not for wheat.

Soil Bray 1 P differences among P fertilized and non-fertilized treatments were determined, but residual effects of N or S fertilization could not be detected in soil nitrate-N or sulfate-S. Depending on the rotation, average soil Bray 1 P increased by 1-4 mg/kg per year, in the NPS treatment which had an almost neutral P balance (P applied as fertilizer minus P removed in grains) in both rotations. Soil Bray 1 P tended to decrease in the NS treatments.

Comparison of soil organic carbon (SOC) concentrations between the Check and NPS treatments showed an average increase of 3.4 g C kg^{-1} soil after four seasons. However, these changes in SOC were highly variable among sites: from -5.2 to +10.3 g C kg^{-1} soil. Fertilization with NPS generally tended to decrease soil pH, -0.4 to +0.1 units depending on the site. No significant differences in cation and micronutrient concentrations were observed at the 0-20 cm depth between the Check and NPS treatments.