Long-term Evaluation of Nitrogen, Phosphorus, Potassium, and Lime Requirements of Continuous Corn

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Introduction

A long-term study was established in 1963 and was continued until 2001 at the Northern Research Farm to evaluate the nitrogen (N), phosphorus (P), potassium (K), and lime requirements of continuous corn. The experimental area was on Nicollet soil, pH was 6.1, and both soil P and K were very low. Because one main objective was to study nutrient interactions, 25 treatments evaluated selected combinations of five annual rates of each nutrient using a complex statistical central-composite experimental design.

The fertilizer treatments applied since 1973 ranged from 0–240 lb N/acre, 0–137 lb P_2O_5/acre, and 0–100 lb K_2O/acre. The agricultural lime rates ranged from 0–900 lb CCE/acre (calcium carbonate equivalent). The lime rates were applied annually to assess the impact of frequent small lime applications on yield and soil pH. The P, K, and lime were applied in the fall before plowing. The N treatments (urea) were applied in the spring before disking for corn planting.

This report summarizes average corn yields for the last five years of the study (1997–2001), and the final soil-test values for P, K, and pH.

Summary Results

Table 1 shows the effects of 39 years of cropping and fertilization on soil-test P (Bray-1 test), K (ammonium acetate test), and pH. The values shown for each nutrient are averages for the rates of other nutrients that produced near maximum corn yield. Results for P suggest that a 69-lb or greater P rate resulted in above-optimum soil-test P values (the optimum range is 16–20 ppm by the Bray-1 or Mehlich-3 tests). Application of the highest K rate resulted in soil-test K values borderline between optimum and high classes. (The optimum class is 130 to 180 ppm by the ammonium acetate or Mehlich-3 tests.) Only the highest lime rate increased soil pH significantly over the initial values or over the value for the check treatment. A remarkable result is that the pH of the check only decreased from 6.1 to 5.8 after 39 years of cropping and N fertilization. It must be remembered, however, that this soil has high organic matter (which ranged from 4.2–5.1%) and highly calcareous subsoil.

High organic matter and calcareous subsoil explain a lack of significant liming effect on corn yield. The average response during the last five years for well-fertilized plots was less than four bushels/acre on the average, and detailed data are not shown. This result confirms Iowa and Minnesota research in showing that little or no response to lime should be expected in soils of the Clarion-Nicollet-Webster association with pHs of about 5.8 or higher.

Corn grain yields were markedly affected by N, P, and K fertilization. Maximum corn yield was achieved with the annual application of 240 lb N/acre. This response to N fertilizer agrees with results of other Iowa research involving continuous corn. However, a very interesting result of this study is that the corn responses to N and K fertilization are closely related. Data in Figure 1 show that the corn response to N is lower when K fertilization is sub-optimal. Data not shown also indicate that adequate N fertilization was needed to attain the largest response to K fertilization. In contrast to these results for N and K, sub-optimal P fertilization reduced yield levels similarly for all N rates.

The results for P fertilization (Figure 2) are interesting in showing that the highest P rate, which increased soil-test P to levels seven times higher than the optimum level compared with the check, decreased corn yield slightly. The yield reduction was smaller when optimum rates of K fertilizer were applied. This result has not been observed before in Iowa, and cannot be explained at this time; however, it has important environmental implications for P management.

The results for K fertilization (Figure 3) show the very large responses that should be expected in soils testing very low or low in K. The 100-lb rate produced about 70 bushels/acre more than the check, which tested borderline between the very low and low soil-test K classes.

Conclusions

Although an in-depth study of these data is not completed yet, the preliminary analysis showed important results. First, the results confirmed key aspects of the Iowa recommendations for continuous corn. Second, slightly acid pH in these soils does not automatically imply large responses to lime. Third, the results confirmed that N:K interactions and yield reductions with very high soil P levels shown in other states can also be observed in Iowa. Producers should use all the information available to avoid applying either deficient or excessive nutrient amounts for crop production.

Table 1. Soil-test P and K values after 39 years of fertilization of continuous corn.

P rate	Soil P	K rate	Soil K	Lime rate	pH
Lb P_2O_5/a	ppm	lb K_2O/a	ppm	CCE/a	
0	3	0	96	0	5.8
34	9	24	112	225	5.8
69	53	48	124	450	6.5
103	81	72	131	675	6.4
137	139	96	180	900	6.9

Fig. 1. Yield response of continuous corn to N fertilizer as affected by P and K fertilization (averages for the last five years).

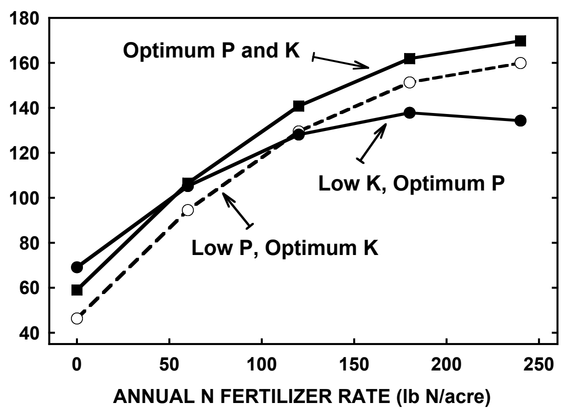

Fig. 2. Yield response of continuous corn to P fertilizer as affected by K fertilization with optimum N fertilization (averages for the last five years).

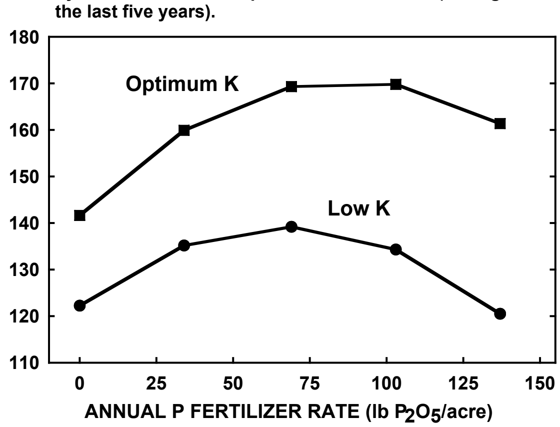

Fig. 3. Grain yield response of continuous corn to K fertilization (averages for the last five years).