# Long-term Potassium Fertilization for the Corn-Soybean Rotation

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## Introduction

Potassium (K) is an essential nutrient for plants and is needed in large amounts by corn and soybean crops. Available soil K levels vary greatly in Iowa soils due to differences in soil parent materials and fertilization practices. Much of the K applied with fertilizers is retained by soil constituents and absorbed by crops. Much K is recycled to the soil in crop residues but part is removed from the soil in harvested products. A long-term study was established in 1976 to evaluate the effect of various annual K fertilization rates on soil-test values and yields of corn and soybeans managed with chisel-disk tillage. Yield responses and soil-test values from this study and from studies conducted at other research and demonstration farms are used to calibrate soil tests and to make fertilizer recommendations. Several changes in fertilization rates and soil test methods occurred since the experiment was established. Earlier results were summarized in previous reports. In this report we summarize the yield responses and soil test values observed since 1994.

## Methods

Before the study was initiated in 1976, three contrasting levels of soil tests were created by broadcasting and incorporating into the soil either no K fertilizer or different high rates. These initial treatments are referred to as Initial 1, Initial 2, and Initial 3 treatments. Four annual K fertilization treatments were superimposed onto these three initial treatments. The annual rates were 0, 24, 48, and 72 lb $K_2O$/acre from 1976 until 1982, and 0, 36, 72, and 108 $K_2O$/acre from 1983 until 1996. Since 1997, only the highest annual rate continued to be applied to improve the soil-test calibration component of the study, but all plots continued to be evaluated. The fertilizer used was potassium chloride broadcast in the fall. The experiment received periodic P fertilization to maintain soil-test P within the High category, and urea was applied for corn at rates of 150 to 180 lb N/acre in spring. Corn and soybeans were grown in a rotation by alternating crops over time. Crop residues were chisel plowed in the fall and disked in spring. The predominant soils are Webster and Canisteo, and soil pH varies from slightly acidic to calcareous (approximately pH 6.2 to 8.1).

## Results

The data are summarized separately for the period 1994 to 1997 and for the last two years. Average crop yields for the period 1994 to 1997 are shown in Table 1. Corn was grown in 1994 and 1996, and soybeans were grown in 1995 and 1997. Both crops responded to annual K fertilization. As expected, the responses were different for the three initial K treatments applied before 1976.

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The underlines in Table 1 indicate the annual rate that produced the statistically highest yield for each initial treatment. The intermediate annual rate (72 $K_2O$/acre) produced statistically maximum yields of both crops for the Initial 1 and Initial 2 treatments. The crops differed for the Initial 3 treatment, however. No annual K rate increased corn yield significantly above the check, but the lowest annual rate (36 $K_2O$/acre) produced the highest soybean yields. In no case did the highest annual rate (108 $K_2O$/acre) produce additional yield increases.

**Table 1. Average effect of long-term K fertilization on corn and soybean yields for the 1994-1997 period (two corn crops and two soybean crops).**

| Corn yield | | | | Soybean yield | | | |
|---|---|---|---|---|---|---|---|
| Annual K rate | Initial 1 | Initial 2 | Initial 3 | Annual K rate | Initial 1 | Initial 2 | Initial 3 |
| lb $K_2O$/acre | ---------- bu/acre ---------- | | | lb $K_2O$/acre | ---------- bu/acre ---------- | | |
| 0 | 164 | 166 | <u>176</u> | 0 | 45.5 | 48.3 | 47.9 |
| 36 | 174 | 173 | 180 | 36 | 49.3 | 50.4 | <u>51.8</u> |
| 72 | <u>177</u> | <u>180</u> | 177 | 72 | <u>50.6</u> | <u>52.2</u> | 52.9 |
| 108 | 180 | 184 | 181 | 108 | 52.1 | 52.5 | 52.6 |

Note: Underlined numbers denote the annual rate that produced the statistically highest yield.

Soil-test K values measured in 1993 and in fall 1998 are shown in Table 2. In 1993, soil-test K of plots that received no annual K fertilization since 1976 was in the Optimum class for the Initial 1 treatment, borderline between Optimum and High for the Initial 2 treatment, and in the middle of the High range for the Initial 3 treatment. Soil test values for all other plots were High or very High. The soil-test data for 1998 show, as expected, a decrease in soil-test values for most plots. The average decrease was only 9 ppm, although this number must be interpreted carefully because much annual variation in soil-test K that is unrelated to fertilization or crop removal. The trends in soil tests cannot be compared with those in earlier years of the study because Iowa State University used to analyze soil K with the ammonium acetate method in field-moist samples. Soil K is analyzed in dried soil samples since 1992.

**Table 2. Soil test K values in fall 1993 and fall 1998.**

| Soil-test K in fall 1993 | | | | Soil-test K in fall 1998 | | | |
|---|---|---|---|---|---|---|---|
| Annual K rate | Initial 1 | Initial 2 | Initial 3 | Annual K rate | Initial 1 | Initial 2 | Initial 3 |
| lb $K_2O$/acre | ---------- ppm ---------- | | | lb $K_2O$/acre | ---------- ppm ---------- | | |
| 0 | 128 | 138 | 149 | 0 | 124 | 139 | 138 |
| 36 | 145 | 151 | 175 | 36 | 135 | 142 | 160 |
| 72 | 171 | 171 | 192 | 72 | 163 | 157 | 178 |
| 108 | 185 | 193 | 237 | 108 | na | na | na |

The responses observed during the last two years were slightly higher than those observed during the 1994-1997 period (Table 3), which agrees with the slightly lower soil tests. Yet, the high annual rate of K (the only one that continued to be applied) was not needed to produce maximum yields of corn.

The additional K was needed for soybeans, however. This does not mean that continued applications of 108 $K_2O$/acre are needed to maximize soybean yield, however. Although lower rates were not applied during the last period, results for the previous period show that a rate of 72 $K_2O$/acre would have achieved the maximum yield. This rate would have supplied an amount of K similar to the K removed in a 50 bu/acre grain yield level.

**Table 3. Effect of long-term annual K fertilization on grain yields of the last two corn and soybean crops (1998 and 1999).**

| Corn yield in 1998 | | | | Soybean yield in 1999 | | | |
|---|---|---|---|---|---|---|---|
| Annual K rate | Initial K1 | Initial K2 | Initial K3 | Annual K rate | Initial K1 | Initial K2 | Initial K3 |
| lb $K_2O$/acre | ---------- bu/acre ---------- | | | lb $K_2O$/acre | ---------- bu/acre ---------- | | |
| 0 | 140 | 136 | 141 | 0 | 47.3 | 49.8 | 47.5 |
| 36† | 144 | 153 | <u>162</u> | 36† | 49.5 | 50.3 | 51.4 |
| 72† | <u>164</u> | <u>158</u> | 165 | 72† | 52.7 | 52.6 | <u>54.6</u> |
| 108 | 171 | 163 | 168 | 108 | <u>56.0</u> | <u>56.6</u> | 55.7 |

† Only the highest annual rate was applied for these two years. Underlined numbers denote the annual treatment that produced the statistically highest yield.

## Conclusions

The responses observed for corn in 1998 and soybeans in 1999 show large crop responses when soil-test K was in the Optimum class or borderline between the Optimum and High classes. However, the data also show a significant response in the High class. Such a response in the High class should not be expected according to current Iowa State University soil-test interpretations. Smaller responses have also been observed during recent years in plots that tested High in other K experiments. These results led to the initiation of a large number of new K fertilization and calibration studies in 1999. Experiments similar to this one are being conducted at two research farms, and strip-trials are being conducted in various farmers' fields. The new studies also include evaluation of alternative soil test methods. The results of these studies will, within one or two more years, suggest if soil-test interpretations or the soil test method (or both) need to be changed for all or some Iowa soils.

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