Optimum Nitrogen Fertilization Rate for Corn

RFR-A2066

Sotirios Archontoulis, associate professor
Department of Agronomy

Introduction

The 2020 cropping year had many challenges. While crops planted earlier than normal set a high yield potential, the lack of precipitation in August (Figure 1) decreased soil moisture. This impacted crop yields and the response to nitrogen (N) fertilizer in two ways—directly by inducing water stress on crop growth, and indirectly by reducing soil N mineralization and N uptake during grain fill period. Typically, 70 percent of maize N uptake is accumulated by silking, while the remaining 30 percent is accumulated during the grain filling period. This report summarizes the 2020 results from a long-term nitrogen trial (established in 2005) with two crop rotations: corn following corn (CC) and corn following soybean (CS).

Materials and Methods

Corn received UREA-N fertilizer April 6, 2020, at varying rates: 0, 40, 80, 120, 160, 200, and 240 lb/acre^{-1}. Corn was planted April 21, with stand counts/plot measured June 26. Each plot followed standard tillage and pest management practices for this region. Final yields were measured with a combine harvester October 5 and reported at 15 percent grain moisture. Economically optimum N application rate (EONR) was calculated by fitting a quadratic-plateau regression through the yield response to N. The point where the regression plateaued when adjusted to the price ratio of a unit of grain yield vs. a unit of N fertilizer was reported as the EONR.

Results and Discussions

From planting to the end of July, the weather conditions were ideal for corn production (Figures 1 and 2). The depth to the saturated soil layer (hereafter water table depth) was near the depth of tile drainage (~3 ft) early in the season and declined to 7 ft by the end of August due to 3.5 in. less than normal precipitation in August (Figures 1 and 2). According to APSIM model simulations, the roots reached a depth of 5 ft in 2020, and through capillary fringe (upward movement of the water) the roots were able to extract moisture for plant growth, thus compensating for the lack of precipitation in August.

Corn yields under optimum N rate were 211 bushels/acre for CC and 227 bushels/acre for CS (Figure 3). Compared with other Iowa regions in which similar long-term experiments were in place, the Northeast Research Farm yields were the highest in 2020, following by the southeast region (maximum corn yields of 190 to 220 bu/ac). The yield at zero N rate was 57 and 73 bushels/acre for CC and CS, respectively. The yield penalty caused by the continuous corn was 15 bushels/acre and unaffected by N fertilization rate (Figure 3).

The 2020 EONR was 240 lb/acre for CC and 223 lb/acre for CS (Figure 3). Compared with the Maximum-Return-to-Nitrogen calculator, the 2020 EONR was 52 lb/acre greater for CC and 83 lb/acre greater for CS. Compared with other long-term experiments, the EONR at the Northeast Farm, Nashua, was greater than that at the Southeast Farm, Crawfordsville, and similar to the Northwest Farm, Sutherland, and to the Northern Farm, Kanawha, Iowa.

Overall, the observed EONR values were high for a "dry year." Factors that possibly explain the high EONR include 1) 15 percent higher radiation levels in July and August than normal that increased crop growth, 2) existence of a shallow water table that provided roots with water to minimize drought stress on crop growth, and 3) low soil N mineralization because the topsoil was dry. In contrast to plant growth in which water can be taken up from anywhere in a 5 ft profile, the majority of soil N mineralization is happening in the topsoil (0 to 1 ft). The researchers believe the combination of these three factors together resulted in high EONR values.

In the high N-rate plots of the CS rotation, there were 5 percent more plants/acre than in CC (Figure 4). As researchers try to explain the causes of the continuous corn yield penalty, such observations are helpful.

Acknowledgements

Thanks to Ken Pecinovsky for managing the experiment and Mitch Baum for calculating the EONR values.

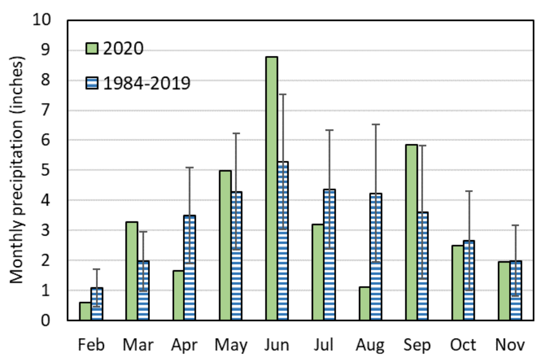

Figure 1. Monthly precipitation for the northeast crop reporting district in Iowa. Data extracted from the ISU FACTS Weather Tool.

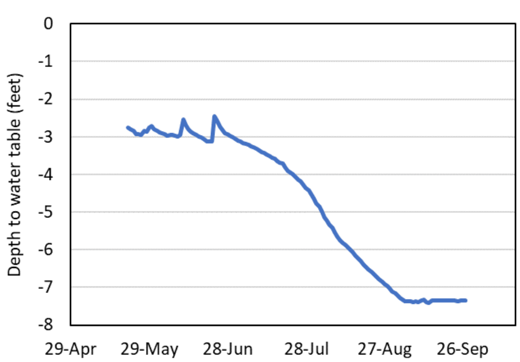

Figure 2. Evolution of the water table depth measured using CTD-10 sensors in a nearby field with tiles installed at a 3-ft depth.

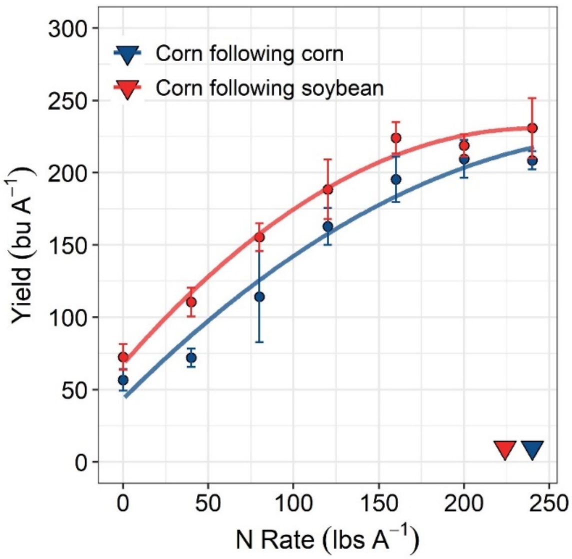

Figure 3. Yield response to N fertilizer rate in 2020. Cycles (± SE) represent measurements and lines the regression fits. The bottom right triangles represent the EONR by rotation.

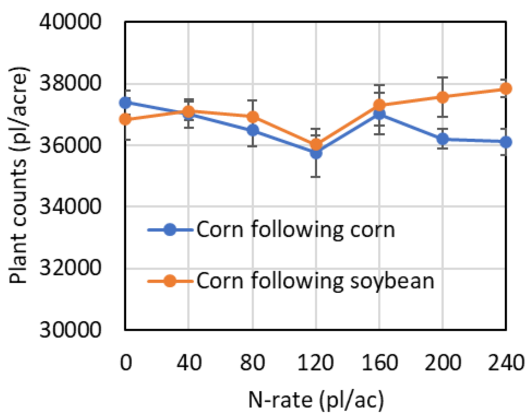

Figure 4. Hand measured plant counts/N rate, cropping rotation, and replication.