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Corn-Soybean Rotation Effects on Soil and Plant N Indices

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Summary

An irrigated study comparing monoculture corn and corn-soybean systems is being conducted on a uniform site in the Platte Valley of Nebraska. Four corn hybrids differing in yield potential, maturity, and stay-green characteristics are used in both the monoculture and rotation systems with five N-fertilizer rates. Stalk nitrate-nitrogen concentrations determined in mature corn plants at harvest have been used in many areas of the country as an indicator of the amount of N available to those plants. In this study, stalk nitrate-nitrogen concentrations (taken after the 1992 and 1993 growing seasons) reflected differences in N status between and within the two cropping systems. Higher stalk nitrate-nitrogen concentrations were obtained with increasing N-fertilizer rates in both cropping systems, but they tended to be greater in the corn-soybean rotation, which indicated the presence of greater amounts of residual N in this system as compared to continuous corn. These data support the results obtained for grain yield in both years in that the corn in rotation required less N fertilizer to achieve optimum (maximum) yield, therefore leaving greater amounts in the soil, which were indicated by the greater stalk nitrate-nitrogen concentrations.

A companion study conducted at the West Central Research and Extension Center at North Platte, Nebraska, is using 14 percolation lysimeters to measure nitrate leaching in irrigated monoculture corn and corn-soybean systems. Leachate continuously collected at the base of the lysimeters in 1991, 1992, and 1993 indicated 28% less water and 19% less nitrate leached from the corn-soybean rotation than from continuous corn. These differences were primarily due to more aggressive soil water extraction by soybean late in the growing season and lower N fertilizer requirements. Increased soil water extraction late in the growing season tended to reduce the off-season leaching following soybean, whereas water leached during the off-season following corn was similar for corn following soybean and continuous corn.

Project Descriptions

Corn-soybean systems have been shown to reduce N fertilizer needs and increase yields, compared to monoculture corn in many situations. More recently, studies have shown that corn-soybean systems effectively reduce residual soil N-levels, especially after soybean in the cropping system. Other research has shown that corn hybrids vary in both the amount of N utilized and duration of N uptake. Potentially, inclusion of an appropriate corn hybrid in a corn-soybean rotation may reduce the amount of N available for leaching late in the growing season.

The objective of our study was to evaluate the effects of N fertilizer applied to irrigated corn in monoculture and corn-soybean cropping systems on grain yield and residual N, which would be susceptible to leaching late in the growing season.

A study on a uniform site in the Platte Valley of Nebraska was initiated in 1991. Four corn hybrids differing in yield potential, maturity, and stay-green characteristics were selected for use in monoculture and rotation systems in combination with five N fertilizer rates. In all years, corn stalks from the previous growing season were shredded and the entire area was disked twice before planting. Planting dates ranged from late April to mid-May for corn and early to late May for soybean from 1991 through 1993. Corn and soybean were planted in 8 row plots using a 36-inch row spacing. Seeding rates were approximately 29,000 seeds/ac for corn and 120,000 to 140,00 seeds/ac for soybean. In early June, N fertilizer treatments as ammonium nitrate were broadcast on the soil surface and immediately incorporated with a 0.25-inch irrigation. Irrigation applications were made as needed throughout each growing season. Final grain yield and stalk nitrate-nitrogen concentrations were determined at physiological maturity after the 1992 and 1993 growing seasons. Soil samples were also taken to a depth of 5 feet from selected treatments just prior to planting in all years to determine residual N levels.

A companion study conducted during the 1991, 1992, and 1993 growing seasons at the West Central Research and Extension Center at North Platte, Nebraska, is using 14 percolation lysimeters to measure nitrate leaching in irrigated monoculture corn and corn-soybean systems. The lysimeters consist of undisturbed soil columns contained in a pipe 3 feet in diameter and 8 feet long. Six lysimeters are under continuous corn and eight are under a corn-soybean rotation. Leachate is continuously collected at the base of the lysimeters. Best management practices included a no-till tillage system; irrigation scheduling from soil water measurements, evapotranspiration, irrigation and rainfall measurements; and N fertilizer applications based yield goals with information from soil samples on residual N levels.

Results

Results from each of the various growing seasons demonstrated several things of importance for irrigated corn management systems. First, it is extremely important to know the current soil N status, previous crop for each field, and the amount of N being added with the irrigation water. High residual soil N levels and a substantial amount of N in the irrigation water resulted in little if any N response in 1991. In 1992 and 1993, preplant residual soil N levels were reduced, less N was applied with irrigation water because of more rainfall, and previous crops for the two systems were now different. Grain yields from 1992 and 1993 were increased with the addition of N fertilizer, especially in continuous corn systems (Fig. 1). Yield data from 1993 are somewhat misleading because it appears that they were lower in rotation than in the continuous corn system. This mainly occurred because corn in the corn-soybean rotation incurred greater damage from a windstorm on July 8 of that year.

As was stated above, it is very important to know how much N is available in the soil before a decision can be made on how much N fertilizer will need to be applied. Soil testing has been shown to be an effective tool for determining how much N is available in the soil for the next crop and has been used to identify the proper amount of N fertilizer for maximum yield and minimum environmental impact. Soil testing continues to be the best method to determine how much residual N is available for the next crop, but it also continues to be labor and time

intensive. Soil testing in coordination with information collected from a recently developed diagnostic tool may be an alternative to intensive soil sampling in areas where monoculture corn predominates. This tool, which involves determining stalk nitrate-nitrogen concentrations at the end of the growing season, appears to have application in these areas.

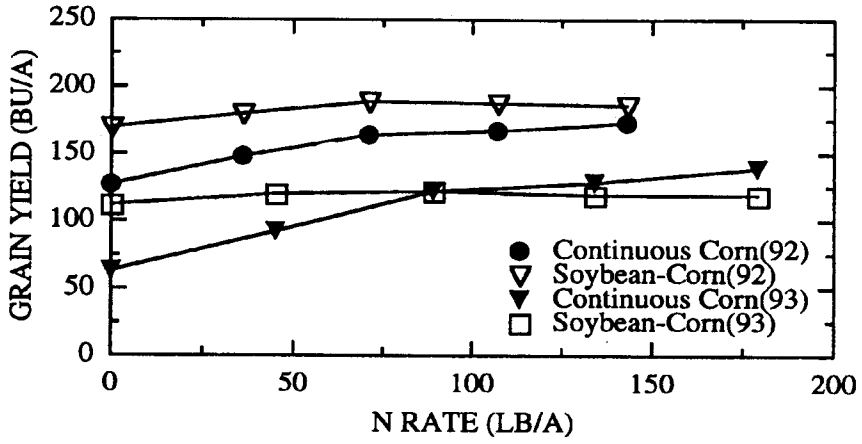

Figure 1. Grain yields as affected by rotation and nitrogen fertilizer rate

This study presented an excellent opportunity to evaluate the stalk nitrate test as a viable tool for determining if excess N was available at the end of the growing season in two different cropping systems. In this study, stalk nitrate-nitrogen concentrations (taken after the 1992 and 1993 growing seasons) reflected differences in N status between and within the two cropping systems (Fig. 2). Higher stalk nitrate-nitrogen concentrations were obtained with increasing N fertilizer rate in both cropping systems, but they tended to be greater in the corn-soybean rotation. This indicated the presence of greater amounts of residual N in this system as compared to those in continuous corn. This data supports the results obtained for grain yield in both 1992 and 1993 in that the corn in rotation required less N fertilizer, therefore leaving greater amounts in the soil, which were indicated by the greater residual stalk nitrate-nitrogen concentrations.

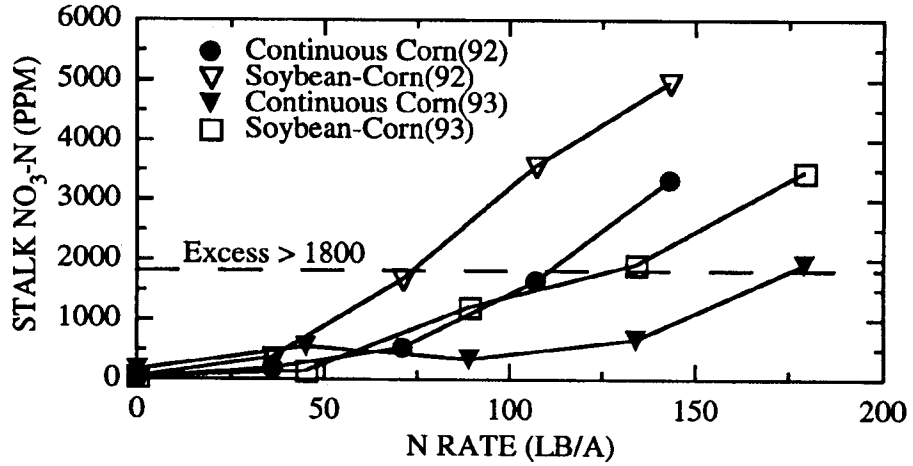

Figure 2. Stalk nitrate-nitrogen concentrations as affected by rotation and nitrogen fertilizer rate.

Results from the North Platte study are shown in Table 1. Samples collected during 1991, 1992, and 1993 indicated 28% less water and 19% less nitrate leached from the corn-soybean rotation than from continuous corn. These differences were primarily due to more aggressive soil water extraction by soybean late in the growing season and lower N fertilizer requirements. Increased soil water extraction late in the growing season tended to reduce the off-season leaching following soybean, whereas water leached during the off-season following corn was similar for corn following soybean and continuous corn. Careful irrigation water management in this study minimized leaching during the growing season. However, greater amounts of leaching are likely to occur under average irrigation water management practices.

Table 1. Water budget and nitrate-nitrogen leaching measurements for an irrigated corn-soybean and continuous corn study in 1991, 1992, and 1993 at North Platte, Nebraska.

	Water budget (inches)			
	1991	1992	1993	Average
Corn ET	24.9	21.7	21.4	22.7
Soybean ET	22.8	19.9	20.1	20.9
Precipitation	20.7	24.0	26.9	23.9
Corn irrigation	11.3	3.5	2.0	5.6
Soybean irrigation	9.9	1.0	0.0	3.6
	Water leaching (inches)			
	1991	1992	1993	Average
Continuous corn	7.6	8.4	7.6	7.9
Corn following soybean	-	5.0	3.4	4.2
Soybean following corn	6.6	7.4	7.7	7.2
	Nitrate-N leaching (ppm)			
	1991	1992	1993	Average
Continuous corn	43	35	19	31
Corn following soybean	-	30	44	37
Soybean following corn	30	58	21	36
	Nitrate-N leaching (lbs/acre)			
	1991	1992	1993	Average
Continuous corn	79	70	34	61
Corn following soybean	-	36	36	36
Soybean following corn	50	101	38	63

Technology Transfer

Information and results could be used by farmers and consultants in coordination with soil test results to better predict nitrogen fertilizer needs for the succeeding corn crop. They could also be used for selecting cropping sequences. Monoculture corn production has been the predominant cropping pattern. These results, when coupled with economic studies, could guide policymakers who are determining the costs and benefits of crop rotations for environmental protection.