EARLY SEASON STRESSES IN CORN

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Abstract

Spatial variability in corn yield is frequently associated with lost yield potential caused by plant stresses. Early-season stresses are difficult to recognize because growing conditions (soil temperature and water status) are not ideal and seldom uniform throughout a field. The impact that climate has on plant growth is difficult to determine because it also affects nitrogen (N) availability. Nitrogen stress was imposed sequentially until the V8 growth stage and then all plots were sidedressed with a uniform N treatment. Yield generally decreased as the delay in starter N application increased, but climate appeared to have a strong influence on yield. A second situation developed after scrutinizing N applications for six years. In years seven and eight, yields from the N management areas were 8.3 and 11.7 bu/A less than the adequately fertilized reference strips, respectively. Chlorophyll meter readings and aerial photographs failed to indicate a spatial variability in biomass or crop color, suggesting the possibility of undetected early-season stresses. Additional starter fertilizer as urea-ammonium nitrate (UAN, 28-0-0) and diammonium phosphate (DAP, 10-34-0) showed the combination of N and phosphorus (P) was superior to extra N starter alone, but comparable to long-term over-application of N fertilizer.

Introduction

Early season crops stresses frequently go undetected or are passed off as being unimportant because young corn plants tend to grow out of such stresses. Yet, there is a mounting pool of evidence suggesting that early-season stresses in corn can reduce yield potential. The metabolic and physiological processes responsible for yield reduction in young corn plants are not well known. In fact, most of the evidence suggesting such yield limiting events or situations is coincidental to other research.

The positive effects of starter fertilizer on early-season corn vigor have been observed for many years. Similar observations have been made for corn following soybeans. Producers who remove or burn corn residues frequently observe enhanced vigor of young corn plants compared to where residues are incorporated into the soil at or before planting. Burying corn residue as part of a plowing operation also removes the material from immediate competition with corn seedlings. These observations suggest that at least part of the reduced early-season vigor observed with residue-incorporation tillage systems is the competition for nutrients between plants and soil microbes.

The mineralization-immobilization process is more widely recognized than appreciated. All too often, mineralization is recognized as a process dependent on temperature. As such, producers frequently feel N made available during the process is largely beyond their control. Concurrently, producers associate tillage and residue incorporation shortly before planting with N immobilization and the potential for yellow corn. Many other factors can contribute to reduced chlorophyll in plants, but N deficiency is the predominant cause in corn. The common precaution against the likelihood of N deficiency is additional N fertilizer. Producers who have the ability to fertigate frequently wait until an N deficiency is visible before attempting to correct the problem.

Approach

One of the N management strategies when the Nebraska Management Systems Evaluation Area (MSEA) project was initiated in 1991, was to apply less than the recommended amount of N fertilizer as a preplant or early sidedress application, with the expectation that fertigation may be required. One potential shortcoming of this strategy is that an N deficiency might not be detected early enough for remediation and a yield loss would result. This could easily happen if the wrong areas of the field were monitored for N status. In the case of the MSEA project, there was no history of spatial or temporal variability in crop N status and yields were good (196 bu/A in 1990). Therefore, three designated areas were selected within each 33-acre field for monitoring with chlorophyll meters. These areas were adjacent to test strips that received extra N fertilizer according to the producer's wishes (usually an extra 80 lb N/A at sidedress). Therefore, it was possible to compare chlorophyll meter readings between the managed areas of the field with the producer's adequately fertilized test strips.

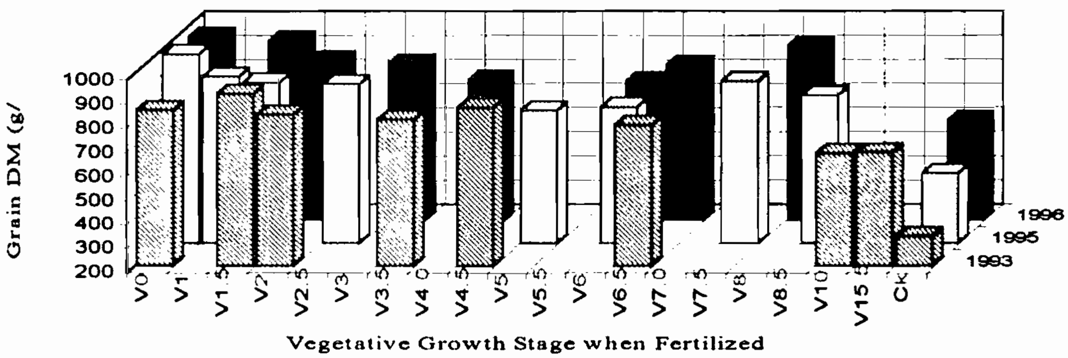
Expression of spatial variability did not become apparent until 1992 (second year of intensive N management), and then only late in the growing season. As might be expected, the N deficient areas were in different locations than the designated N-status monitoring sites. Observed spatial variability added a concern to the list of potential shortcomings of a spoon-feeding strategy for sprinkler irrigated corn. The initial concern had to do with the possibility that any reduction in yield might be attributed to problems of the spoon-feeding strategy, when in fact, the yield potential was lost because of early-season stresses. Following up on this concern, studies were initiated in 1993 to determine if a short-term stress prior to the V8 growth stage would ultimately reduce corn yield. The difficult part of such studies is imposing the stress at the desired time and for a quantifiable duration.

The strategy for imposing an early season N stress consisted of withholding starter N fertilizer from an area with low levels of residual N. At approximately weekly intervals, starter fertilizer (25 lb N/A as ammonium nitrate) was applied over the row and lightly watered into selected plots. At the end of eight weeks, all plots except the check plot had received the same quantity of starter fertilizer at one time or another. At the eighth week after planting, all plots received a sidedress application sufficient for a yield of 190 to 200 bu/A. This aspect of the study was conducted on a medium and fine textured soil in hopes that one would demonstrate the desired stress.

A back-up strategy was to impose a light stress for one and two week periods between emergence and when the crop reached a height of 6 ft. Sun-screen material that reduced the amount of radiation by ~50% was attached to the top of 12 x 12 ft PVC frames (2-in dia. pipes) supported by PVC pipes. Legs of 2, 4, and 6-ft length were used to position the shade above the canopy. The sides of the chambers were also shaded to restrict indirect light penetration.

Results of the delayed starter N applications showed a trend for greater yield reduction with increased length of delay. Variation in the trend between years is attributed to climatic conditions. Data for 1995 were not significantly different between N application dates.

Figure 1. Grain yield of irrigated corn for three years as influenced by timing of starter N application.



One of the goals of the MSEA project initiated in 1990 was to evaluate the effect of improved water and nitrogen (N) management practices on ground water quality. Spoon-feeding the crop using fertigation as needed was one of the practices evaluated. This strategy used chlorophyll meters to monitor crop N status. Monitoring the N status of corn using Minolta SPAD chlorophyll meters before the V8 growth stage is unreliable because the sensors are small (2x3 mm) and light green stripes in leaves are frequently prominent. Fully extended leaves (i.e., visible collar) are much more uniform in greenness and thus can be used to monitor chlorophyll status. A common "leap of faith" is that relative greenness in corn is directly correlated to crop N status.

One potential weakness of the crop monitoring and spoon-feeding concept is that even if adequate levels of crop N are maintained after the V8 growth stage, early season stresses might unknowingly reduce yield potential. If the early stress scenario were to materialize and yield reductions occur, the cause might unfairly be attributed to failure of the crop monitoring and spoon-feeding strategy.

Within the last two years, the effect of apparent early-season stress has been demonstrated on strip trials at the MSEA project. Two fields each 33 acres in size under improved water management (surge-flow furrow irrigation and center-pivot sprinkler irrigation) have received reduced rates of N fertilizer since 1991. In the first year, N rates were reduced 70 to 90% with no reduction in yield. The greatest yield loss was in 1992 when the effects of variable residual N and organic matter content resulted in spatial variability in yield that was more than anticipated. Yield reduction amounted to $62/A while N saving only amounted to $15/A. From 1993 to 1996, N fertilizer savings amounted to 30 to 50% with little reduction in yield (<2%) compared to adequately fertilized reference strips. Fertility in these strips usually amounted to an extra 80 lb N/A at sidedress. Starter fertilizer applications have remained at ~20 lb N and P/acre throughout the duration of the study (blend of UAN and 10-34-0 at 15 gal/acre). Groundwater used for irrigation contains ~30 ppm nitrate-N (~7 lb N/inch). In 1997 and 1998, average yield for the field was 8.3 and 11.7 bu/A less, respectively, than for the producer reference strips. These yield reductions occurred even though aerial photography and chlorophyll meter readings failed to identify any difference in crop N status between the producer reference strips and the rest of the field.

The lack of any apparent N stress in 1997 and 1998 after the V8 growth stage suggests that the yield reduction in the N management areas of the field was due to an early season plant stress that reduced yield potential. This hypothesis is consistent with the findings of the early season stress studies noted above. In 1999, extra N was banded over the row in 8-row strips immediately after planting. Nitrogen application rates were either 20 or 40 lb/acre as UAN or DAP. Since 1998, both fields have been under center-pivot irrigation and similar nutrient management practices. As such, the 1999 study includes six replications with six treatments:

1. Spoon-feeding (80 lb N/A preplant, starter, fertigation as needed)
2. Producer reference (same as #1 plus 80 lb N/A sidedress)
3. Same as #1 plus 20 lb N/acre as UAN.
4. Same as #1 plus 40 lb N/acre as UAN.
5. Same as #1 plus 20 lb N/acre as DAP.
6. Same as #1 plus 40 lb N/acre as DAP.

Aerial photographs (color and color infrared) in June and July of 1999 failed to show any difference between the above treatments. However, photographs on August 18 showed segments of several 8-row strips that were beginning to show an N deficiency or early signs of senescence.

Table 1. Yield response to supplemental starter fertilizer to irrigated corn in 1999. All areas received 80 lb/A preplant as anhydrous ammonia, 20 lb/A of N and P starter, and fertigation as needed.

Form	Starter N lb/A	Starter P lb/A	Sidedress N lb/A	Yield bu/A
None	0	0	0	174.3
DAP	20	30	0	191.9
DAP	40	60	0	189.3
UAN	20	0	0	181.2
UAN	40	0	0	187.6
None	0	0	80	189.1

Summary

Starter P fertilizer applications to irrigated corn that amounted to less than grain removal amounts for the past decade or more have resulted in declining soil test P levels. Even though soil test P levels are still in the moderate range, reduced yields for the past several years suggest some type of early season stress. Application of additional starter as DAP increased yield to the level attained with long-term over application of N fertilizer. Additional starter as UAN resulted in a lower response than DAP. Starter N fertilizer showed the greatest response when applied at planting, suggesting that minimizing early season N stress is important to maintain productivity. Climate appeared to play a significant role in mineralization and early season N availability.

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