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Iron Deficiency Chlorosis (IDC): Evidence in the Mystery

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For many years, an explanation of the severity of IDC has evaded those who have worked to solve the problem. That situation changed in 2005 when there was an effort to get an explanation for green soybeans that were growing in wheel tracks through otherwise yellow soybeans. These yellow plants were affected by the malady of IDC.

A search of published literature combined with the results of the survey produced a theory that the severity of IDC was linked to high levels of nitrate-nitrogen in the soil that subsequently increased the concentration of nitrate-nitrogen in the soybean plant. If this theory was, in fact, true a competition crop that would take up nitrogen from the soil should be effective in reducing the severity of IDC. Soybean producers provided observations that supported the concept of the competition crop.

With the financial support from the soybean check-off in 2006, trials were established in West-Central Minnesota to test the accuracy of the theory proposed at the end of the 2005 growing season. At three sites (Chippewa County, Yellow Medicine County, West-Central Research and Outreach Center) soybeans were planted with and without oats as a competition crop. Three rates of N (0, 100, 200 lb. N per acre supplied as 46-0-0) were broadcast and incorporated before planting of soybeans in both planting systems (oats, no oats).

It appears that there will be limited opportunities to discuss the results of these trials in meetings during the up-coming winter. Therefore, the results will be summarized in this newsletter. To keep the amount of data to a minimum, information from the West-Central Research and Outreach Center will not be included.

Glyphosate was applied to the soybean crop when the oats reached a height of 12 to 14 inches. Oat samples were collected at this time and analyzed for nitrogen. Nitrogen uptake by the oat crop was calculated from the nitrogen concentration and dry weight data (Table 1).

Table 1. Effect of rate of applied nitrogen on oat yield and uptake of nitrogen by the oat crop.

	Chippewa Co.		YM Co.	
N Applied	oat yield	N uptake	oat yield	N uptake
lb./acre	- - - - - - - - lb./acre		- - - - - - - -	
0	1450	52.2	1903	64.7
100	1462	67.1	2033	88.0
200	1345	63.2	2339	109.3

Moisture was limited in Chippewa County and this probably limited both oat growth and nitrogen uptake. Rain was more favorable in Yellow Medicine (YM) County and oat growth increased as the rate of applied nitrogen increased. Results from this site also show that the oat crop is capable of absorbing substantial amounts of nitrogen from the soil system. Thus, oats could be an effective competition crop.

Soil samples were also collected at the time of glyphosate application and analyzed for nitrate-nitrogen. The uptake of nitrogen by this competition crop was reflected in lower concentrations of nitrogen at depths of 0 to 6 and 6 to 12 inches (Table 2). In theory, nitrogen taken up by oats will not be available for the soybeans.

Table 2. Nitrate-nitrogen in soil as affected by planting of oats and nitrogen application.

		Chippewa Co.		YM Co.	
N Applied	Oats Planted	0 to 6 in.	6 to 12 in.	0 to 6 in.	6 to 12 in.
lb./acre	- - - - - - - -	ppm NO_3-N	- - - - - - - -		
0	no	25.5	16.5	18.0	12.0
0	yes	12.5	7.5	10.0	6.5
100	no	69.0	17.0	42.0	19.5
100	yes	48.5	13.5	35.5	11.5
200	no	109.5	20.5	62.0	21.5
200	yes	69.5	14.5	63.0	17.0

The higher levels of nitrate-nitrogen in the soil did produce higher concentrations of nitrogen in whole soybean plants and nitrate-nitrogen in the most recently matured leaflets (Table 3). As with the nitrogen supply in the soil, nitrogen in the soybean plant was reduced by the oats crop.

Table 3. Nitrogen concentration in soybean plants and leaflets as affected by planting oats and rate of applied nitrogen.

		Chippewa Co.		YM Co.	
N Applied	Oats Planted	whole plant N	leaflet nitrate	whole plant N	leaflet nitrate
lb./acre		%	ppm	%	ppm
0	no	3.74	683	3.62	69
0	yes	2.66	28	2.98	12
100	no	4.11	1150	4.27	655
100	yes	3.23	241	3.70	350
200	no	4.23	1535	4.46	1273
200	yes	3.67	607	4.17	857

Consistent with the theory proposed in 2005, the addition of nitrogen to the soil system reduced soybean yield at both locations (Table 4). This reduction was most evident at the site in YM County. The oat crop in competition with soybeans early in the growing season had a positive effect on yield at this site. The improvement in yield was not measured where no nitrogen was applied. When additional nitrogen was added to the soil system, however, planting of oats increased soybean yield by 6 to 10 bushels per acre.

The oat crop reduced yield at the Chippewa County site regardless of the rate of nitrogen applied. This reduction in yield illustrates the risk associated with the use of a competition crop. With limited rainfall, the oats crop is probably depleting soil moisture. As a result, the soybean plant is stressed for moisture and there was a reduction in soybean yield. Although there were no measurements of rainfall at the experimental sites, rainfall in Yellow Medicine County was generally higher and, consequently, soybean yields were higher.

Table 4. Soybean yield as affected by the planting of oats and rate of applied nitrogen.

	Chippewa Co.		YM Co.	
N Applied	no oats	oats	no oats	oats
lb./acre	- - - - - - - - bu./acre - - - - - - - -			
0	42.1	22.5	52.0	52.4
100	28.6	20.5	32.2	42.6
200	25.3	18.9	19.1	25.9

The impact of the oats crop on soil moisture at the time of glyphosate application is summarized in Table 5. Since soil texture was not the same at both sites a direct comparison between sites is not appropriate. Application of fertilizer N appeared to have no affect on soil moisture at each site. Soil moisture at both depths, however, was affected by the planting of oats.

At 0 to 6 inches, soil moisture was 3% lower when oats were planted at the Chippewa County site and 1.5% lower with oats planted at the YM County site. Those differences were measured relatively early in the growing season. With limited rainfall throughout the summer, the differences may have been larger during the later portions of the growing season.

Table 5. Soil moisture as affected by planting of oats and rate of applied nitrogen.

		Chippewa Co.		YM Co.	
Oats Planted	N Applied	0 to 6 in.	6 to 12 in.	0 to 6 in.	6 to 12 in.
	lb./acre	- - - - - - % H_2O - - - - - -			
no	0	34.2	31.3	34.9	33.6
no	100	33.5	32.3	34.8	34.6
no	200	34.2	31.8	35.3	34.7
yes	0	30.8	30.5	34.2	34.0
yes	100	31.0	30.9	33.8	32.8
yes	200	31.3	31.0	32.5	31.7

In evaluating the information collected at both sites, it appears that the theory developed from the survey conducted in 2005 was correct. The severity of IDC was increased by the addition of N to the soil system. The additional N in the soil resulted in more N in the soybean plant as well as additional nitrate-nitrogen. In support of the basic research in plant physiology at other locations, the higher concentrations of nitrate-nitrogen apparently inhibited the conversion of ferric iron (Fe^{+++}) to ferrous iron (Fe^{++}). As a result, there were lower concentrations of chlorophyll in the soybean plant resulting in lower yields.

The challenge, now, is to develop management practices that keep concentrations of nitrate-nitrogen in the soil to a minimum. One approach would be to avoid using excessive amounts of fertilizer nitrogen for the preceding corn crop. Another approach is to use a competition crop such as oats. Obviously, more research is needed to develop management practices for this competition crop.