An Overview of the Nitrogen Response of Corn and Wheat at the Carrington Research Extension Center from 2013 to 2024

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The Soils Program at the Carrington Research Extension Center (CREC) has been heavily involved in fertility research since its inception. Almost every year since 2013, wheat or corn trials have included a nitrogen curve with plain urea as a comparison to test other treatments. Yield response to nitrogen varies widely year to year even on the same field, mostly due to climatic factors such as rainfall, temperature, and length of season. As the studies are conducted, we have the opportunity to address the objectives of each individual trial and to continue learning about the nitrogen response we can expect to see on fields. Even though the data presented only applies to the fields immediately surrounding the CREC, it provides a real-world example of the variability of nitrogen response that any farmer may experience.

The tables presented show the yield and nitrogen rate at which the highest yield was achieved, as well as the starting soil nitrogen levels. As a reference, the table also displays the nitrogen rate and corresponding yield, at which nitrogen fertilizer had the highest return on investment (ROI). The ROI was calculated using the recent local prices of $0.4 per lb of N ($368/ton of urea), $3.57 per bushel of corn and $5.92 per bushel of wheat. Each row represents an individual trial. In some years there were multiple nitrogen fertility trials. Each one has its own entry.

Dryland corn (Table 1)
Under dryland conditions, the average nitrogen rate producing the highest yield was 110 lbs. However, the individual values vary greatly between trials and years and range from 0 to 200 lbs of N. The average of the nitrogen rates for each trial at which return on N investment was the highest was only 57 lbs. The lowest value was 0. This was the case for 5 out of 12 trials in which the most profitable scenario would have been to forego nitrogen application altogether. The highest most profitable nitrogen rate was 200 lbs of N in a trial in 2020.

Table 1. Dryland corn nitrogen yield response from 2013 to 2024.

		Highest Yield		Highest ROI		
Year	Spring Residual Soil N	N Rate	Yield	N Rate	Yield	Rainfall May 1 - Aug 31
	lb/a	lb/a	bu/a	lb/a	bu/a	inches
2013	57	143	105	61	96	6.82
2013	60	100	120	0	113	6.82
2014	52	79	114	0	99	9.26
2014	58	70	130	70	130	9.26
2015	54	150	137	0	131	12.74
2016	65	0	147	0	147	11.09
2017	22	50	147	50	147	9.15
2017	22	180	152	60	143	9.15
2020	14	142	104	120	102	8.46
2020	45	200	121	200	121	8.46
2021	56	100	73	0	70	5.87
2022	38	100	73	120	172	12.21
Average		110	118	57	123	--
Median		100	121	55	125	--
Minimum		0	73	0	70	--
Maximum		200	152	200	172	--

Irrigated corn (Table 2)
Under irrigation, the highest yield was achieved at 157 lbs N on average. The average nitrogen rate for highest return on nitrogen investment was at 107 lbs N. Unlike on dryland, there were no trial sites or years in which the highest yield was achieved with no nitrogen, neither was foregoing nitrogen the most profitable option. Both the high yields and the nitrogen rates to achieve them tended to be higher for irrigated corn than dryland corn. Notably, there was less variability in optimum nitrogen rates.

Table 2. Irrigated corn nitrogen yield response from 2013 to 2024.

		Highest Yield		Highest ROI	
Year	Spring Residual Soil N	N Rate	Yield	N Rate	Yield
	lb/a	lb/a	bu/a	lb/a	bu/a
2014	53	196	152	153	150
2014	53	146	160	124	159
2014	53	177	155	141	153
2015	47	180	163	180	163
2016	36	157	132	121	130
2020	44	80	169	80	169
2020	15	240	163	60	153
2020	58	129	177	83	175
2021	43	98	228	72	225
2022	14	160	195	160	195
Average		157	170	107	164
Median		159	163	123	161
Minimum		80	132	60	130
Maximum		240	228	180	225

Dryland wheat (Table 3)
Dryland wheat nitrogen response was more consistent than the response seen in dryland corn. Out of 15 trials only one had its highest yield associated with no nitrogen application. Furthermore, there were only three trials in which no nitrogen application would have been the most economic option. The average nitrogen rate at which yield was maximized was 91 lbs. The range for this value was 0 to 200 lbs of N. The average nitrogen rate at which profit was maximized was 47 lbs with a range of 0 to 105 lbs of N.

Unfertilized passes of wheat next to fertilized passes.

Table 3. Dryland wheat nitrogen yield response from 2013 to 2024.

		Highest Yield		Highest ROI		
Year	Spring Residual Soil N	N Rate	Yield	N Rate	Yield	Rainfall May 1 - Aug 31
	lb/a	lb/a	bu/a	lb/a	bu/a	inches
2013	71	60	44	0	41	6.82
2014	32	70	71	70	71	9.26
2015	35	105	50	105	50	12.74
2015	52	200	61	50	56	12.74
2016	23	50	33	50	33	11.09
2016	20	77	34	77	34	11.09
2016	26	102	34	5	30	11.09
2017	81	50	54	50	54	9.15
2017	14	0	59	0	59	9.15
2018	84	100	51	0	47	8.80
2018	17	136	55	16	49	8.80
2019	19	138	52	83	51	11.19
2020	18	60	33	60	33	8.46
2023	28	120	50	30	48	11.44
2024	15	90	42	90	42	16.02
Average		91	48	46	47	--
Median		90	50	50	48	--
Minimum		0	33	0	30	--
Maximum		200	71	105	71	--

Irrigated wheat (Table 4)
Under irrigation there was no trial in which yield was maximized without nitrogen application and there was only one trial in which foregoing nitrogen would have been the most economic option. The average nitrogen rate at which yield was maximized was 119 lbs with a range of 70 to 200 lbs of N. The average of the most economic nitrogen rate was 75 lbs with a range of 0 to 120 lbs. The differences between dryland and irrigated wheat nitrogen response were less noticeable than in a similar comparison in corn. Maximum yield was 71 bushels in both dryland and irrigated wheat. However, irrigation produced good yields more consistently.

Table 4. Irrigated wheat nitrogen yield response from 2013 to 2024.

		Highest Yield		Highest ROI	
Year	Spring Residual Soil N	N Rate	Yield	N Rate	Yield
	lb/a	lb/a	bu/a	lb/a	bu/a
2014	35	70	72	70	72
2014	35	100	71	90	71
2015	35	100	51	100	51
2015	81	140	61	70	57
2018	84	150	46	0	44
2018	76	200	68	80	67
2019	35	120	56	90	54
2019	35	120	56	120	56
2020	13	80	57	80	57
2020	13	150	59	50	57
2020	13	80	71	80	71
Average		119	61	75	60
Median		120	59	80	57
Minimum		70	46	0	44
Maximum		200	72	120	72

Discussion

Spring residual nitrate levels in the top two feet of soil for all the trials ranged from 14 to 84 pounds (Tables 1 through 4). Residual nitrogen seems to have had no predictive value on nitrogen response in any of the scenarios. At our site, which has a loam soil and an average annual precipitation of 18.79 inches, the availability of moisture likely affected the profitability of nitrogen application as evidenced by the fact that under irrigation some amount of nitrogen application was necessary to maximize profit in almost every case, but the same was not true for dryland. This could be due to the fact that under dryland, yield potential was limited by the availability of moisture. Rainfall amounts had some correlation with highest yields in dryland corn (Figure 1) and with economic N rates in dryland wheat (Figure 2). Still, the fact that these correlations are not stronger and more consistent, suggest that the timeliness of the rainfall was a major factor determining yield and nitrogen response. Irrigation likely had a stronger impact because of the consistency with which water was supplied throughout the season.