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Update on Starter Fertilizer Research in Corn

Applying a small amount of fertilizer near the corn seed while planting is a common practice. There are questions, however, about the need for starter fertilizers when soils have high nutrient concentrations, particularly with the application of phosphorus (P) in the starter. There has been a lot of research done with starter fertilizers in corn. However, there has been little work done in Delaware since the early 1980s and there has been little work done on soils that are considered excessive in soil test P. University recommendations typically suggest that starter fertilizer responses can be obtained with the application of fertilizers containing only nitrogen (N) if soil test P levels are very high or excessive. However, many corn growers who use starter fertilizer will typically apply both N and P regardless of the soil test P concentration. This report is a summary of the results of numerous starter fertilizer strip plots that have been conducted in cooperation with corn growers during the past several years, and it will also summarize several small-plot studies that evaluated the impact of various fertilizer scenarios on corn yield.

Strip Plots

We initiated strip trials during the 2000, 2001, and 2002 growing seasons to determine the magnitude and frequency of grain yield responses to the application of starter fertilizer in corn (Table 1). These strip trials were done in cooperation with corn growers throughout Delaware and consisted of replicated field-length strips comparing both with and without starter fertilizer. All management factors (e.g., planting date, hybrid, type and rate of starter, tillage, and irrigation) were determined by the corn grower. These strip trials were simply side-by-side comparisons of with and without starter fertilizer and had usually three to four replications at each site. A two-by-two placement of fertilizer, which means the fertilizer was placed two inches below and two inches to the side of the seed, was used at most sites. Pop-up fertilizer was used at three sites and refers to the placement of the fertilizer directly into the seed furrow. Three common pop-up fertilizers that are being used are Riser (registered trademark of Nortrace Ltd.), Germinator (registered trademark of Growmark FS, Inc.), and Natures (registered trademark of Natures Alpine Solutions). Harvest was done with the grower's combine and grain yields were determined by using either a weigh wagon or a yield monitor on the combine.

The cost of starter fertilizer in these trials typical ranged from about $8/acre to as much as $17/acre depending on the material that was used. The average cost of the fertilizer used in the strip trials was about $12/acre. This means that a grower would need a yield increase of slightly less than 5 bu/acre from the starter fertilizer to recover the cost of the fertilizer, assuming a price of $2.50/bu for corn grain. Therefore, our assumption in this discussion is that any response of 5 bu/acre or greater would be profitable.

In these strip trials we had 22 sites that had some combination of both N and P in the starter fertilizer (not including the pop-up sites), 18 of these 22 sites had a yield increase of 5 bu/ac or more and the average yield increase across these 22 sites was 8 bu/ac or about 5%. It is interesting to note that Bill Mitchell, a former Extension Specialist with the University of Delaware, reported an average yield increase of about 6 bu/acre from the starter fertilizer trials he conducted from 1970 through 1984; this 6 bu/acre increase in grain yield from starter was about a 5% increase. In these strip trials, we only had five sites that consisted of N without P in the

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fertilizer material. Of these five sites, only one of them had a yield increase greater than 5 bu/acre. We believe, however, that it would be inappropriate to make conclusions of N-only versus N and P combinations with such a small number of N-only trials. We had only two sites (25 and 28) that were only pop-up and one site (22) that had N applied in a 2x2 placement with pop-up (Riser) also applied in the seed furrow. The yield increase at site 22 was dramatic, but it is not possible to determine if this yield increase came from the N, the Riser, or a combination of both.

It is usually assumed that the probability of getting a response to starter fertilizer will decrease as the planting date becomes later in the spring and as soil test P level increases. From these strip trials during the past three years, it appears that there is little relationship between planting date or soil test P level and the frequency or magnitude of response to starter fertilizers containing P. Another typical assumption is that responses to starter fertilizer are not as likely when animal manures are applied. The yield responses from these strip trials during the past three years suggest that poultry litter applications had little impact on determining when a response to starter fertilizer would occur. One last assumption with the use of starter fertilizer is that responses are less likely in conventionally-tilled fields as compared to no-till fields. There are not enough no-till fields in this data set to make any conclusions about the impact of tillage on starter fertilizer responses.

Small Plots: 2001

In 2001, we initiated small-plot research trials at three locations in Sussex County (Table 2). These plots were planted with a four-row (30-inch) research planter that was able to apply dry fertilizer in a two-by-two placement or liquid fertilizer in a two-by-two placement, in the seed furrow (i.e., pop-up fertilizer), or on the soil surface behind the press wheels of the planter. We evaluated 19 different fertilizer treatments and each treatment was replicated six times at each site (Table 3). The individual plots at each site were four rows wide and 50 feet in length. Yields were determined by harvesting 30 feet of the center two rows of each plot with a small-plot combine. Site 1 had a previous crop of corn, was planted on April 20th into ideal soil conditions, and was irrigated as needed throughout the season. Site 2 had a previous crop of soybeans, was planted on May 4th into extremely dry soil conditions, and was not irrigated throughout the growing season. Site 3 had a previous crop of corn and was planted on May 8th into dry soil conditions; this site had irrigation during the season, however, the irrigation system was not used to help with stand establishment. The hybrid planted at each site was Pioneer 33A14 and all three sites used conventional tillage. Nitrogen fertilizer was applied at all three locations at rates considered to be optimum for grain yield production; this N fertilizer was dribbled in a surface band when the corn was about 8 to 12 inches tall. With the exception of extremely dry conditions in May, the 2001 growing season was ideal for growing corn. In fact, the Delaware state average corn yield was the greatest on record. This dry weather in May, however, did impact stand establishment at Site 2 and this variable stand establishment likely resulted in some of the yield variability observed at this site that was unrelated to the applied fertilizer treatments. It is important to note that some of these treatments included pop-up fertilizer at rates much greater than would be recommended because of potential salt damage to the seedlings. The highest rates of pop-up fertilizer did cause significant injury to seedling development and resulted in reduced stand establishment at Site 2. At Sites 1 and 3 there was visual damage to the roots of the seedlings at these high pop-up rates, however, the seedlings survived due to ideal weather conditions.

Small Plots: 2002

In 2002 we established small plot studies at five locations throughout Sussex County (Table 4). These plots were planted with the same planter used for the 2001 studies; however, the actual

treatments applied were different from the 2001 studies (Table 5). There were six replications of each treatment at all sites except Site 5, which had only four replications. Individual plots were four rows wide and the length of each plot varied among the sites but ranged from 110 to 180 feet depending on the distance between the irrigation wheels. Yields were determined by harvesting 85 feet of the center two rows of each plot with a small-plot combine. Site 4 was no-tilled, while the other four sites were conventionally tilled. All five sites were planted to Pioneer 33B51. Site 1 had a previous crop of corn and was planted on May 15th. Site 2 had a previous crop of winter wheat/soybeans and was planted on May 8th. Site 3 had a previous crop of corn and was planted on May 9th. Site 4 had a previous crop of winter wheat/soybean and was planted on April 23rd. Site 5 had a previous crop of corn and was planted on May 10th. Nitrogen fertilizer was applied at all five sites at rates considered to be optimum for grain yield production; this N fertilizer was dribbled in a surface band when the corn was about 8 to 12 inches tall. All five sites had excellent stand establishment and were irrigated throughout the growing season. The 2002 growing season started off with a rather wet planting season and unusually cool temperatures during April and May. After the cool and wet spring, the remainder of the growing season was hot and extremely dry. In fact, the 2002 growing season was the driest year on record in Sussex County.

Because of the frequency of responses observed from the strip-plot trials, the goal of these small plot studies was to determine if the often-observed starter fertilizer responses are occurring due to N, P, or a combination of nutrients. An additional goal of these small-plot studies was to determine if starter fertilizer responses could be obtained or improved by placing less total nutrient closer to the developing seedling (i.e., pop-up fertilizer). Unfortunately, at each of the eight small plot studies there was no statistically significant difference in grain yields from the application of the fertilizer treatments. In fact, there were no noticeable trends among treatments. The data in the right column of Table 5 show the average percentage yield across all five sites. This overall average yield (i.e., right column of Table 5) was calculated by representing treatment yields within each site as a percentage of the control (i.e., no starter fertilizer) treatment yield within each site. This overall average percent yield shows that there was no response to starter fertilizer across these five sites.

Final Comments

The results of these starter fertilizer trials are similar to those Bill Mitchell found in his early reported work from Delaware; starter fertilizer often results in profitable yield increases in corn. These data suggest that corn growers could jeopardize significant yield increases in some situations if starter fertilizer is taken out of their fertilizer program. Unfortunately, these results do not allow a determination of which nutrients are causing the fertilizer response, and they also do not allow a determination of the value of using a pop-up fertilizer. It is our plan to continue this work for at least another year to address these questions.

Table 1. Summary of 30 strips plots with and without starter fertilizer*.

Site	Year	Grain Yield (bu/acre)		Yield Resp	P FIV	Starter Fertilizer**	Planting Date	Poultry Litter	Till	Irr
		without starter	with starter	bu/ac		-- lb/ac --		ton/ac		
1	2000	178	186	8	23	10-32-0	May 8	0	CT	yes
2	2000	174	181	7	177	21-73-0	May 1	0	NT	yes
3	2000	185	195	10	235	11-36-0	May 15	2.5	NT	yes
4	2000	180	197	17	214	23-15-0B	May 4	0	CT	yes
5	2000	161	166	5	68	23-15-0B	May 26	0	CT	no
6	2000	117	117	0	304	13-17-0S	May 3	3	CT	no
7	2000	155	164	9	41	12-40-0Zn	May 23	3	CT	yes
8	2000	125	135	10	232	10-32-0	May 10	0	NT	no
9	2000	177	191	14	112	18-36-18	May 15	3	CT	yes
10	2000	137	146	9	119	9-22-4SZn	May 15	5	CT	no
11	2001	148	151	3	115	30-0-0SZn	May 8	3	NT	yes
12	2001	125	126	1	56	54-0-0	May 2	0	CT	no
13	2001	152	147	-5	205	33-0-0	May 29	3	CT	yes
14	2001	154	153	-1	282	13-17-0S	April 4	3	NT	no
15	2001	106	113	7	56	40-48-0S	May 2	0	CT	no
16	2001	216	221	5	246	13-17-0S	April 18	0	CT	yes
17	2001	149	162	13	235	35-25-0	April 27	4	CT	no
18	2001	135	144	9	228	13-17-0S	April 26	3	NT	no
19	2001	108	121	13	138	14-45-14	May 31	0	NT	no
20	2002	218	223	5	207	11-28-0	April 9	0	CT	yes
21	2002	181	182	1	244	13-17-0S	April 15	3	CT	yes
22	2002	159	179	20	407	65-0-0 & 2 gal pop_up	April 24	0	CT	yes
23	2002	154	172	18	244	40-25-0S	April 18	3	CT	yes
24	2002	161	168	8	164	30-28-0	May 16	0	CT	yes
25	2002	195	201	6	324	3 gal p_up	May 21	4	CT	yes
26	2002	199	207	8	147	38-68-0Zn	April 17	0	CT	yes
27	2002	182	196	14	181	33-0-0	May 8	4	NT	yes
28	2002	185	187	2	401	2 gal p_up	May 6	4	CT	yes
29	2002	208	202	-6	137	25-17-17	April 13	0	CT	yes
30	2002	207	208	1	137	25-0-0	April 13	0	CT	yes

* Yield Resp = yield response to starter; P FIV = soil test P (FIV is equal to ppm of Mehlich 3P); Till = Tillage, where CT is conventional tillage and NT is No-Till; Irr = irrigation; poultry litter was applied in early spring.

** Fertilizer was applied in a two-by-two placement at all sites, except sites 25 (Riser) and 28 (Natures) where only a pop-up fertilizer was placed directly into the seed furrow and site 22 where N was added in a 2x2 placement and 2 gal/ac of pop-up was placed into the seed furrow. Some sites also had a small amount of other nutrients and are identified as follows: Zn=zinc, S=sulfur, B=boron.

Table 2. Soil characteristics for small plot studies in 2001.

Site	Soil Type	Soil pH	O.M.	P	K	Mn	Zn
			- % -	------- Mehlich 3 (ppm) -------			
1	Hammonton Loamy Sand	5.8	1.9	81	72	5.9	3.4
2	Fallsington Sandy Loam	5.3	1.9	244	90	14.7	2.0
3	Woodstown Sandy Loam	5.8	1.4	88	74	11.0	5.0

Site 1 was located at the Georgetown Research and Education Center, while Sites 2 & 3 were located in fields of local area corn growers. Soil samples were taken from the surface 8-inch layer of soil in the fall of 2001 following corn harvest.

Table 3. Grain yields for small plot starter studies in 2001.

Treatment / Placement	Rate		Site 1	Site 2	Site 3
			----- Grain Yield (bu/acre) -----		
Control	0		173	115	153
0-46-0 / 2x2	100	lb	167	115	170
0-46-0 / 2x2	180	lb	148	107	167
30-0-0 / 2x2	2	gal	176	117	168
8-0-0-9 / 2x2	8.1	gal	171	124	164
10-34-0 / 2x2	5.5	gal	161	103	160
30-0-0 / 2x2	4.1	gal	151	111	167
8-0-0-9 / 2x2	16.7	gal	157	112	172
10-34-0 / 2x2	11.4	gal	176	108	164
30-0-0 / 2x2	7.4	gal	162	118	158
10-34-0 / 2x2	20.5	gal	183	122	156
8-0-0-9 / 2x2	30.2	gal	175	115	150
30-0-0 / pop-up	2	gal	154	118	160
8-0-0-9 / pop-up	8.1	gal	167	110	167
10-34-0 / pop-up	5.5	gal	158	111	161
30-0-0 / pop-up	4.1	gal	155	126	167
8-0-0-9 / pop-up	16.7	gal	171	108	166
10-34-0 / pop-up	11.4	gal	164	108	157
30-0-0 / pop-up	7.4	gal	173	109	174
C.V. (%)			10.0	12.1	9.4

NOTE: 8-0-0-9 is liquid ammonium sulfate.

Table 4. Soil characteristics for small plot studies in 2002.

Site	Soil Type	Soil pH	O.M.	P	K	Mn	Zn
			- % -	------- Mehlich 3 (ppm) -------			
1	Evesboro Loamy Sand	5.9	1.6	226	141	15	3.1
2	Rumford Loamy Sand	5.8	1.1	161	98	5	9.1
3	Woodstown Sandy Loam	5.5	2.1	237	267	21	6.3
4	Sassafras Sandy Loam	5.7	1.3	103	53	6	4.9
5	Woodstown Sandy Loam	5.9	1.4	77	64	9	3.7

Site 4 was located at the Georgetown Research and Education Center, while Sites 1, 2, 3, and 5 were located in fields of local area corn growers. Soil samples were taken from the surface 8-inch layer of soil in the spring just prior to planting.

Table 5. Grain yields for small plot starter studies in 2002.

Treatment	Trt #*	Site 1	Site 2	Site 3	Site 4	Site 5	Average**
		---------- Grain Yield (bu/acre) ----------					-- % --
No starter	1	142	227	194	188	198	100
3 gal Riser	2	134	224	193	176	202	98
3 gal Germinator	3	137	220	185	180	200	97
3 gal 10-34-0	4	132	229	185	175	188	95
3 gal 8-0-0-9	5	134	229	190	183	206	99
11.4 gal 10-34-0	6	143	227	187	181	194	98
4.1 gal 30-0-0	7	138	238	198	179	195	100
16.7 gal 8-0-0-9	8	142	227	197	180	199	100
100 lb 0-46-0	9	141	232	194	185	205	101
180 lb 7.5-25-7.5	10	141	238	194	176	201	100
11.4 gal 10-34-0	11	137	230	187	172	199	97
11.4 gal 10-34-0	12	146	221	195	179	202	100
21-0-0 +Riser	13	140	229	199	176	199	99
21-0-0 +8-0-0-9	14	139	231	192	179	196	99
C.V. (%)		7.3	3.9	5.1	6.4	4.4	--

* Trts 2-5 were all applied as pop-up; Trts 6-10 were applied as 2x2; Trt 11 was applied as 3 gal of 10-34-0 as pop-up and 8.4 gal of 10-34-0 as 2x2; Trt 12 was applied on the soil surface behind the press wheels of the planter; Trt 13 was applied as 64 lb of 21-0-0 as 2x2 and 3 gal of Riser as a pop-up; Trt 14 was applied as 64 lb of 21-0-0 as 2x2 and 18.5 gal of 8-0-0-9 on the soil surface behind the press wheels of the planter.

** This is the average treatment yield across all five sites calculated as a percentage of the control (i.e., no starter treatment; trt 1) within each location.

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