FFF Research

Fluid Fertilizer Foundation research work conducted from 1983-85 by university scientists shows justification for using starter fertilizers in conservation-till systems

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Studies Show Starters Work In Conservation-Till

Acceptance of conservation-till systems by corn growers has been hampered by erratic crop performance. Reduced yields and poor early-season plant growth have occurred more frequently in these systems than in conventional-tilled systems.[1, 2, 3, 4]

On some southeastern soils, root-restricting traffic or tillage pans may exacerbate poor crop growth and grain yields in conservation-till systems. In-row subsoiling at planting has increased grain yields where root-restricting hardpans exist.[5, 6, 7] Current no-till planters now have in-row subsoilers incorporated in their design.

Placing small amounts of soluble fertilizers in proximity to the seed at planting (i.e., starter fertilizer applications) has increased early-season plant growth and yields of cotton,[8] grain sorghum[9] and soybeans[10] in both tilled and no-till production systems. Various NPK combinations have been used in starter fertilizer studies, but a strict, definable starter fertilizer combination does not exist.

Starter fertilizers traditionally have been applied in shallow, incorporated bands close to the seed at planting (2 x 2 in placement). When in-row subsoilers are used at planting, however, the easiest placement of starter fertilizers (from a mechanistic standpoint) is directly behind the subsoil shanks in the channel below the seed. A possible drawback to placement of starter fertilizers in the subsoil channel is reduced plant response to starter applications if young plant roots haven't reached the zone of application early in the growing season.

Purposes of this three-year study were to:

1. Determine if starter fertilizers improve growth and yield of corn in conservation-till systems
2. Compare placement of starter fertilizer in the in-row subsoiler channel to traditional 2 x 2-inch placement
3. Determine if corn response to various starter combinations varies among tillage systems and subsoiling practices.

Variables

Treatment variables included: tillage systems (conventional- and conservation-till), starter fertilizer placement (deep in the subsoil channel or shallow incorporation near seed row), starter fertilizer combinations (N, NP, NPK or none), and in-row subsoiling (subsoiled or not subsoiled).

Soil. Studies were conducted in 1983, 1984 and 1985 on a Decatur silt loam at Belle Mina, Alabama, and on a Dothan sandy loam at Headland, Alabama, in 1984 and 1985. Both soils are deep and well-drained. The Dothan soil has a 1.5- to 3-inch tillage or traffic pan located approximately 10 inches below the surface.

At Belle Mina, the initial soil pH, organic matter and cation exchange capacity were 6.4, 1.4 percent and 11 meq/100 g, respectively. Soil test rating for P and K remained high or very high throughout the studies. In February of 1985, 20 pounds per acre of P and 40 pounds per acre of K were broadcast-applied to the experimental site at Belle Mina.

At Headland, the initial soil pH, organic matter and cation exchange capacity were 6.0, 1 percent and 4.8 meq/100 g, respectively. In November of 1984, 1 ton per acre of dolomitic limestone, 18 pounds per acre of P, 33 pounds per acre of K and 10 pounds per acre of S were broadcast-applied to the experimental site.

Tillage. One to two weeks prior to planting, conventional plots were tilled and rye in the no-till plots was killed with paraquat (0.5 lb/A). At Belle Mina, tillage consisted of disking and chisel plowing (8 inches deep), followed by working soil with a leveling disk. At Headland, the same procedure was followed except the final working was accomplished with a roterra.

Planting. A no-till planting unit with in-row subsoilers was used to plant all plots. Subsoilers were removed to plant non-subsoiled plots. Subsoiler depth was 8 and 12 inches at the Belle Mina and Headland locations, respectively.

At Belle Mina, Pioneer 3369A corn was planted May 2, 1983, April 13, 1984 and March 26, 1985. Seeding rate was 24,000 plants per acre and population was thinned to 20,000 plants per acre after stand establishment. Row width was 36 inches in 1983 and 30 inches in 1984 and 1985.

At Headland, Dekalb-Pfizer Genetics T-1230 corn was seeded at 32,000 plants per acre and thinned to 28,000 plants per acre. Row spacing at Headland was twin 7-inch rows on 36-inch centers.

Fertilizers. Starter fertilizer combinations were made from 32% UAN, 10-34-0 and 0-0-62 to supply 22 pounds per acre of N, 9.7 pounds per acre of P and 6.6 pounds per acre of K, where applicable.

Placement. For subsoil fertilizer treatment, starter fertilizers were dropped into the subsoil channel through a 0.5 inch diameter tube welded to the rear of the subsoiler shanks and mixed with the soil directly under the seed at a depth of 6-10 inches. For shallow-placed treatment, fertilizers were incorporated with a double disk (2 inches deep) in proximity to the seed.

At Belle Mina, shallow placement was 2 inches from the row while at Headland, where corn was planted in twin 7-inch rows, starter fertilizers were incorporated between the twin rows, resulting in a 3 x 2-inch placement.

Experimental design. At Belle Mina, the experimental design was a randomized complete block replicated four times. Within the no-till system, all combinations of starters and placements were included and compared to all starter combinations placed 2 x 2 in conventional-till, non-subsoiled plots. At this location, there is no well-defined tillage pan and conventional-till plots with 2 x 2 starter fertilizer placement would be considered standard practice.

At Headland, coarser-textured Dothan soil is subject to formation of a tillage pan and in-row subsoiling is a common practice on this soil. Consequently, treatments were expanded to include all starter combinations, subsoiling treatments and fertilizer placements in both conventional- and no-till systems. The experimental design was a split plot within a randomized complete block replicated four times. Tillage systems were whole-plot treatments. Starter combinations, subsoiling and starter placement variables were split-plot treatments. Plots were 12 x 40 feet, cotton was the previous crop and rye was grown as a winter cover crop.

Weed control. Weeds were effectively controlled each year with AAtrex (1.2 lb/A) plus Dual (1.2 lb/A) at Headland, and AAtrex (1 lb/A) and Lasso (1.5 lb/A) at Belle

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Table 1

Rainfall and irrigation distribution by location and year during growing season.

Date		Headland 1984	Headland 1985	Belle Mina 1983	Belle Mina 1984	Belle Mina 1985
		Inches				
March	15-21	1.09	1.02	1.29	2.56	0.06
	22-31	0.39	0.03	0.96	3.32	1.69
April	1-7	2.17	1.19	4.53	1.99	0.72
	8-14	1.28	0.0	1.75	0.23	0.03
	15-21	1.29	0.56	0.70	0.36	1.06
	22-30	1.46	0.02	1.31	4.01	1.26
May	1-7	2.24*	0.14	0.87	4.04	3.86
	8-14	1.0 *	2.95	0.51	2.92	1.70
	15-21	1.76*	1.07*	6.97	0.01	0.06
	22-31	1.55	2.05*	1.83	0.81	0.55
June	1-7	1.0	1.00*	2.51	0.0	0.0
	8-14	3.14*	2.35*	0.01	1.83	0.17
	15-21	0.20	0.99	3.18	0.59	1.96
	22-30	6.73*	1.43*	0.65	3.10	1.01
July	1-7	0.64	2.53	0.50	0.04	0.84
	8-14	0.85	1.47	0.01	1.39	0.94
	15-21	0.80	0.88	0.06	1.04	0.55
	22-31	2.08	0.72	0.0	1.75	3.55
August	1-7	2.96	0.0	0.18	1.19	0.32
	8-15	0.09	2.02	0.13	0.04	0.90

*Irrigation applications (1-2 inches) supplemented rainfall.

Mina.

Application rate. At Belle Mina, 32% UAN was dribble-banded beside the row four weeks after planting to deliver 120 pounds per acre of N in 1983 and 130 pounds per acre of N in 1984 and 1985.

At Headland, 200 pounds per acre of N as 32% UAN, 20 pounds per acre of S, 4.5 pounds per acre of Zn and 2 pounds per acre of B were dribble-banded beside the row four weeks after planting in 1984. In 1985, 180 pounds per acre of N and 10 pounds per acre of S were sidedressed four weeks after planting in a similar manner.

Water. Corn at Headland was irrigated an average of six inches in 1984 and 1985 during an eight-week period starting approximately four weeks before silking. At Belle Mina, corn was not irrigated.

Rainfall and supplemental irrigation distribution throughout the growing season are shown in Table 1.

Plot management. Plant heights were measured (top of whorl) and whole plant samples were taken for nutrient analyses six weeks after planting at both locations in 1984 and 1985. Earleaf samples were analyzed for nutrient concentrations in all years. The inner 30 feet of the two middle rows of each plot were hand-harvested and grain yields were adjusted to 15.5 percent moisture. Data were analyzed using analysis of variance for the appropriate model at each location. The 10 percent level of probability was used to declare significant differences.

The balance of this article will report results from the above three-year studies set up at the test sites in Belle Mina and Headland.

Belle Mina

Plant heights increased an average of 33 percent in 1984 and 39 percent in 1985 (Table 2) when averaged over tillage systems, starter combinations and placements. With the exception of the NP combination in conventional-tilled plots in 1985, N alone was as effective in increasing plant height as NP and NPK. In 1985, there were no differences in plant height caused by placement, but in 1984 deep-placed N was inferior to 2 x 2-placed N. In both years, NP and NPK combinations were equally effective when placed either 2 x 2 or in the subsoil channel. Subsoiling without application of starter fertilizer had little effect on plant heights in 1984 and 1985.

Nutrient concentrations. Average nutrient concentrations in whole-plant and earleaf tissue are given in Table 3. The only nutrients affected in whole-plant samples six weeks after planting were N in 1984 and N and P in 1985. The primary effect was a dilution effect in which plants responding best to treatments had lower concentrations of these elements. However, in 1985, P averaged 0.43 vs. 0.37 percent in tilled and no-till plots, respectively. The only earleaf nutrient affected by treatments was manganese in 1984. Generally manganese was lower in conventional-till plots than in no-till plots (78 vs. 88 ppm).

Grain yields in 1983 were limited by severe drought in July (Table 1), but yield responses to starter fertilizers occurred (Table 2). Primary response was to NPK in the conventional-till system and NP and NPK combinations in the no-till system. Within the no-till system, yields from NP applications were equivalent to those from NPK applications (57 bu/A and 59 bu/A, respectively). Starter placement and tillage system did not affect yields.

In 1984, starter fertilizers did not affect yields in conventional-till plots (Table 2). Within no-till plots, there was a trend for starter fertilizers to increase yields. The trend was similar for all starter combinations and placement methods.

Primary yield response was to tillage and subsoiling. However, within no-till plots, starter fertilizer applications could, in part, substitute for subsoiling in increasing yields.

In no-till plots without subsoiling, yields were 125, 136, 140 and 140 bushels per acre for zero, N, NP and NPK starter treatments, respectively, compared to 158 bushels per acre in subsoiled, no-till plots where no starter was used (Table 2). Subsoiling no-till plots did not result in yield increases over conventional-till non-subsoiled plots unless starter fertilizers were applied.

In 1985, the beneficial effects of starter fertilizers on early-season plant growth did not result in increased grain yields (Table 2). Within no-till subsoiled plots, NP and NPK starter combinations applied in the subsoil channel reduced grain yields an average of 16 bushels per acre, compared to subsoiled plots where starters were not applied.

Table 2

Effect of tillage system, starter fertilizer combination and placement, and in-row subsoiling on early season growth and corn grain yield at Belle Mina, AL.

Tillage	Starter Fertilizer[1] Combination	In-Row Subsoiling	Starter Fertilizer[2] Placement	Plant Height[3] 1984	Plant Height[3] 1985	Grain Yield 1983	Grain Yield 1984	Grain Yield 1985
				—inches—		—bu/A—		
Conventional	None	No	---	11	17	50	153	104
Conventional	N	No	2x2	17	23	48	152	92
Conventional	N-P	No	2x2	16	33	51	150	94
Conventional	N-P-K	No	2x2	15	23	59	153	94
No-till	None	Yes	---	14	17	51	158	97
No-till	None	No	---	13	15	51	125	104
No-till	N	Yes	deep	15	20	55	169	99
No-till	N	Yes	2x2	17	20	56	165	100
No-till	N	No	2x2	19	22	54	136	91
No-till	N-P	Yes	deep	17	22	58	167	83
No-till	N-P	Yes	2x2	17	22	56	168	87
No-till	N-P	No	2x2	17	22	57	140	91
No-till	N-P-K	Yes	deep	16	21	56	172	80
No-till	N-P-K	Yes	2x2	17	22	60	171	87
No-till	N-P-K	No	2x2	17	22	61	140	93
LSD (0.10) any two values				1.9	2.0	6.6	14.0	12.0

[1] N = 22 lb/A, P = 9.7 lb/A, K = 6.6 lb/A.
[2] Deep placement was in subsoil track.
[3] Height to top of whorl 6 weeks after planting.

Drought resistance. It is possible that larger plants resulting from application of starter fertilizers at the non-irrigated Belle Mina site caused silking earlier (at a time coinciding with an 18-day drought) or were more sensitive to short-term droughts than plants not fertilized with starters. Rainfall records indicate that plants silking before June 15 would be subject to drought stress, while those silking after June 15 would not be. This period coincides with the observed period for silking in this year.

Table 3

Average nutrient concentrations in early-season corn whole plant tissue and earleaf at silking by location and year.

	Belle Mina				Headland			
	Whole plant		Earleaf		Whole plant		Earleaf	
Nutrient	1984	1985	1984	1985	1984	1985	1984	1985
	%							
N	2.94	4.70	3.20	4.70	2.38	2.80	2.82	3.30
P	0.54	0.38	0.34	0.38	0.40	0.35	0.32	0.30
K	5.51	3.03	2.01	3.03	3.02	2.72	1.72	1.91
Ca	0.71	0.53	0.57	0.53	0.68	0.65	0.76	0.75
Mg	0.27	0.21	0.12	0.21	0.28	0.29	0.23	0.24
	ppm							
Zn	63	51	32	49	50	62	50	48
Mn	170	170	85	92	104	110	100	126
Cu	15	14	16	23	17	15	19	37
B	50	15	18	51	49	35	25	28

Headland

Plant heights. In 1984, subsoiling increased early-season plant heights in both tillage systems only when fertilizers were applied (Table 4). With the exception of reduced plant heights in the no-till NP starter treatment (3 x 2-placed), tillage systems did not affect plant heights.

In 1985, subsoiling increased early-season plant growth in the no-till system. Within the conventional-till system, early-season plant growth responded to deep-placed NP and NPK starter combinations in 1984 and 1985.

In the no-till system, the only deep-placed starter combination that increased plant heights was NPK. This response occurred both years. The 3 x 2 placement proved the best method for applying starter fertilizer in both tillage systems in both years. Maximum plant height was generally obtained by in-row subsoiling and applying starter fertilizers in 3 x 2 placement.

Within the conventional-till system, application of N alone generally resulted in plant heights equivalent to those resulting from NP or NPK applications. In 1985, however, deep-placed NP and NPK increased plant heights over deep-placed N in the conventional-till system.

In 1984, NP or NPK combinations in no-till, subsoiled plots resulted in greater plant heights than N applied alone in 3 x 2 placement. In 1985, the NP combination in no-till plots resulted in increased plant heights compared to N alone when in-row subsoiling was used. However, the NPK combination was no better than NP.

Nutrient concentrations in the whole plant and earleaf tissue are listed in Table 3. Concentrations of N, P, K, Ca, Mg and Mn in whole plants sampled six weeks after planting were affected by treatments. However, as at Belle Mina, the primary effect was a dilution effect in which plants responding best to treatments (3 x 2-placed starters with in-row subsoiling) had lower concentrations of these elements. Slight treatment differences in earleaf K, Ca and Mg concentrations occurred in 1984 and again in 1985 for Mg and Mn, but there were no discernible relationships in either year between treatment effects on the concentrations of these elements and yield.

Grain yields. Because grain yields did not vary between tillage systems in both 1984 and 1985, yields were averaged over both tillage systems for presentation in Table 4.

In 1984, lack of rainfall, during the two-week period coinciding with silking, amplified subsoiling treatment effects on grain yield despite supplemental irrigation (Table 4). Yield increases due to subsoiling generally occur when drought periods are of short duration.[5,11] Moisture stress at silking can reduce grain yield by 50 percent.[12]

Averaged over tillage systems and starter fertilizer treatments, in-row subsoiling increased grain yields 116 percent. In non-subsoiled treatments, yields were increased an average of 37 percent by application of starter fertilizers.

NP or NPK combinations did not increase yields more than applications of N alone in the non-subsoiled treatments.

Grain yields of in-row subsoiled plots were also increased by the use of starter fertilizers. However, N alone increased yields only when applied in a 3 x 2 placement. The NP and NPK combinations increased yields when applied in the subsoil channel or in a 3 x 2 placement. The 3 x 2 placement, regardless of starter combination, resulted in higher yields.

In 1985, the only yield response was to in-row subsoiling. Yields averaged 176 bushels per acre with and 147 bushels per acre without subsoiling.

Conclusions

Starter fertilizers increased early-season plant growth in both conventional- and no-till corn production systems. Crop response to starter applications and placement methods was dependent on tillage system, climatic conditions and soil conditions.

Response of early-season crop growth to starter fertilizer applications may be greater in conservation-till systems.

On coarse-textured Dothan soil, with a root-restricting hardpan, maximum response was obtained when both N and P were applied in a 3 x 2 placement in conjunction with in-row subsoiling. On the finer-textured Decatur soil, the best growth generally was obtained with NP starter applications, although N seemed more essential. Neither starter placement nor subsoiling proved critical on this soil.

Early-season plant growth was

Table 4

Effect of tillage system, starter fertilizer combination and placement and in-row subsoiling on early season growth and corn grain yield at Headland, AL.

Starter Fertilizer[1] Combination	In-Row Subsoiling	Starter Fertilizer[2] Placement	Plant Height[3] 1984 Conventional	1984 No-Till	1985 Conventional	1985 No-Till	Grain Yield[4] 1984	Grain Yield[4] 1985
			inches				bu/A	
None	Yes	---	18	17	20	18	109	174
None	No	---	19	15	18	15	40	147
N	Yes	deep	21	19	20	19	114	173
N	Yes	3x2	26	22	26	25	128	178
N	No	3x2	20	18	24	21	51	147
N-P	Yes	deep	24	20	24	19	124	174
N-P	Yes	3x2	29	29	26	28	141	176
N-P	No	3x2	28	17	26	23	57	152
N-P-K	Yes	deep	22	24	23	21	125	178
N-P-K	Yes	3x2	28	27	26	26	137	178
N-P-K	No	3x2	22	20	23	23	56	140
LSD (0.10) within tillage			3.9		2.6			
LSD (0.10) any two values			4.3		2.9		10.0	12.0

[1] N = 22 lb/A, P = 9.7 lb/A, K = 6.6 lb/A
[2] Deep placement was in the in-row subsoil track
[3] Height to top of whorl 6 weeks after planting
[4] Grain yields are average over tillage systems

not always indicative of good grain yields.

On Dothan soil, yield responses to starter applications, placement and subsoiling were similar to plant growth responses in a year of sufficient rainfall. When rainfall was more adequate, only subsoiling improved yields.

On Decatur soil, optimal yields were generally obtained with applications of N either in the subsoil channel or in a 2 x 2 placement. Response to subsoiling was erratic on this soil. Generally, subsoiling silt loam soils with no distinct tillage or hardpan does not result in yield increases.[13,14,15]

Our data indicate that yield increases from starter applications occur frequently enough to justify the practice and that N and P generally should be applied in a shallow, incorporated band (2 x 2 or 3 x 2-inch placement). On soils with root-restricting hardpans, subsoiling in conjunction with shallow incorporation of NP applications is necessary to achieve the maximum benefit of the starter application.

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