STARTER FERTILIZER APPLICATION RATES AND APPLICATION METHODS FOR CONVENTIONAL AND NO-TILLAGE COTTON IN TENNESSEE AND LOUISIANA

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INTRODUCTION

Banding starter fertilizers has increased cotton (Gossypium hirsutum L.) yields in some studies, but increases were influenced by year, tillage, N-P_2O_5-K_2O combination in the starter, and placement methods (Touchton et al., 1986; Funderburg, 1988; Howard and Hoskinson, 1990). Touchton et al. (1986) reported starter applications increased no-tillage (NT) cotton yields 2 out of 3 years and conventional tillage (CT) yields in 1 out of 3 years in north Alabama. When cotton was subjected to moisture stress during flowering and fruiting, yields were increased by banding 23-23-8 lb/a of N, P_2O_5, and K_2O, respectively, but were not increased by banding either 23-0-0 or 23-23-0 lb/A. Funderburg (1988) reported a 93 lb/A average lint yield increase from 17 of 18 locations over a 3-year period from banding 150 lb/A of either 10-34-0 or 11-37-0 (N, P_2O_5, and K_2O) solutions to CT cotton in Mississippi. The band was 3 to 4 inches wide and was applied as a surface band (SB) directly over the row and behind the planter press wheel. Banding N plus P_2O_5 increased yields at two locations relative to banding N alone. Howard and Hoskinson (1990) reported that 2x2 banding of 15-15-0 lb/A of N and P_2O_5 produced higher NT cotton yields when compared with starters containing higher P_2O_5 rates. They also reported that starters did not affect yields in a year when spring weather conditions were hot and dry.

Information on cotton response to starter fertilizer, as affected by placement, nutrient composition, and tillage, is limited. This research was initiated to evaluate methods and rates of applying 11-37-0 for CT and NT cotton production on the loess soils in Tennessee and Louisiana.

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METHODS AND MATERIALS

Field experiments evaluating rates and methods of applying 11-37-0 in CT and NT systems were initiated in 1991 at the Milan Experiment Station in Milan, TN on a Loring silt loam (Typic Fragiudalf) and at the Macon Ridge Branch Research Station in Winnsboro, LA on a Gigger silt loam (Typic Fragiudalf). Soil extractable P and K levels were both high on the Loring soil, while the P level was high and the K level was low on the Gigger soil. The Loring soil starter application methods included 1) in-furrow (IF) spraying of 1157-0 directly into the seed furrow, 2) banding 11-37-0 2 inches to the side and 2 inches below the planted seed (2x2), and 3) applying 11-37-0 in a 2- to 4-inch wide surface band over the row behind the planter (SB). Rates of 11-37-0 applied IF were 1.5, 3.0, and 4.5 gal/A diluted with water and applied at a constant pressure. The 2x2 and SB treatments were applied at 7.5 gal/A of undiluted 11-37-0. Starter fertilizer treatments were supplemented with broadcast applications of ammonium nitrate, triple super phosphate, and potassium chloride to provide the total fertilizer rates presented in Table 1. In addition, two broadcast (no starter) treatments were included for comparison. One broadcast fertilization treatment did not include phosphorus (P) in the fertilizer application while the other received a broadcast rate of 40 lb/A P_2O_5,

Separate CT and NT tests were located in adjacent areas on each soil. The experimental design was a randomized complete block for each tillage system at both locations. Treatments were replicated five times on the Loring soil and six times on the Gigger soil. Individual plots were 13.3 ft wide (four rows) and 30 ft long on the Loring soil and 50 ft long on the Gigger soil. The cultivar 'Deltapine 20' was planted by mid-May in 1991 and 'Deltapine 50' was planted by mid-May on the Loring soil in 1992. 'Deltapine 50' was planted both years by late-April on the Gigger soil. Recommended rates of fungicides and insecticides were applied IF at planting at both locations. A winter

Table **1.** Fertilizer rates and application methods.

Treatment	Rate of 11-37-0	Application methods Broadcast	Starter	Total
	-gal/A-	lb/A N-P_2O_5-K_2O		
No Starter	**0**	**80- 0-60**	-------	**80-0-60**
No Starter	**0**	**8040-60**	----	**80-40-60**
In-furrow'	**1.5**	**78-33-60**	**2-7-0**	**80-40-60**
In-furrow	**3.0**	**76-27-60**	**4-13-0**	**80-40-60**
In-furrow	4.5	**74-20-60**	**6-20-0**	**80-40-60**
2x2 band'	**7.5**	**70- 7-60**	**10-33-0**	**80-40-60**
Surface band[3]	**7.5**	**70- 7-60**	**10-33-0**	**80-40-60**

[1] Materials applied in direct contact with seed.
[2] Fertilizer applied 2 inches to the side and 2 inches below planted seed.
[3] Fertilizers applied in a 4-inch wide surface band over the row behind the planter.

wheat cover crop was fall planted on the Gigger soil. Roundup was applied prior to planting the NT sites at both locations to kill existing vegetation. Recommended herbicides and application rates were used at both locations for weed control.

Yield measurements were obtained by harvesting the two middle rows of each plot with a mechanical spindle picker. At Milan, sub-samples from each replicated treatment were combined following harvest for ginning to determine gin turnout. At Winnsboro, a given length of row was hand harvested from each plot and ginned on a 20-saw laboratory gin to determine lint percentage. Yields and other plant measurements were statistically analyzed using standard analysis of variance procedures (SASInstitute, 1988). The least square means procedure was utilized to separate means that were determined to be significant at the **0.05** probability level.

Means for the individual treatments by soil and year were utilized to calculate relative yield, relative plant heights, and relative leaf surface area to be utilized in a regression analysis of early plant measurements with yield. An additional analysis of variance was conducted evaluating treatment effects across soils and years. Treatment means for each individual treatment of a tillage system were utilized as a replication of the treatment. The data were analyzed as a split plot; with location, the main plot and tillage, the sub-plots.

RESULTS

Starter effectson early plant growth measurements and yields were inconsistent with year and location. Therefore, the data will be presented by year and location.

Loring soil, 1991:

Starter fertilizers did not affect early CT plant stand or height, but yields were affected by the starter applications (Table 2). Applying 4.5 gal/A of 11-37-0 IF increased yields when compared with either broadcasting 80-40-60 or applying 1.5 and 3.0 gal/A IF. Broadcasting 80-40-60 resulted in lower yields when compared with yields of other treatments, except banding 1.5 and 3.0 gal/A IF.

Table 2. Effect of starter fertilizer treatments on plants/ft row, plant height, and yield of conventional-tilled cotton on a Loring silt loam at Milan during 1991.

Treatment	Rate of 11-37-0	Plants /Ft.[1]	Plant Height[2]	Lint Yield	First Harvest
	-gal/A-		--in.-	-lb/A-	---%--
No Starter'	**0**	**2.9**	**20.6**	**1249**	**66**
No Starter'	**0**	**3.1**	**20.1**	**1074**	**64**
In-furrow	**1.5**	**3.1**	**203**	**1176**	**66**
In-furrow	**3.0**	**3.1**	**21.4**	**1142**	**73**
In-furrow	**4.5**	**3 2**	**20.1**	**1388**	**63**
2x2 band	**7.5**	**3 3**	**213**	**1288**	**70**
Surface band	**7.5**	**3.0**	**21.0**	**1311**	**68**
L.S.D. (0.05)		NS	**NS**	**150**	

[1] Evaluated June **25.**
[2] Evaluated June **28.**
[3] 80-0-60 Ib/A N-P_2O_5-K_2O broadcast.
[4] 80-40-60 Ib/A N-P_2O_5-K_2O broadcast.

Surface banding the starter reduced NT plant stand but starters did not affect plant height or yield (Table 3). Yields were relatively high for both tillage systems, averaging approximately 2.5 bales/A.

Table 3. Effect of starter fertilizer treatments on plants/ft row, plant height, and yield of no-tilled cotton on a Loring silt loam at Milan during 1991.

Treatment	Rate of 11-37-0	Plants /ft.[1]	Plant height[2]	Lint yield	First harvest,
	-gal/A-		--in--	-lb/A-	---%---
No Starter'	0	2.7	28.3	1199	88
No Starter'	0	3.1	28.5	1239	88
In-furrow	1.5	2.1	24.8	1241	87
In-furrow	3.0	2.6	27.9	1261	88
In-furrow	4.5	2.5	26.0	1213	85
2x2 band	7.5	2.6	27.4	1174	86
Surface band	7.5	2.0	26.1	1185	88
L.S.D. (0.05)		0.7	NS	NS	

[1] Evaluated June 25.
[2] Evaluated June 28.
[3] 80-0-60 lb/A N-P_2O_5-K_2O broadcast.
[4] 8040-60 lb/A N-P_2O_5-K_2O broadcast.

Gigger soil, 1991:

Starter fertilizers applied as a 2x2 band generally increased the early CT plant growth measurements of stand, plant height, and plant leaf surface area compared with other treatments (Table 4). Applying starters IF reduced stands when compared with other treatments. The 2x2 banded treatment significantly increased plant height compared with 4.5 gal/A applied IF and broadcasting only N and K_2O. Maturity of the IF starter treatments was delayed significantly compared with the 2x2 and SB treatments. Lint yields were unaffected by starter fertilizer applications regardless of application method.

Starters applied at 1.5 gal/A IF or as a 2x2 band increased NT plant stands when compared with broadcast fertilization (Table 5). Plant height was unaffected by treatment. Leaf surface area was greater for 2x2 banding than other treatments. No-tillage yields were higher for the SB than for other treatments, except for the 2x2 banding. Maturity of NT cotton was not affected by treatments.

Loring soil, 1992:

Starters increased early CT plant measurements and yields (Table 6). Applying starters IF reduced plant stand when compared with other treatments. Banding 2x2 increased plant height more than IF and SB applications. In-furrow applications had lower leaf surface areas than with the 2x2 application method. Starters applied 2x2 resulted in higher yields than either starter applied IF or the broadcast treatments. Surface banding tended to increase yields, but the increase was significant only when compared with applying 3.0 gal/A IF.

Starter applications affected NT plant stand and height and yield (Table 7). Compared with other treatments, all IF treatments reduced stands. Stand differences due to applying other starter treatments were not observed. Plant heights were greater for 2x2 banding than applying either 3.0 or 45 gal/A IF. Leaf surface area was unaffected by treatment. Banding either 3.0 or 4.5 gal/A reduced yields more than other starter or broadcast treatments did, probably as a result of stand reduction.

Yields were relatively high for both tillage systems, averaging approximately 25 bales/A.

Gigger soil, 1992:

Plant stands of CT cotton were reduced by all starter treatments compared with broadcast treatments (Table 8). The greatest stand reduction was observed with 4.5 gal/A applied IF. No significant differences in plant height, leaf area, or maturity were noted among treatments.

Applying starters IF reduced NT stands when compared with either 2x2 or SB application methods (Table 9). The 45 gal/A IF treatment caused the greatest stand reduction. Starters did not affect plant height, leaf area, yield, or maturity.

Yields were slightly lower than the previous year for both tillage systems, averaging approximately 1.5 bales/A.

Table 4. Effect of starter fertilizer treatments on plants/ft of row, plant height, leaf surface area, and yield of conventional-tilled cotton on a Gigger silt loam at Winnsboro during 1991.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height'	Leaf area/ plant'	Lint yield	First harvest
	-gal/A-		--in--	-cm²-	-Ib/A-	---%---
No Starter[2]	0	2.4	6 5	219	1006	*84*
No Starter'	0	2.4	7 3	261	973	*84*
In-furrow	1.5	2.0	7 2	289	980	*82*
In-furrow	3.0	1.9	6.4	252	1024	*83*
In-furrow	4 5	1.7	6.8	300	944	*82*
2x2 band	7 5	2.9	8.6	403	1024	*86*
Surface band	7 5	2.6	7.7	304	1000	86
L.S.D. (0.05)		0.4	1.4	104	NS	2.7

[1] Evaluated June 3.
[2] 80-0-60 lb/A N-P_2O_5-K_2O broadcast.
[3] 80-40-60 lb/A N-P_2O_5-K_2O broadcast.

Table 5. Effect of starter fertilizer treatments on plants/ft of row, plant height, leaf surface area, and yield of no-tilled cotton on a Gigger silt loam at Winnsboro during 1991.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height'	Leaf area/ plant'	Lint yield	First harvest
	-gal/A-		...in...	--cm²--	-Ib/A-	---%--
No Starte?	0	2.3	5.1	106	1019	*88*
No Starter'	0	2..4	5.2	105	1080	*88*
In-furrow	1.5	2.7	4.6	93	1064	*88*
In-furrow	3.0	2..4	4.5	97	1085	*88*
In-furrow	4.5	2.3	4.8	107	1070	*86*
2x2 band	7.5	2.8	5.5	150	1100	*88*
Surface band	7.5	2.3	5.3	111	1166	87
L.S.D. (0.05)		0 3	NS	27	74	NS

[1] Evaluated May 24.
[2] 80- 0-60 Ib/A N-P_2O_5-K_2O broadcast.
[3] 80-40-60 Ib/A N-P_2O_5-K_2O broadcast.

Table 6. Effect of starter fertilizer treatments on plants/ft row, plant height, leaf surface area, and yield of conventional-tilled cotton on a Loring silt loam at Milan during 1992.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height[1]	Leaf area/ plant[2]	Lint yield	First harvest
	-gal/A-		--in--	--cm²--	-lb/A-	---%---
No Starter[1]	0	3.4	4 2	107	1256	58
No Starter[1]	0	3.6	4.1	108	1306	65
In-furrow	1 5	2.7	3 8	91	1293	56
In-furrow	3.0	2.0	3.6	84	1182	55
In-furrow	4 5	2 2	4.0	90	1248	60
2x2 band	7 5	3.8	4 5	123	1423	61
Surface band	7.5	3.5	3.9	104	1354	59
L.S.D. (0.05)		0.5	0.5	31	110	

[1] Evaluated June 5.
[2] Evaluated June 10.
[3] 80-0-60 lb/A N-P_2O_5-K_2O broadcast.
[4] 80-40-60 Ib/A N-P_2O_5-K_2O broadcast.

Table 7. Effect of starter fertilizer treatments on plants/ft row, plant height, leaf surface area, and yield of no-tilled cotton on a Loring silt loam at Milan during 1992.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height[1]	Leaf area/ plant[2]	Lint yield	First harvest
	·gal/A·		--in--	.em,--	-lb/A-	---%--
No Started	0	3.9	4.9	163	1387	73
No Starter[1]	0	3.8	4.6	130	1328	74
In-furrow	1.5	3.1	5.0	175	1322	70
In-furrow	3.0	2.0	44	145	1230	68
In-furrow	4 5	1.9	4 5	144	1215	65
2x2 band	7.5	4.0	5 2	194	1413	74
Surface band	7.5	3.8	4.9	139	1403	73
L.S.D. (0.05)		0.7	0.6	NS	135	

[1] Evaluated June 5.
[2] Evaluated June 10.
[3] 80-0-60 Ib/A N-P_2O_5-K_2O broadcast.
[4] 80-40-60 lb/A N-P_2O_5-K2O broadcast.

Table 8. Effect of starter fertilizer treatments on plants/ft row, plant height, leaf surface area, and yield of conventional-tilled cotton on a Gigger silt loam at Winnsboro during 1992.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height'	Leaf area/ plant'	Lint yield	First harvest
	-gal/A-		--in--	--cm²--	-lb/A-	---%---
No Starter[2]	0	4.0	8.0	255	847	81
No Starter[3]	0	4.1	8.0	252	807	76
In-furrow	1 5	3 8	7.6	253	803	79
In-furrow	3.0	3.7	7.9	264	*840*	77
In-furrow	4 5	3.4	7.1	248	778	78
2x2 band	7 5	3.7	8.0	281	841	78
Surface band	7 5	3 8	8.1	243	806	80
L.S.D. (0.05)		0 2	NS	NS	NS	NS

[1] Evaluated June 1.
[2] 80-0-60 Ib/A N-P_2O_5-K_2O broadcast.
[3] 80-40-60 Ib/A N-P_2O_5-K_2O broadcast.

Table 9. Effect of starter fertilizer treatments on plants/ft row, plant height, leaf surface area, and yield of no-tilled cotton on a Gigger silt loam at Winnsboro during 1992.

Treatment	Rate of 11-37-0	Plants /ft[1]	Plant height'	Leaf area/ plant'	Lint yield	First harvest
	-gal/A-		--in--	--cm²--	-Ib/A-	---%--
No Starter[2]	0	3.1	6.9	162	823	75
No Starter'	0	3.2	6 2	190	862	77
In-furrow	1 5	2.8	6.6	200	911	76
In-furrow	3.0	2.8	6.7	229	896	75
In-furrow	4 5	2 5	6 3	213	835	76
2x2 band	7 5	3 3	7.6	259	849	76
Surface band	7 5	3 2	6.9	223	936	77
L.S.D. (0.05)		0.3	NS	NS	NS	NS

[1] Evaluated June 1.
[2] 804-60 Ib/A N-P_2O_5-K_2O broadcast.
[3] 80-40-60 Ib/A N-P_2O_5-K_2O broadcast.

DISCUSSION

Starter fertilizer applications were inconsistent in increasing either CT or NTearly plant growth or yields at the two locations. Treatment responses in 1991 on the Loring soil may have been affected by rainfall. Within 30 minutes after planting, it began to rain, with a total of 5.67 inches recorded 2 weeks after planting. It has been speculated this rainfall may have leached the fertilizers from the application zone (measurements were not taken to evaluate movement). This speculation was supported by the CT data showing the highest yield resulted from applying 4.5 gal/A IF. Most of the other data indicated that 4.5 gal/A applied IF tended to reduced plant stands and yields. Also, the 1991 NT stands were reduced by the SB application indicating that fertilizer movement into the seed zone may have reduced germination.

Stands of both tillage systems appeared to be most affected by IF applications, especially at the two higher fertilizer rates. Applying 3.0 and 4.5 gal/A IF reduced stand counts of both tillage systems and appeared to be a questionable application method for cotton production. In 1991, the highest yield on the NT Gigger soil was the SB treatment having 2 3 plants/row ft. The cotton plant has the ability to compensate for low plant populations through increased production from the vegetative branches. Regressing stand counts (means for each treatment by year and soil) with relative yields showed a positive linear relationship for NTyields across soil and years (RY = 0.8565 + 0.0303 S, R^2 0.18), but the relationship for CT was not significant. This relationship suggested that NT plant population may have been affected more by starter fertilizers than CT stands.

Treatment effect on plant height was limited to the CT Gigger site in 1991 and both tillage systems on the Loring soil in 1992. Regressing relative plant height with relative yield showed a positive linear relationship for NTplots across soil and years (RY = 0.6648 + 03014 RPH, R^2 0.17). Alternatively, this relationship for CT was not significant, which suggested that plant height may be more affected by fertilizer starters applied to NTcotton than CT.

Leaf surface area appeared to be affected more by starters in CT cotton than in NT. Regressing relative leaf surface area of each year and tillage site with relative yield showed a positive quadratic relationship For CT plots across soil and years (RY = 1.7416 - 2.1643 RLA + 1.4252 **RLA^2, R^2 036).** However, the relationship for NTsites was not significant.

CONCLUSIONS

Yield responses to starter Fertilizer treatments were inconsistent. Compared with broadcast Fertilization at 80-40-60 Ib/A of N, P_2O_5, and K_2O, cotton yields were increased in only three oF eight experiments from 1991-1992. In Tennessee (Loring soil), starters increased yields in the CT system in 1991 and 1992, while in Louisiana (Gigger soil), yield increases were observed with NTin 1991. Otherwise, responses to starter fertilizers were generally similar at both locations. In most instances, 2x2 placement and surface banded treatments were superior to in-furrow application methods.

In-furrow applications of starter Fertilizer (11-37-0) at 3.0 and 4.5 gal/A usually reduced cotton stands and, in several instances, reduced yield and/or delayed maturity. Applying 1.5 gal/A IF generally had no effect on stands, growth, or yield.

Early plant growth and leaf area responses to starter fertilizers were also inconsistent. In several instances, however, plant height or leaf area increased with the 2x2 starter compared with other starter treatments and broadcast applications.

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