Fungicide Treatment Effects on Cotton (*Gossypium Hirsutum*) Emergence, Establishment and Yield

N.W. Hopper*
Box 42122, Texas Tech University and Texas Agricultural Experiment Station, Lubbock, TX 79409-2122
J. Supak
Texas Agricultural Extension Service, Texas A&M University, College Station, TX 77843

ABSTRACT

Seedling diseases account for major losses in stands of cotton (*Gossypium hirsutum* L.). The use of fungicide treatments may enhance seedling survival. Our objectives were to evaluate the effect of several fungicide treatments on emergence, stand establishment and yield of cotton, and to compare the effectiveness of seed treatment versus in-furrow soil applications. During 1987, four fungicide seed treatments (Captan, Captan + Apron, Captan + Apron + Vitavax, and Nuflow ND + Apron) and three in-furrow fungicide applications (two rates of Ridomil PC and one rate of Terrachlor Super X) were evaluated. Treated seed had higher (P < 0.05) emergence rates (97% to 194%) than the control. There were no differences (P > 0.05) among in-furrow applications. Stand establishment for the treated seed was higher (140 to 330%) than the control as was the in-furrow treatments of Ridomil PC (high rate) and Terrachlor Super X (150% for each). The seed and in-furrow treatments produced 37 to 84% higher lint yields than the control. The highest emergence and stand establishment resulted from seeds treated with Captan + Apron, and Nuflow ND + Apron. The highest lint yield resulted from seeds treated with Captan + Apron, Captan + Apron + Vitavax, and Nuflow ND + Apron. During 1988, the seed treatments, Captan, Captan + Apron, and Captan + Apron + Demosan were evaluated. Multiple seed treatments (Captan + Apron, and Captan + Apron + Demosan) generally produced 42 to 43% higher seedling emergence and 36% higher stand establishment compared to the control; however, no yield differences among the treatments were observed. Our results show that for improving emergence, establishment and yield of cotton, multiple fungicide seed treatments are generally superior to single seed treatments and to in-furrow treatments.

KEYWORDS: seedling disease, chemical protectants

Diseases account for major losses in cotton yield across the Cotton Belt (Blasingame, 1992; Ridgway et al., 1984). Blasingame (1992) estimated that the major cotton diseases caused the loss of 1.97 million bales during 1991. Of these diseases, the seedling disease complex (*Rhizoctonia solani*, *Pythium* spp., *Thielaviopsis* spp., and *Fusarium* spp.) accounted for the largest number of bales

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lost. In Texas the economic loss was over $28 million. Minton (1988b) reported that tremendous progress has been made in disease control with the introduction and use of inorganic and organic fungicides, and more recently the systemic fungicides. The fungicides used earlier were primarily broad spectrum types; however, recently developed fungicides are more specific for certain organisms (Minton, 1986). Therefore, selection of a certain fungicide or fungicide combination can be implemented to target specific organisms, thus accomplishing better disease control.

A good stand of cotton plants is a prerequisite for a high yield. Good stands are characterized by the following factors: 1) adequate number of plants per hectare, 2) uniform spacing of the plants, 3) uniform growth rate of the plants, and 4) seedlings that are free from disease. Good stands require the planting of high quality seed in a moist and properly prepared seedbed with some form of pesticide protection (Jividen, 1985; Minton, 1986; Minton and Garber, 1983; Waddle, 1985). Pesticide protection may be applied to the seed prior to planting, at planting (planter box treatment), or by the use of an in-furrow soil treatment. A misconception is that planting at higher seeding rates can replace the use of high quality seed and pesticide treatment. A higher seeding rate may produce an adequate plant population; however, it will not ensure uniform spacing and growth of seedlings.

Historically, Captan has been an effective fungicide in disease control for cotton. Minton and Green (1980) reported increased emergence and survival of cotton seedlings from the use of various rates of Captan in both greenhouse and field studies. Later reports have noted the effectiveness of several other compounds such as Ridomil PC, Terrachlor Super X, Apron, Vitavax, TCMTB, and Demosan used alone or in combination (DeVay et al., 1987; DeVay et al., 1988; Minton et al., 1986; Minton, 1988a; Sciumbato, 1987). Seedling survival rates and yield results have been somewhat variable among studies with different fungicides. Undoubtedly, variable results are due in part to the presence and/or virulence of certain organisms and the particular environmental conditions. More recent recommendations have included the use of fungicide combinations for the most effective control of seedling diseases (DeVay et al., 1988; Minton, 1988b; Papavizas et al., 1980).

The purpose of this study was to evaluate several fungicides and fungicide combinations on the emergence, stand establishment, and lint yield of cotton under Texas High Plains conditions. In addition, the effectiveness of seed treatment versus in-furrow applications was evaluated.

METHODS AND MATERIALS

This study was conducted over two growing seasons (1987 and 1988) at the Texas Tech University Research Farm. The soil type at this location is a Pullman clay loam (torrertic Paleustoll). Fungicide preparations for the seed were made by mixing the selected fungicide(s) with water to a final volume of 15 ml kg^{-1} of seed (Tables 1 and 2). One kilogram of seed for each treatment was placed in a laboratory seed treater and rotated as the seed treatment was applied using a syringe. After drying, the seeds were counted into individual packets in preparation for planting with a cone attachment on a field planter. The in-furrow applications were made by directing the selected materials (Table 1) through a tube from pesticide boxes mounted on the planter to the seed furrows where the materials would be in contact with the seed.

Table 1. Seed and in-furrow fungicide treatments evaluated for Experiment 1, 1987.

Treatment	Active ingredient (ai)	Method[†]	Rate[‡]
Control	-	-	-
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	S	0.938
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	S	0.938
+ Apron	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	S	0.155
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	S	0.469
+ Apron	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	S	0.155
+ Vitavax	carboxin: 5,6-dihydro-2-methyl-1,4-oxantyiin-3-carboxanilide	S	0.748
Nuflow ND	TCMTB: 2-(thiocyanomethythio) benzothiazole	S	0.322
	chloroneb: (1,4-dichloro-2,5-dimethoxybenzene)	S	0.841
+Apron	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	S	0.155
Ridomil PC	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	I	0.056
	PCNB: pentachloronitrobenzene	I	0.560
Ridomil PC	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	I	0.084
	PCNB: pentachloronitrobenzene	I	0.840
Terrachlor Super X	PCNB: pentachloronitrobenzene	I	1.120
	terrazole: 5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole	I	0.280

[†]S denotes seed treatment and I denotes in-furrow application.

[‡]Seed treatment rates expressed as g ai kg^{-1} of seed and in-furrow applications as kg ai ha^{-1}.

Table 2. Fungicide seed treatments evaluated for Experiment 2, 1988.

Treatment	Active ingredient (ai)	Rate[†]
Control	-	-
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	0.938
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	0.938
+ Apron	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	0.155
Captan	captan: N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarboximide	0.938
+ Apron	metalaxyl: N-(2,6-dimethylphenyl)-N-(methoxylacetyl) alanine methyl ester	0.155
+ Demosan	chloroneb: (1,4-dichloro-2,5-dimethoxybenzene)	1.300

[†] g ai kg^{-1} of seed.

A 3-meter section of a center row of each plot was delineated for daily stand counts through 28 days after planting. These data rows were selected so they were planted by a common planter unit to avoid any differences in planting depth. The daily emergence counts were used to calculate an Emergence Rate Index (ERI) according to the following equation:

$$\text{ERI} = \sum_{i=1}^{y} [E_i((y + 1) - x_i)]$$

where:

E_i	=	total emerged seedlings on day "i"
y	=	days to final count (28 days)
x_i	=	assumes the value of "i"

An Establishment Index (EI) was calculated 6 weeks after planting according to the following equation:

$$\text{EI} = \frac{\text{number of seedlings / 3m}}{\text{number of seeds planted / 3m}} \times 100$$

Lastly, a 5-meter section of one of the two center rows was harvested and the lint yield determined.

Experiment 1 (1987)

Prior to planting, the study area was fertilized with 90 kg ha^{-1} of N and 40 kg ha^{-1} of P_2O_5. In addition, Treflan or trifluralin [2,6-Dinitro-N,N, dipropyl-4-(trifluoromethyl) benzenamine] at the rate of 0.84 kg ai ha^{-1} was applied for weed control and the area was irrigated to ensure adequate moisture for germination and early season growth. Cotton ('Paymaster 145') was planted on 14 May at a seeding rate of 23.3 seeds per meter of row. Individual plots were 4 rows spaced 1.02 m apart and 12.2 m long. At the time of planting, Temik or aldicarb [2-Methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl) oxime] (0.51 kg ai ha^{-1}) was applied for early season insect control. Seasonal applications of insecticide were made as needed to control insect infestations. Two irrigations were applied during the growing season to prevent plant moisture stress. Eight treatments were investigated which included a control (no fungicide), Captan, Captan + Apron, Captan + Apron + Vitavax, Nuflow ND + Apron, Ridomil PC (two rates), and Terrachlor Super X (Table 1.)

Experiment 2 (1988)

The study area was fertilized with 87 kg ha^{-1} of N and 38 kg ha^{-1} of P_2O_5. Weeds were controlled with a preplant application of trifluralin (0.84 kg ai ha^{-1}) and a pre-emergence application of metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide] (1.92 kg ai ha^{-1}) and prometryne [2,4-bis (isopropylamino)-6-(methylthio)-S-triazine] (1.35 kg ai ha^{-1}). Prior to planting, the area was irrigated. Two seasonal irrigations were applied to minimize plant moisture stress. Plots consisted of four rows spaced 1.02 m apart and 11 m long. The cultivar Paymaster 145 was planted on 17 May at a rate of 26 seeds m^{-1} of row.

Aldicarb (2.8 kg ha^{-1}) was applied for early-season insect control with seasonal insecticide applications as needed. Four treatments (Control, Captan, Captan + Apron, and Captan + Apron + Demosan) were evaluated during 1988 (Table 2).

Both years, the experimental design was a randomized complete block with four blocks. The data were analyzed using analysis of variance and the means were separated using the Duncan's Multiple Range Procedure.

RESULTS AND DISCUSSION

Experiment 1 (1987)

The germinating and emerging seedlings were exposed to more stressful environmental conditions during the first 14 days after planting in 1987 than in 1988. Precipitation was received on 12 of these days in 1987 (trace to 24 mm) and only on 6 days in 1988 (trace to 25 mm). The four seed treatments of Captan (C), Captan + Apron (C+A), Captan + Apron + Vitavax (C+A+V), and Nuflow ND + Apron (NF+A) all had higher ($P < 0.05$) ERI values than the control (Fig. 1). These seed treatments produced ERI increases of 97, 110, 158, and 194% over the control for C+A+V, C, NF+A and C+A, respectively. The in-furrow treatments, Ridomil PC at the low rate [RPC(L)] and high rate [RPC(H)] and Terrachlor Super X (TSX), did not perform significantly better ($P > 0.05$) than the control.

Within the seed treatments, the C+A and NF+A treatments had the highest ERI values; however, the NF+A was not different ($P > 0.05$) than the C or C+A+V treatments. There were no differences ($P > 0.05$) among the in-furrow treatments [RPC(L), RPC(H), and (TSX)] nor were they different from the control. In general, the seed treatments had higher ERI values than the in-furrow treatments, the only exception being that the C+A+V treatment was not significantly different ($P > 0.05$) from the RPC(H) and TSX in-furrow treatments.

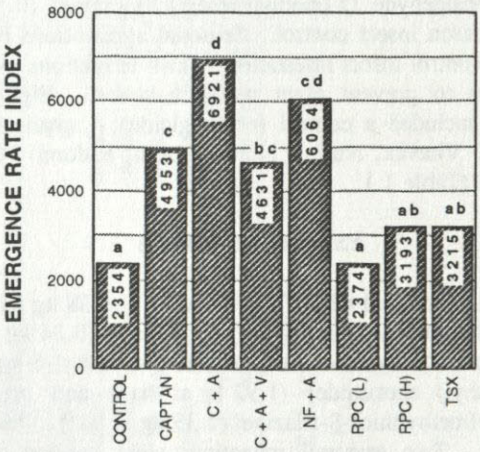

Figure 1. Emergence rate index of cotton as influenced by seed and in-furrow fungicide treatments during 1987. Bars with the same letter are not significantly different (P> 0.05).

The establishment index (EI) values represent the percentage of seeds planted that produced established plants 6 weeks after planting (Fig. 2). The EI values ranged from 10 to 43%. Again, the environmental conditions were especially stressful during the spring of 1987. All fungicide treatments, with the exception of RPC(L), produced higher ($P < 0.05$) EI values than the control. Within the seed treatments, both the C+A and NF+A treatments had higher EI values (43 and 40%, respectively) than the C (24%) and C+A+V (30%) treatments. Within the in-furrow treatments, higher ($P < 0.05$) EI values were noted for RPC(H) (25%) and TSX (25%) treatments than for the RPC(L) (14%). The C+A and NF+A seed treatments had the highest ($P < 0.05$) EI values.

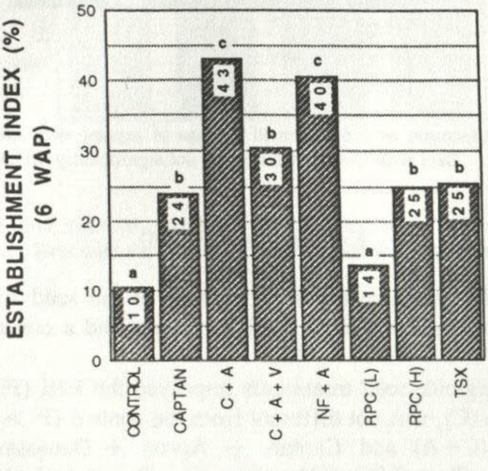

Figure 2. Relationship between the cotton seedling establishment index 6 weeks after planting (6 WAP) and the use of seed and in-furrow fungicide treatments during 1987. Bars with the same letter are not significantly different ($P > 0.05$)

The yield differences were not as pronounced as the ERI and EI values; however, all fungicide treatments produced significantly greater yields ($P < 0.05$) than the control (Fig. 3). The seed treatments of C, C+A, C+A+V, and NF+A caused yield increases over the control of 42, 83, 84, and 84%, respectively. The in-furrow treatments of RPC(L), RPC(H), and TSX generated yield increases over the control of 45, 37, and 38%, respectively.

Within seed treatments, yields from the C+A (936 kg ha^{-1}), C+A+V (938 kg ha^{-1}), and NF+A (940 kg ha^{-1}) treatments were higher ($P < 0.05$) than the C (726 kg ha^{-1}) treatment. However, no differences ($P > 0.05$) were noted among the C+A, C+A+V, and NF+A treatments. In addition, no differences ($P > 0.05$) were noted among in-furrow treatments.

The seed treatments of C+A, C+A+V, and NF+A produced higher ($P < 0.05$) yields than the control and in-furrow treatments.

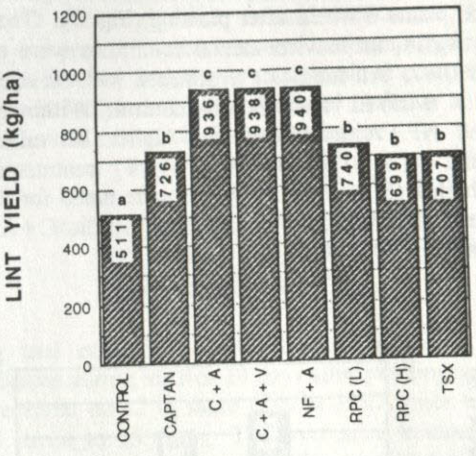

Figure 3. Lint yield of cotton as a function of the use of several seed and in-furrow fungicide treatments during 1987. Bars with the same letter are not significantly different (P> 0.05).

Experiment 2 (1988)

Results from 1987 had indicated an advantage of the seed treatments over the in-furrow applications, so only three seed treatments and a control were evaluated in 1988.

Again, certain fungicide seed treatments improved the ERI (Fig. 4). The single treatment of Captan (C), was not different from the control (P > 0.05). However, Captan + Apron (C+A) and Captan + Apron + Demosan (C+A+D) had significantly greater (P < 0.05) ERI values than the control (10042, 10078, and 7069 units, respectively). This represented an increase over the control of 42 and 43%, respectively, for the C+A and C+A+D treatments. There were no significant differences (P > 0.05) among the C, C+A, and C+A+D treatments.

Similar trends were noted for the EI values (Fig. 5). The C+A and C+A+D seed treatments were significantly better (36% for both) than the control with no difference being noted between the C treatment and the control. Again, no differences (P > 0.05) among the C, C+A, and C+A+D treatments were observed.

Although yields from the various treatments ranged from 571 kg ha^{-1} (Control) to 739 kg ha^{-1} (C+A), no significant differences (P > 0.05) existed among the treatments (Fig. 6). While the yield trends followed that of the ERI and EI parameters, a midseason hail storm (approximately 7 weeks after planting) may have been responsible for masking any potential yield differences. The 1987 data indicated a general advantage for seed treatments over the in-furrow applications. No real differences existed among the in-furrow treatments for ERI or yield.

Based on our findings, multiple seed treatments could be expected to produce higher ERI and EI values than untreated seed (1987 and 1988) and higher yields (1987). In addition, the lower ERI and EI values noted during 1987 were likely due to the greater number of days with precipitation during the first 14 days after planting.

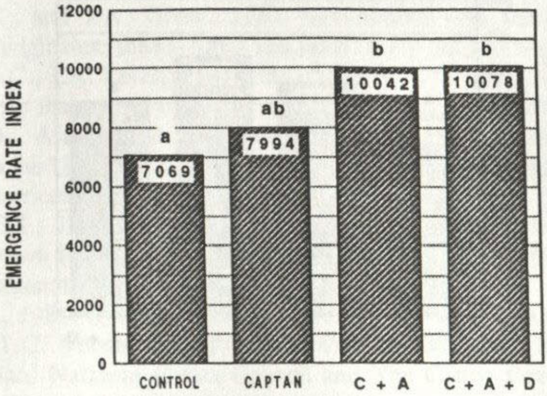

Figure 4. Emergence rate index of cotton as influenced by single and multiple fungicide seed treatments during 1988. Bars with the same letter are not significantly different (P > 0.05).

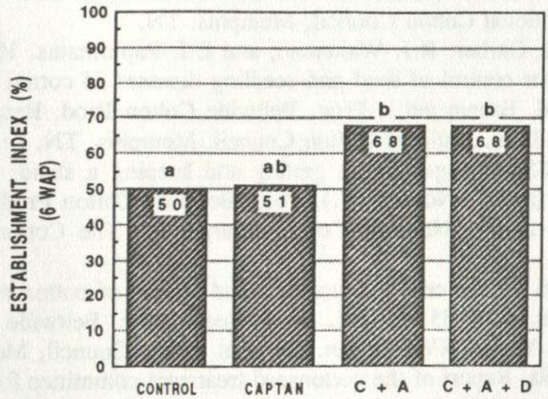

Figure 5. Relationship between cotton seedling establishment index 6 weeks after planting (6 WAP) and use of single and multiple fungicide seed treatments during 1988. Bars with the same letter are not significantly different (P > 0.05).

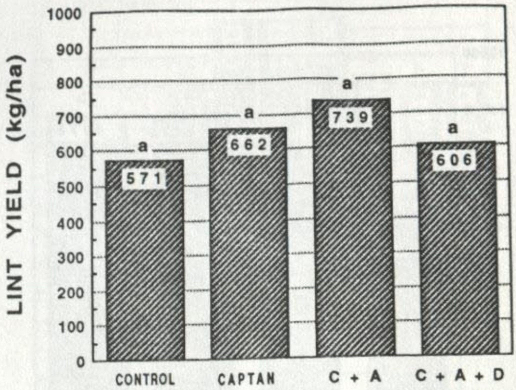

Fig. 6. Lint yield of cotton as a function of the use of single and multiple fungicide seed treatments during 1988. Bars with the same letter are not significantly different (P > 0.05).

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