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Multiple Chemical Treatment of Cotton Seed, Effects on Seedling Survival[1]

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ABSTRACT

Multiple chemical seed treatments which included fungicides and combination of systemic fungicides and insecticides were of value for pest control in cotton, *Gossypium hirsutum* L. Nonmercurial protectant fungicides were as effective as organic mercury compounds. Inclusion of a systemic fungicide in the treatment combination significantly increased plant survival. Inclusion of a systemic insecticide in the treatment combination resulted in consistent reductions in plant survival. Reduction in plant survival was minimized when a systemic fungicide was included in the treatment combination. Significant interactions between chemical treatments indicate a need to identify desirable combinations of chemicals for seed treatment.

Additional index words: **Fungicides, Systemic insecticides, Chemical interactions, *Gossypium hirsutum* L.**

THE object of this study was to evaluate the effects of multiple fungicide and insecticide seed treatment on seedling survival under field conditions. Treatment of cottonseed, *Gossypium hirsutum* L., with a protectant fungicide is a standard practice throughout the cotton belt. In the 1950's, seed treatment with systemic insecticides was recommended for thrip control (8, 12), but in some instances reductions in seedling survival resulted and recommendations were discontinued (9). However, stand reductions were more frequently associated with environment-soil interactions (2, 3, 4, 5) than with application rate (7). In the late 1960's, different formulations, applied at lower dosages, were tested and recommended for thrip control (10, 13). In the late 1960's, systemic fungicides were found to be effective in extending seedling disease control beyond that obtained from a single protectant fungicide (11). Multiple seed treatment with a protectant fungicide and a systemic fungicide are recommended in many areas of the cotton belt (Ranney, C.D., Chairman, 1969. Report to the Seed Treatment Committee, Cotton Disease Council. Proc. Beltwide Cotton Prod. Res. Conf. pp 16-19).

MATERIALS AND METHODS

Seed used in the 1967 trials was machine-delinted 'Stoneville 213' (82 to 85% germination) and acid-delinted Stoneville 213 (85 to 87% germination). Acid-delinted 'Stoneville 7A' seed (78-80% germination) was used in the 1969 trials. Chemicals were sprayed through a nasal-atomizer onto seed tumbling in a rotating drum mixer. Application rates are shown in the tables. In all treatments, protectant fungicides were applied first, followed by systemic fungicides. Seed was then air-dried in the laboratory for 5 days to equalize seed moisture. Seed samples treated with a systemic insecticide were packaged within an hour after treatment to reduce chemical loss. Treated seed were packaged in plastic envelopes and planted within 2 weeks. A single replicate consisted of 100 seed planted in a 6-m row with a belt planter. Stand counts were made 28 to 36 days after planting.

In the 1967 trials the following chemicals were used:

Seed protectant fungicides:

- Daconil[2] + ctptan — 40% tetrachloroisophthalonitrile + 32% *N*-trichloromethylthio-4-cyclohexane-1,2,dicarboximide
- Daconil + Dexon — 40% tetrachloroisophthalonitrile + 32% P-(dimethylamino)benzenediazo sodium sulfonate
- Ceresan L — 2.89% methyl mercury 2,3-dihydroxypropyl mercaptide + .62% methyl mercury acetate

Systemic fungicide:

- Demosan — (chloroneb) 65% 1,4-dichloro-2,5-dimethoxybenzene

Systemic insecticide:

- DiSyston — (disulfoton) 95% *0,0*-diethyl *S*-[*2*-(ethylthio)ethyl] phosphorodithioate

Field trials in 1969 were conducted by using a split-split design with six replications. Main plots were four seed protectants; split plots were three systemic fungicides; and split-split plots were three systemic insecticides. Two planting dates, early (April 10) and normal (May 9) were utilized.

The following chemicals were used in 1969:

Seed protectants:

- Ceresan L
- Panogen 15 — 2.2% cyano (methylmercuric)guanidine
- Terracoat L21 — 22.9% pentachloronitrobenzene + 11% 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole
- Arasan 70 — (thiram) 70% tetramethylthiruam disulfide

Systemic fungicides:

- Demosan
- Vitavax — 75% 2,3-dihydro-5-carboxanilide-6-methyl-1,4-oxathiin

Systemic insecticides:

- Di-Syston
- Go-Better — (monocrotophos) 56% 3-hydroxy-*N*-methyl-*cis*-crotonamide dimethyl phosphate

RESULTS

In 1967, several of the treatments significantly increased survival of plants grown from both machine- and acid-delinted cottonseed (Table 1). With two exceptions these increases were associated with a seed protectant + systemic fungicide combination. The combination treatment of Ceresan L and disulfoton on acid-delinted seed resulted in a significantly lower stand. Systemic fungicides were beneficial to seedling survival irrespective of other treatments. Treatment combinations with the systemic fungicide chloroneb had higher plant survival than those with protectant fungicides alone. The opposite effect was noted in analysis of the systemic insecticide data. Fewer plants survived if a systemic insecticide was included in the treatment combination.

Effects of early and late planting dates on seedling survival in 1969 are summarized in Table 2. In the early planted trial, seedling diseases were very severe with the major loss due to preemergence seedling disease. In the second trial, disease incidence was severe but most of the loss was due to postemergence seedling disease development. The effect of planting date and the interactions of the different chemical treatments associated with time of planting are presented in Table 3.

Only systemic fungicides resulted in significant increases in plant survival in the early planting, irrespective of other chemicals. Results from the second

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Table 1. Effect of seed treatment with seed protectant fungicides, a systemic fungicide, and a systemic insecticide on survival of cotton seedlings. Planted April 7, 1967; stand evaluated May 13, 1967.

Seed treatments				% seedling survival†	
	Dosage, g-ml/kg		Disulfoton 4.50 ml/kg		
Fungicides	Machine-delinted	Acid delinted		Machine-delinted	Acid-delinted
Daconil - captan	1.88	1.25	No	59.2*	66.8
Daconil - captan	1.88	1.25	Yes	53.0	54.0
Daconil - captan + chloroneb	1.88+6.25	1.25+6.25	No	66.4**	70.2*
Daconil - captan + chloroneb	1.88+6.25	1.25+6.25	Yes	54.0	66.0
Daconil - Dexon	1.88	1.25	No	57.2*	62.6
Daconil - Dexon	1.88	1.25	Yes	44.0	51.2
Daconil - Dexon + chloroneb	1.88+6.25	1.25+6.25	No	64.0**	72.4**
Daconil - Dexon + chloroneb	1.88+6.25	1.25+6.25	Yes	60.0*	67.8
Ceresan L	1.96	1.30	No	56.6	63.8
Ceresan L	1.96	1.30	Yes	47.6	43.0 (-)
Ceresan L + chloroneb	1.96+6.25	1.30+6.25	No	65.0**	70.4*
Ceresan L + chloroneb	1.96+6.25	1.30+6.25	Yes	61.2**	66.6
Check	0	0	No	47.6	55.2
Average				56.6	62.3
With systemic fungicide				61.8	68.9
Without systemic fungicide				52.9	56.9
LSD at .01 level for fungicide differences				4.6	6.2
With systemic insecticide				53.3	58.1
Without systemic insecticide				61.4	67.7
LSD at .01 level for insecticide differences				4.6	6.2

† Asterisks denote treatments significantly better than the check treatment, ** at the .01 level, * at the .05 level, (-) denotes a treatment significantly poorer than the check at the .05 level, as measured by Duncan's New Multiple Range Test.

Table 2. Seedling survival from seed treated with various combinations of seed protectant fungicides, systemic fungicides, and systemic insecticides at two planting dates in 1969.

Treatment			Rates, g-ml/kg			% seedling survival 30 days after planting on:		
Seed protectant	Systemic fungicide	Systemic insecticide	SP	SF	SI	Apr. 10	May 9	Avg
Ceresan L	None	None	1.3	0	0	6.5	33.9	20.2
Ceresan L	None	Disulfoton	1.3	0	4.5	7.8	28.8	18.3
Ceresan L	None	Monocrotophos	1.3	0	10.4	10.5	27.4	18.9
Ceresan L	Chloroneb	None	1.3	6.25	0	14.9	45.9	30.4
Ceresan L	Chloroneb	Disulfoton	1.3	6.25	4.5	17.3	41.5	29.3
Ceresan L	Chloroneb	Monocrotophos	1.3	6.25	10.4	15.0	37.5	26.3
Ceresan L	Vitavax	None	1.3	5.0	0	16.8	37.6	27.2
Ceresan L	Vitavax	Disulfoton	1.3	5.0	4.5	19.2	44.5	31.9
Ceresan L	Vitavax	Monocrotophos	1.3	5.0	10.4	17.2	35.0	26.1
Average for Ceresan L						13.9	36.9	25.4
Panogen 15	None	None	1.3	0	0	5.1	26.3	15.7
Panogen 15	None	Disulfoton	1.3	0	4.5	4.9	25.4	15.2
Panogen 15	None	Monocrotophos	1.3	0	10.4	4.5	16.1	10.3
Panogen 15	Chloroneb	None	1.3	6.25	0	8.0	44.5	26.2
Panogen 15	Chloroneb	Disulfoton	1.3	6.25	4.5	13.6	41.9	27.8
Panogen 15	Chloroneb	Monocrotophos	1.3	6.25	10.4	17.5	38.8	28.2
Panogen 15	Vitavax	None	1.3	5.0	0	11.9	40.2	26.0
Panogen 15	Vitavax	Disulfoton	1.3	5.0	4.5	18.2	37.3	27.7
Panogen 15	Vitavax	Monocrotophos	1.3	5.0	10.4	16.5	35.9	26.2
Average for Panogen 15						11.1	34.0	22.6
Terracoat L21	None	None	7.8	0	0	13.2	41.4	27.3
Terracoat L21	None	Disulfoton	7.8	0	4.5	9.9	33.2	21.5
Terracoat L21	None	Monocrotophos	7.8	0	10.4	8.4	30.2	19.3
Terracoat L21	Chloroneb	None	7.8	6.25	0	15.3	43.6	29.4
Terracoat L21	Chloroneb	Disulfoton	7.8	6.25	4.5	14.5	43.2	28.8
Terracoat L21	Chloroneb	Monocrotophos	7.8	6.25	10.4	15.7	28.2	27.0
Terracoat L21	Vitavax	None	7.8	5.0	0	25.5	41.4	32.4
Terracoat L21	Vitavax	Disulfoton	7.8	5.0	4.5	18.5	46.2	32.3
Terracoat L21	Vitavax	Monocrotophos	7.8	5.0	10.4	17.9	38.6	28.3
Average for Terracoat L21						15.2	39.6	27.4
Arasan 70	None	None	1.9	0	0	12.3	25.5	18.9
Arasan 70	None	Disulfoton	1.9	0	4.5	13.0	20.4	16.7
Arasan 70	None	Monocrotophos	1.9	0	10.4	5.2	16.0	10.6
Arasan 70	Chloroneb	None	1.9	6.25	0	19.1	43.0	31.1
Arasan 70	Chloroneb	Disulfoton	1.9	6.25	4.5	19.4	41.0	30.2
Arasan 70	Chloroneb	Monocrotophos	1.9	6.25	10.4	20.1	38.3	29.2
Arasan 70	Vitavax	None	1.9	5.0	0	13.1	41.8	27.5
Arasan 70	Vitavax	Disulfoton	1.9	5.0	4.5	15.0	39.4	27.2
Arasan 70	Vitavax	Monocrotophos	1.9	5.0	10.4	12.1	29.4	20.8
Average for Arasan 70						14.4	32.8	23.6
Average for all treatments						13.6	35.8	24.7

trial planted on May 9 indicate significant differences due to use of all three types of chemical treatments. The seed protectant Terracoat L21 gave the best results in terms of plant survival, irrespective of other chemicals. Both of the systemic fungicides gave significant increases in plant survival, irrespective of other chemicals used. The systemic insecticide monocrotophos reduced seedling survival; however, treatments with disulfoton were not different from those not receiving a systemic insecticide. The interactions among chemicals and planting dates are indicated in Table 4.

Table 3. Main effects of seed treatment with seed protectant fungicides, systemic fungicides, and systemic insecticides on percent seedling survival at two planting dates in 1969.

Chemical treatment		% seedling survival from plantings on:* April 10	May 9	Avg
Seed protectants:	Ceresan L	13.9	36.9 ab	25.4 ab
	Panogen 15	11.1	34.0 bc	22.6 b
	Terracoat L21	15.2	39.6 a	27.4 a
	Arasan 70	14.4	32.8 c	23.6 b
Systemic fungicides:	None	8.4 b	27.0 b	17.7 b
	Chloroneb	15.9 a	41.6 a	28.7 a
	Vitavax	16.7 a	39.0 a	27.8 a
Systemic insecticides:	None	13.3	38.8 a	26.0 a
	Disulfoton	14.3	36.9 a	25.6 a
	Monocrotophos	13.4	31.8 b	22.6 b
Average, planting date		13.6	35.8	
Difference due to date		22.2		
LSD at .01 level		2.0		

* Means not followed by the same letter are significantly different at the .01 level as measured by Duncan's New Multiple Range Test.

Table 4. Summary of interactions among different chemicals; seed protectant fungicides, systemic fungicides, and systemic insecticides, when applied as seed treatments at two planting dates in 1969.

Interaction	Planting date: April 10	May 9	Avg
Seed protectant × Systemic fungicide	ns	.01	.01
Seed protectant × Systemic insecticide	.05	ns	ns
Systemic fungicide × Systemic insecticide	ns	.05	.05
Seed protectant × Systemic fungicide × Systemic insecticide	ns	.05	ns
Seed protectant × Date	--	--	.05
Systemic fungicide × Date	--	--	.01
Systemic insecticide × Date	--	--	.01
Seed protectant × Systemic fungicide × Date	--	--	.05
Seed protectant × Systemic insecticide × Date	--	--	ns
Systemic fungicide × Systemic insecticide × Date	--	--	ns
Seed protectants × Systemic fungicides × Systemic insecticides × Date	--	--	ns

Table 5. Numerical illustration of significant interaction between seed protectant fungicides and systemic insecticides, when applied as seed treatments, on percent seedling survival, April 10, 1969, planting date.

Seed protectant fungicide	% seedling survival: Systemic insecticide: None	Disulfoton	Monocrotophos	Avg
Ceresan L	12.7	14.7	14.3	13.9
Panogen 15	8.3	12.2	12.8	11.1
Terracoat L21	17.3	14.2	14.0	15.2
Arasan 70	14.8	15.8	12.5	14.4
Avg	13.3	14.3	13.4	

The significant interaction between seed protectants and systemic insecticides in the early planting is illustrated numerically in Table 5. In the presence of the mercurial seed protectants Ceresan L or Panogen 15, the stand was higher where either insecticide was added. In contrast, plant survival was reduced where systemic insecticides were used with the nonmercurial seed protectant Terracoat L21, and variable with Arasan 70. A fungicide effect for several systemic insecticides, alone (2) or with a mercurial seed protectant (6) have been reported. Trial results with mercurial seed protectants support these findings. However, plant survival was reduced where systemic insecticides were included in combination with effective nonmercurial seed protectants.

A significant interaction occurred between protectant fungicides and systemic fungicides in both the late planting and the combined evaluation of planting dates (Table 6). In the May 9 planting in the absence of systemic fungicides, there was considerable variation

Table 6. Numerical illustration of significant interaction between seed protectant fungicides and systemic fungicides, when applied as a seed treatment, on percent seedling survival, May 9, 1969, planting date.

Seed protectant fungicide	% seedling survival			
	Systemic fungicide			
	None	Chloroneb	Vitavax	Avg*
Ceresan L	30.0	41.6	39.1	36.9 ab
Panogen 15	22.6	41.7	37.8	34.0 bc
Terracoat L21	34.9	41.7	42.1	39.6 a
Arasan 70	20.6	40.8	36.9	32.8 c
Avg*	27.0 b	41.4 a	39.0 a	

* Means not followed by the same letter are significantly different at the .01 level as measured by Duncan's New Multiple Range Test.

Table 7. Numerical illustration of significant interaction between systemic fungicides and systemic insecticides, when applied as a seed treatment, on percent seedling survival, average of two dates of planting in 1969.

Systemic insecticide	% seedling survival			
	Systemic fungicide			
	None	Chloroneb	Vitavax	Avg*
None	20.5	29.3	28.3	26.0 a
Disulfoton	17.9	29.0	29.8	25.6 a
Monocrotophos	14.8	27.6	25.4	22.6 b
Avg*	17.7 b	28.7 a	27.8 a	

* Means not followed by the same letter are significantly different at the .01 level as measured by Duncan's New Multiple Range Test.

in plant survival among the four seed protectants. When either of the systemic fungicides were included in the treatment, there was an increase in survival with reduced variation among the seed protectants.

In Table 7, a numerical illustration of the interaction between systemic fungicides and systemic insecticides is presented. Systemic fungicides increased plant survival in the presence or absence of a systemic insecticide. With one exception the presence of systemic insecticides resulted in reduced plant survival, especially in the absence of a systemic fungicide.

All three of these interactions indicate that some combinations of chemical treatments are better than others. This is emphasized by the fact that the seed protectant $\times$ systemic fungicide $\times$ systemic insecticide interaction was significant in the trial planted on May 9.

In these trials, environmental conditions, severity, and type of disease development were different. Most of the interactions between chemical treatments and date of planting are evident in the data presented in Table 3. Terracoat L21 gave the highest plant survival of the seed protectants at both planting dates. Performance of the other seed protectants varied between the two planting dates sufficiently to account for the significant interaction. The systemic fungicide treatments gave significant stand increases at both planting dates. In the April 10 trial, increases in plant survival were 100% or more. The May 9 trial increases were about 60%. Although the differences were small, there was a reversal in maximum plant survival between the two systemic fungicides that also contributed to the significant interaction.

In the systemic insecticides, the cause of the significant interaction is more apparent. In the April 10 plantings, there were no significant differences among systemic insecticide treatments. However, treatment combinations not receiving a systemic insecticide resulted in the lowest plant survival. In the May 9 plantings, the seed not treated with the systemic insecticide monocrotophos gave the highest plant survival.

DISCUSSION

Data from trials where multiple chemical seed treatments were used indicate the value of this type of treatment in seedling disease control. The addition of a systemic fungicide to seed protectant treatments resulted in significant increases in seedling survival under different levels of disease severity. The use of a systemic insecticide for early season insect control is desirable for the timely and low cost benefits that can be realized. However, results have shown that seed treatment with systemic insecticides can result in reduced plant survival and predispose seedlings to disease attack (1, 2, 3, 4, 5). Data reported here support these findings, but my results indicate that the inclusion of a systemic fungicide in the treatment combination of protectant fungicide, either mercurial or nonmercurial, and systemic insecticide reduces the deleterious effect of the systemic insecticide on plant survival.

Significant interactions between protectant fungicides, systemic fungicides, and systemic insecticides were present in these trials and the data indicate that some combinations are better than others. The significant multiple interaction, seed protectant fungicides $\times$ systemic fungicides $\times$ planting date, indicates that not only chemical combinations but also environmental conditions associated with planting date contribute to the response to multiple chemical treatments. The results of these trials point out the need for extensive testing to identify combinations of chemicals that result in maximum plant survival under various environmental conditions with effective pest control.

LITERATURE CITED

1. Beckman, C. M. 1966. Storage effect of disulfoton and phorate on germination and emergence of cottonseed. Ga. Agr. Exp. Sta. Mimeo. Series N.S. 250. 6 pp.
2. Erwin, D. C. and H. T. Reynolds. 1958. The effect of seed treatment of cotton with thimet, a systemic insecticide, on *Rhizoctonia* and *Phytium* seedling disease. Plant Disease Reptr. 42:174-176.
3. ———, ———, and M. J. Garber. 1959. Effect of seed treatment of cotton with thimet, a systemic insecticide, on seedling diseases in the field. Plant Disease Reptr. 43:558-561.
4. ———, ———, and ———. 1961. Pre-disposition to Pythium seedling disease and an activated charcoal-fungicide interaction on factors influencing emergence of cottonseed treated with phorate. J. Econ. Ent. 54:855-858.
5. Hacskaylo, Joseph, and C. D. Ranney. 1961. Emergence of phorate-treated cottonseed as affected by substrate moisture and temperature. J. Econ. Ent. 54:296-298.
6. ———, and R. B. Stewart. 1962. Efficacy of phorate as a fungicide. Phytopath. 52:371-372.
7. Lindquist, D. A., Joseph Hacskaylo, and T. B. Davich. 1961. Laboratory and field investigations with phorate-treated cottonseed. J. Econ. Ent. 54:379-382.
8. Mississippi Agricultural Extension Service. 1957. 1957 Guide to Cotton Insect Control. Miss. Agr. Ext. Ser. Pub. 343.
9. ———. 1960. 1960 Guide to Cotton Insect Control. Miss. Agr. Ext. Ser. Pub. 343.
10. ———. 1967. 1967 Guide to Cotton Insect Control. Miss. Agr. Ext. Ser. Pub. 343.
11. Ranney, C. D., and E. G. Burchfield. 1967. Evaluation of seed treatment with 1,4-dichloro-2,5-dimethoxybenzene as a cotton seedling disease control measure. Plant Disease Reptr. 51:558-562.
12. Texas Agricultural Extension Service. 1956. 1956 Texas Guide for controlling cotton insects. Texas Agr. Ext. Ser. L-218.
13. ———. 1968. 1968 Texas Guide for controlling cotton insects. Texas Agr. Ext. Ser. L-218.