Published January, 1980

# Germination and Stand with Cottonseed Treatment Fungicides: Formulations and Rates[1]

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## ABSTRACT

**Obtaining a stand of vigorous seedlings is a major problem in cotton (*Gossypium hirsutum* L.) production. The purpose of this study was to determine the effects of fungicide formulations and concentrations applied to cottonseed on germination in the laboratory and on emergence and survival of seedlings in greenhouse and field tests. Germination percentages with standard procedures at two temperature regimes were similar for cottonseed treatment with different rates and formulations of captan, *N*-[(trichloromethyl)thio]-4-cyclohexene-1, 2-dicarboximide, and carboxin, 5,6-dihydro-2-methyl-1, 4-oxathiin-3-carboxanilide, alone and in combination. No fungicide seed treatment gave significantly higher germination percentage than captan 0.94 g ai/kg, the rate used commercially. Germination was higher for some fungicide seed treatments than for the control (untreated), but most responses were not significant. Initial seedling stands for the control and the captan seed treatments were higher in field than in greenhouse evaluations, but coating the seed with either carboxin or captan + carboxin gave higher initial stands in the greenhouse. Final stands for all treatments were higher in field because of lower disease pressure from *Rhizoctonia solani* and *Fusarium* spp. than in greenhouse tests. Both pre- and post-emergence damping-off were more severe in greenhouse than in field tests. Slightly higher stands were obtained with the high rate of the fungicide seed treatments. All formulations of each fungicide gave similar results when used at comparable rates of active ingredient. Carboxin was superior to captan in increasing plant populations under severe disease infestations. Stands were higher for captan + carboxin than for either fungicide used alone but were lower than the sum of the effects of each fungicide alone.**


***Additional index words:* *Gossypium hirsutum*, Seedling diseases, Seedling emergence, Pest control, Human exposure.**

PRACTICALLY all cottonseed (*Gossypium hirsutum* L.) used for planting in the United States is treated with protectant fungicides, and most are also treated with a systemic fungicide (4, 5, 7, 9, 10). From the mid-1950's until 1971 alkyl-mercury fungicides were the major seed protectants applied to cottonseed (3, 8). When the use of these fungicides was prohibited in 1971, the seed processors immediately switched to application of nonmercurial protectant fungicides that were already available but were not being used commercially. Primarily wettable powder formulations of systemic fungicides were developed during the 1960's to use with the alkylmercury fungicides. Some of the recently developed emulsion, emulsifiable-concentrate, flowable, and oil-base formulations of both protectant and systemic fungicides are being used at lower rate of active ingredient than is used with wettable powder formulations (2, 4, 5). Liquid suspension of fungicides are easier to mix and apply than wettable powders, but more information is needed on performance of different formulations and concentrations of fungicides. The purpose of these studies was to determine whether formulations and rates of application of captan and carboxin applied alone and in combination on cottonseed affects germination, seedling emergence, and survival.

## MATERIALS AND METHODS

Acid-delinted seed of 'Stoneville 213' cotton was coated with captan, *N*-[(trichloromethyl)thio]-4-cyclohexene-1, 2-dicarboximide, and carboxin, 5,6-dihydro-2-methyl-1, 4-oxathiin-3-carboxanilide, in the formulations and at the rates shown in Table 1. When two fungicides were used, they were applied sequentially. The fungicides were mixed with water, 2% by seed weight, to ensure uniform distribution on the seed. Each fungicide suspension was applied to a small lot of seed with a hand sprayer, and the seed was then tumbled 5 min in a rotating drum to ensure uniform coverage and drying (6). The untreated and captan 75 WP (wettable powder) at 0.94 g ai/kg of seed, the rate used commercially, treatments served as a control and standard, respectively.

Six samples of 100 seeds of each treatment were germinated at alternating 20/30 C (standard procedure) and at constant 18 C 4 weeks after application of the fungicides. Standard seed germination procedures were used to record percentage germination (1).

An Amarillo loam soil (a member of the fine-loamy, mixed thermic Aridic Paleustalfs) heavily infested with *Rhizoctonia solani* Kuhn, and *Fusarium* spp. was used in the greenhouse tests. Greenhouse plantings in randomized complete blocks were made 25 April, 25 May, and 24 July. The ambient temperature ranged from 20 to 30 C. Eight replicates were included in the first planting and three in the second and third ones. In each test, 40 seeds were planted per plot.

Field tests were planted 11, 18, and 31 May in an Amarillo loam soil at Lubbock, Tex. Field test planted 18 May was established where cotton stands were destroyed by severe seedling disease after planting 20 April. In each test, six replicates of 100 seeds per treatment were planted in a randomized complete block design. The minimum and maximum daily ambient temperatures ranged from 14 to 20 C and 20 to 33 C, respectively. The lowest temperature occurred 1 to 8 June, and the highest 22 to 26 June.

Plant counts in the greenhouse and the field tests were recorded 14 (total emergence) and 35 (final stand) days after planting. The data were subjected to analysis of variance. Duncan's multiple range test was used to locate significant differences among treatment means. The data are shown as the percentage of the seed planted.

## RESULTS AND DISCUSSION

At both temperature regimes, no treatment gave significantly higher percentage of germination than captan at 0.94 g ai/kg of seed, the standard (Table 1). However, significant differences in percentage of germination occurred among the treatments at both temperature regimes. At 20/30 C, only seed treated with captan 75 WP + carboxin 75 WP (0.94 + 1.88 g ai/kg) had significantly higher percentage of germination than the control. Percentage of germination for all other fungicide seed treatments except captan 75 WP

[1] A contribution from the Cotton Res. Lab., AR, SEA, USDA, and Texas Agric. Exp. Stn., Lubbock. Received 2 Apr. 1979.

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[3] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be available.

**Table 1. Percentage of germination in the laboratory at two temperative regimes and of emergence and survival (14 and 35 days after planting) in greenhouse and field tests with acid-delinted Stoneville 213 cottonseed coated with different formulations and rates of captan and carboxin.***

| | | Germination | | Greenhouse | | Field | |
|---|---|---|---|---|---|---|---|
| Treatment† | Dosage | 20/30 C | 18 C | Emergence | Survival | Emergence | Survival |
| | g ai/kg | % | | | | | |
| Control (no fungicide) | - | 86 b-e | 84 a-d | 32 c | 12 dc | 43 c | 33 c |
| Captan 75 WP | 0.54 | 81 ef | 83 a-e | 36 c | 8 c | 54 ab | 44 ab |
| Captan 75 WP (standard treatment) | 0.94 | 90 ab | 87 ab | 50 b | 15 cde | 53 ab | 40 b |
| Captan 29.5 FE | 0.54 | 87 a-d | 80 b-e | 31 c | 10 e | 54 ab | 42 ab |
| Captan 30 FOB | 0.54 | 90 ab | 86 abc | 31 c | 5 e | 51 ab | 42 ab |
| Carboxin 75 WP | 0.77 | 84 c-f | 85 abc | 53 b | 26 abc | 48 bc | 41 b |
| Carboxin 75 WP | 1.88 | 84 c-f | 83 a-e | 54 ab | 28 ab | 51 ab | 39 b |
| Carboxin 17 F | 1.88 | 83 def | 88 a | 52 b | 26 abc | 52 ab | 41 b |
| Carboxin 29.5 FE | 0.77 | 87 a-d | 77 de | 49 b | 23 bcd | 49 bc | 39 b |
| Carboxin 30 FOB | 0.77 | 89 abc | 77 de | 50 ab | 26 abc | 52 bc | 42 ab |
| Captan 75 WP + carboxin 75 WP | 0.94 + 1.88 | 92 a | 84 a-d | 66 a | 36 a | 56 a | 47 a |
| Captan 75 WP + carboxin 17 F | 0.94 + 1.88 | 79 f | 81 a-e | 60 ab | 28 ab | 53 ab | 42 ab |
| Captan 75 WP + carboxin 75 WP | 0.54 + 0.77 | 87 a-d | 76 e | 56 ab | 29 ab | 51 ab | 42 ab |
| Captan 29.5 FE + carboxin 29.5 FE | 0.54 + 0.77 | 89 abc | 69 f | 55 ab | 27 abc | 54 ab | 43 ab |
| Captan 30 FOB + carboxin 30 FOB | 0.54 + 0.77 | 89 abc | 79 cde | 56 ab | 25 abc | 52 ab | 42 ab |

* Within each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test, field and greenhouse data are the means of three planting dates. † Abbreviations: WP = wettable powder; FE = flowable emulsion; FOB = flowable oil base; F = flowable.

+ carboxin 17 F (flowable), (0.94 + 1.88 g ai/kg) and the control was similar, even though some fungicide treatments had slightly higher values than the control. Captan 75 WP + carboxin 17 F performed well at 18 C indicates that this treatment was not phytotoxic.

At 18 C only two treatments gave germination percentages significantly different from that of the control. Low percentage of germination was obtained for WP and FE (flowable emulsion) captan + carboxin. These responses did not appear to be used by phytotoxicity, since germination was high at 20/30 C.

The data indicated that the quality of this seed was was comparable to the quality of the seed planted on a high percentage of the cotton acreage in the United States. Thus, adverse effects would not be expected to occur from application to planting seed.

In all greenhouse tests the average total seedling emergence was higher for all fungicide treatments, except captan at 0.54 g ai/kg, than the control (Table 1). The maximum percentage of initial stand among the single fungicide treatments was obtained with carboxin 75 WP (1.88 g ai/kg), but this treatment did not give significantly higher initial stand than other treatments with this chemical and captan 75 WP (0.94 g ai/kg). Emergence was slightly higher with combination than with single treatments, but were lower than the sum of the effect of each fungicide alone.

The trends in efficacy established for seedling emergence in the greenhouse tests were apparent in seedling survival (Table 1). A highly significant correlation (r = 0.94) occurred between seedling emergence and survival in the greenhouse. All seed treatments containing carboxin increased the average stand over that of the control and all formulations of captan applied at 0.54 g ai/kg of seed. Carboxin alone and in combination with captan gave higher stands than those with the low rate of captan. Stands were generally related to the amount of active ingredient of the fungicides for single and combination treatments, but plant populations were similar for identical rates of active ingredient of different fungicide formulations.

Significant differences in stands 14 and 35 days after planting the field tests occurred among seed treatments (Table 1). Similar trends occurred in seedling emergence among the treatments within each field test, even though they were about 10 and 20% lower in field tests planted 18 and 31 days than 11 May. Pre-emergence mortality was higher in the tests planted 18 and 31 May than the earlier one because cool, rainy weather suitable for disease development occurred after these later planting dates. A much higher incidence of damping-off occurred in the test planted 18 May than in the other tests. This response was believed to be related to build up of pathogen following the planting on 20 April.

Average seedlings emergence in the field tests was significantly higher for all fungicide treatments except carboxin 75 WP and carboxin 29.5 FE at 0.77 g ai/kg of seed than that of the control. Among the treatments, maximum initial plant stand was permitted by the high rate of captan 75 WP + carboxin 75 WP, but this fungicide treatment was not superior to captan, carboxin 17 F, or carboxin 30 FOB (flowable oil base) alone and combinations of these fungicides.

Average seedling survival in the field tests differed significantly among the treatments. Seedling emergence and survival were correlated (r = 0.94) in the field tests. Thus, effective treatments controlled both pre- and post-emergence damping-off. Similar trends in stands occurred among the treatments within each test. Final plant populations were similar in tests planted 11 and 31 May but were about 20% lower for each respective treatment in the test planted 18 May. The lower stands in this test were associated with the April planting of cotton, which apparently increased the inoculum level of seedling disease pathogens. All fungicide treatments permitted consistently higher stands than the control in the field tests, where disease pressures were lower than in the greenhouse tests.

The average stands for the greenhouse and field tests showed that captan gave higher stands in field than in greenhouse tests, but carboxin gave similar stands in both tests sites. These responses were caused by much higher levels of infection of seed and seedlings by *R. solani* and *Fusarium* spp. in the greenhouse than in the field tests. The primary cause of damping-off was caused by *R. solani*. The disease was most severe in the greenhouse tests. The most infection in the field occurred in the test planted 18 May. High plant population was observed with the high rates of captan 75 WP + carboxin which suggest that high rates of fungicide combinations should be used for establishing maximum stands of cotton for a wide range of environments.

All formulations of both fungicides appeared to be equally effective when comparable rates of active ingredients were applied to cotton-seed. Since all formulations applied to cottonseed gave higher stands under a wide range of test conditions than the untreated seed, these fungicides should perform well when used commercially on planting seed. The flowable formulations of both fungicides are easier to mix and appear to adhere to the seed coats more tenaciously than the wettable powder. Thus, the flowable formulations of fungicides could reduce human exposure and pollution during treating and handling of treated seed.

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