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Influence of Mechanical Damage and Fungicide Seed Treatments on Germination and Stand with Cottonseed[1]

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ABSTRACT

Mechanical damage to the seed coat of cotton (*Gossypium hirsutum* L.) seeds may occur during harvesting, ginning, and processing. The extent of damage varies considerably among seed lots and it is impossible to remove all damaged seed while processing seed for planting. Fungicide-treated and non-treated seed with damaged seed coats germinate slower and produce poorer stands than seed with nondamaged seed coats. The percentage germination at standard temperatures in the laboratory and the stands and seedling growth in the greenhouse were inversely related to the extent of damage to the seed coat of acid-delinted cottonseed. Scratches or cracks in the seed coats that did not expose the embryonic tissues adversely affected germination and stand less than did damage that exposed the embryonic tissues. Coating cottonseed with fungicides improved the performance of all seed classes, but the most improvement was obtained from seed with a damaged seed coat. However, no fungicide treatment completely compensated for the damage to the seed coat.

Additional index words: **Seedling weight, Seedling disease, Seed protectants, *Gossypium hirsutum* L.**

SEED quality of cotton (*Gossypium hirsutum* L.) is an important factor in stand establishment. Lack of an adequate stand necessitates replanting (which is expensive) and reduces pesticide effectiveness associated with low-vigor seedlings (4, 6, 10). Late crops can result from poor-quality planting seed and they are usually affected more by low temperature and frost than early crops. The damage to late crops can be caused by adverse weather during the period of maturation to harvest.

High-quality seed is essential for the production of uniformly vigorous stands, maximum yields, and early maturity (4, 7, 9, 10, 12, 13). Seed quality is determined primarily by the climatic conditions before harvesting. However, mechanical damage to seed during harvesting and processing can also reduce seed quality (2, 4, 10).

Low-quality seed has been shown to be a contributing factor to the development of seedling diseases. Besides causing stand establishment problems, seedling disease damages the root system of surviving plants, affects the uptake of moisture and nutrients by these plants, and intensifies the damage caused by other diseases and insects (3, 12, 13).

The objectives of this study was to determine the effects of various degrees of damage to the seed coat and embryo on seed index, germination, and plant stands of cottonseed treated with fungicides.

MATERIALS AND METHODS

Acid-delinted seed of 'Stoneville 213' cotton were treated with commercially-used fungicides either alone or in combinations such as follows: I, none (check), untreated; II, captan, *N*-[(tricholormethyl)thio]-4-cyclohexene-1,2-dicarboximide, wettable powder (WP) 75%; III, captan, flowable (F) 29.5%; IV, carboxin, 5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide WP 75%; V, carboxin, F 29.5%; VI, CERESAN M,[3] *N*-(ethylmercuri)-*p*-toluenesulfonanilide, WP 7.7%; VII, chloroneb, 1,4-dichloro-2, 5-dimethoxybenzene, F 29.5%; VIII, PCNB-ETMT (TERRA-COAT) L-21, mixture of pentachloronitrobenzene and 5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole, liquid suspension (S) 22.8 to 11.4%; IX, thiram, bis (dimethylthiocarbamoyl) disulfide, F 29.5%.

The seed for all treatments was separated into five classes (5) based on damage to the seed coat and embryo: Class I—no visible damage; Class II—seed coat scratched or bruised, but not broken; Class III—seed coat broken, but embryonic tissues are not visible; Class IV—seed coat broken, portions of embryonic tissues visible; Class V—large sections of all of the seed coat removed with some damage to the embryo. The fungicides were applied to small lots of seed in a rotating drum and tumbled about 5 min to insure uniform coating of the seed (8). All WP and liquid formulations except PCNB-ETMT L-21 were diluted with water (2% by weight of the seed) before the fungicide suspension was sprayed with an atomizer onto the tumbling seed. When two or more fungicides were used on a sub-lot of seed, a plus (+) between their names indicate that they were mixed and applied singly. The seed was allowed to dry between application of each fungicide.

Seed in each class was weighed (g/100) and standard procedures (1) were used for germination in a randomized complete block design with 10 replications of 10 seeds. Observations were made to determine seedling size (including root development) and frequency and type of disease organisms present. The organisms were identified directly from the seed.

Seed was also planted in Amarillo loam soil (a member of the fine-loamy mixed, thermic Aridic Paleustalfs) in the greenhouse. The experimental design was a randomized complete block with 12 replications. Ten seeds were planted per plot and were covered with 1.3 cm of moist soil. Greenhouse temperatures ranged from 16 to 33 C. Seedling counts were recorded periodically and at the conclusion of the experiment both fresh and oven-dry weights of the surviving seedlings were recorded. Also, cotyledons of seedlings were observed for size and distortions. The data were subjected to analysis of variance and means were separated utilizing Duncan's multiple range test.

RESULTS AND DISCUSSION

Seed Index. Seed indexes (g/100 seed) varied significantly among seed classes (Table 1). The heaviest seed was in Class I, but its weight was not significantly different from the weights for Classes III and IV. Seed of Class V had a significantly lower index than the seed in all other classes.

Germination. Growth of the organisms from seed in the germinator was directly related to the extent of seed coat damage. *Rhizopus* spp. was the primary or-

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[3] This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation by the USDA nor does it imply registration under FIFRA.

Table 1. Relationships of classification of damaged seed to seed index, germination, seedling emergence, survival, and oven-dry weight in Stoneville 213 cotton averaged across all fungicide treatments.*

		12 days		24 days	
Seed class†	Seed index	Germination, laboratory	Total emergence, greenhouse	Seedling survival, greenhouse	Seedling wt., greenhouse‡
	g/100 seeds	%			g
I	9.4 a	90 a	87 a	84 a	0.22 a
II	9.0 b	87 a	80 b	78 b	0.20 b
III	9.3 ab	79 b	75 c	68 c	0.17 c
IV	9.3 ab	60 c	62 d	50 d	0.13 d
V	8.0 c	27 d	30 e	20 e	0.08 e

* Within columns means followed by the same letter are not significantly different at P ≈ 0.05 by Duncan's multiple range test. † Seed classes: Class I ≈ no damage; Class II = seed coat scratched or bruised, but not broken; Class III = seed coat broken but embryo tissues not visible; Class IV = seed coat broken and embryo tissues visible; Class V = large section or all of seed coat removed, with damage to the embryo. ‡ Seedling weight was based on the number of surviving seedlings.

Table 2. Relationship of seed treatments to germination and seedling emergence, survival, and oven-dry weight in Stoneville 213 cotton averaged across all seed classes.*

		12 days		24 days	
Treatment	Dosage	Germination, laboratory	Total emergence, greenhouse	Seedling survival, greenhouse	Seedling wt., greenhouse
	g/kg	%			g
None (check)	–	51 e	48 c	42 c	0.17 ab
TERRA-COAT L-21	7.4	65 d	45 c	40 c	0.16 ab
CERESAN M	1.2	72 abc	74 ab	68 ab	0.18 a
Captan F—carboxin F, 29.5% each	1.8–2.5	69 bcd	70 b	64 ab	0.16 ab
Captan F—chloroneb F, 29.5% each	1.8–4.2	74 a	69 b	63 b	0.15 b
Thiram F—carboxin F, 29.5% each	2.5–2.5	73 ab	77 a	70 a	0.15 b
Captan F—carboxin F—chloroneb F, 29.5% each	1.8–2.1–4.2	67 cd	69 b	64 ab	0.16 ab
Carboxin 75 WP + captan 75 WP	2.4 + 1.2	72 abc	72 ab	65 ab	0.16 ab
Captan F—thiram F—chloroneb F, 29.5% each	1.3–1.3–2.5	75 a	75 ab	66 ab	0.15 b

* Within columns means followed by the same letter are not significantly different at P = 0.05 by Duncan's multiple range test.

ganism growing from seed, but bacteria were also present. These organisms occurred on about 1 and 10% of the seed in Classes I and V, respectively. Intermediate values occurred on Classes II through IV. Most organisms originated inside the seed coat or from the embryo and were not controlled with the fungicides.

Percentages of germination in the laboratory differed significantly among the seed classes (Table 1). The overall average germination percentage by seed classes was inversely related to the extent of damage to the seed coat with the largest difference occurring between Classes IV and V. Seedling size, including root development, was inversely related, while percentage of nub-root seedlings was directly related to the level of damage to the seed coat. A significant correlation coefficient ($r = 0.84$) for the averages of all seed classes was obtained for seed weight vs. germination percentage.

Percentage germination for seed treatments averaged across all seed classes differed significantly (Table 2). The percentage germination for each respective seed class was significantly higher for fungicide treated than for the untreated seed lots. The highest germination was obtained with seed coated with captan-chloroneb and the lowest germination was with untreated seed.

The interaction of seed class × seed fungicide treatment on percentages of germination was significant ($P < 0.05$). Small differences were obtained in the percentages of germination between seed in Classes I and II, and in some instances among the seed in Classes I, II, and III, for each respective seed fungicide treatment (Fig. 1). Germination was consistently higher with Class III than with Class IV and Class IV was higher than Class V.

Stand. Total seedling emergence among seed classes 12 days after planting in the greenhouse (Table 1) was related ($r = 0.88^*$) to seed weight. Also, the percentage of total seedling emergence differed significantly among seed classes and was inversely related to the amount of damage to the seed coat. Each succeedingly greater damage class performed significantly poorer than the preceeding one representing a trend similar to that obtained for germination. A significant correlation coefficient (r) for seed in Classes III and IV and for the averages for all seed classes was obtained between laboratory germination and seedling emergence in the greenhouse (Table 3). The other values were not significant and all were positive except for Class I. The largest r value was obtained with Class III and the smallest with Class I.

The interaction of seed class × fungicide treatment on percentage of seedling emergence was significant ($P < 0.01$). Thus, fungicide treatments did not always perform similarly across all seed classes (Fig. 2). Most fungicide-treated seed in Classes IV and V produced significantly sparcer stands than those obtained

Table 3. Relationship of classification of damaged seed to correlation coefficients (r) for percent germination and seedling emergence, survival, and dry weights in Stoneville 213 cotton averaged across all fungicide treatments.

	Correlation coefficient					
	For indicated seed class					
Characters correlated	I	II	III	IV	V	Overall avg.
% germination vs. % total emergence	−0.17ns	0.62ns	0.92**	0.68*	0.59ns	0.81**
% total emergence vs. % seedling survival	0.99**	0.99**	0.98**	0.99**	0.98**	0.99**
% germination vs. % seedling survival	−0.25ns	0.62ns	0.90**	0.69*	0.46ns	0.80**
% seedling survival vs. seedling dry wt.	−0.60ns	−0.65*	−0.54ns	0.11ns	0.92**	−0.24ns

*,** Significant at the 0.05 and 0.01 levels, respectively; ns = nonsignificant.

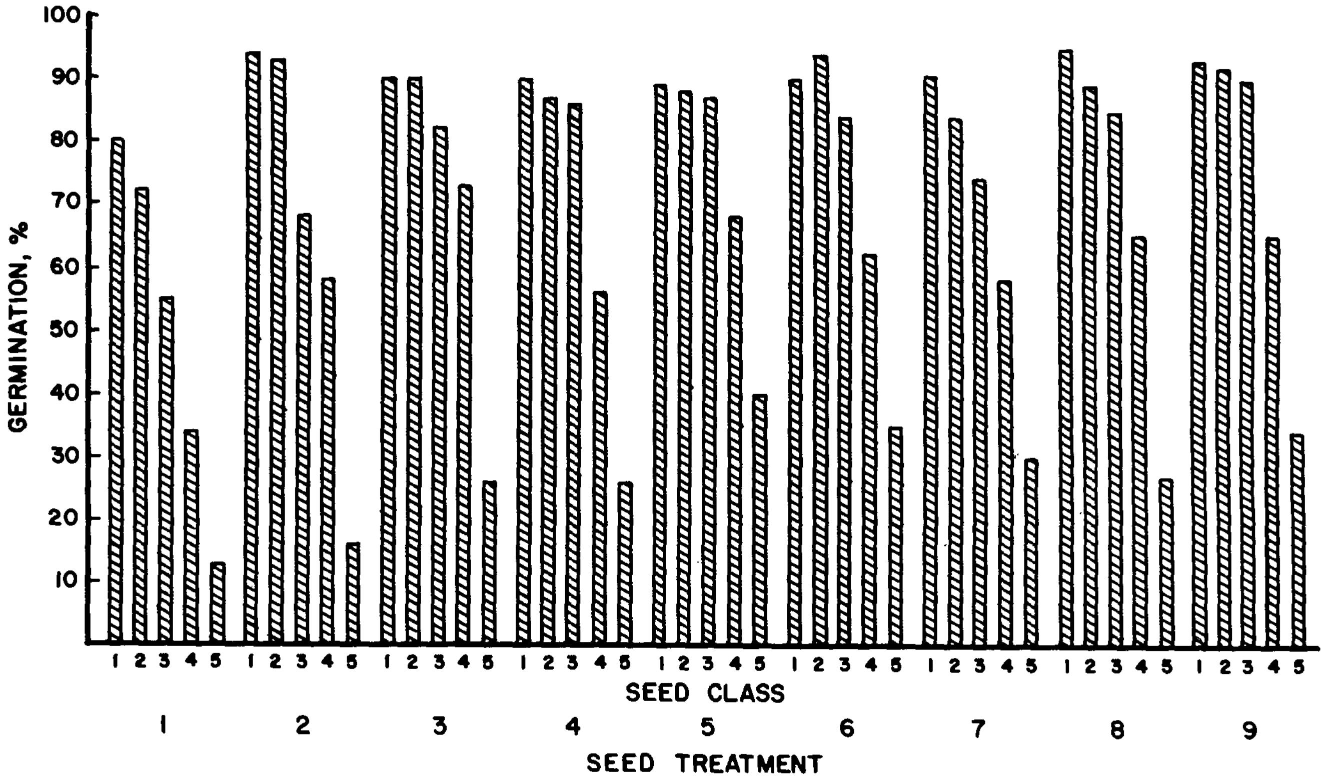

Fig. 1. Effect of seed damage and fungicide treatments on germination of Stoneville 213 cotton seed. Seed classes: I = no visible damage; II = seed coat scratched or bruised, but not broken; III = seed coat broken, but embryo tissues not visible; IV = seed coat broken and portions of embryo visible; V = large areas of seed coat removed and embryo damaged. Fungicide treatments with rates (g/kg of seed): 1 = none (check); 2 = PCNB-ETMT L-21, 7.5; 3 = CERESAN M, 1.2; 4 = captan-carboxin, 29.5 F each, 1.8-2.5; 5 = captan-chloroneb 29.5 F each, 1.8-4.2; 6 = thiram-carboxin, 29.5 F each, 2.5-2.5; 7 = captan-carboxin-chloroneb, 29.5 F each, 1.8-2.1-4.2; 8 = carboxin + captan, 75WP each, 2.4 + 1.2; 9 = captan thiram-chloroneb, 29.5 F each, 1.3-1.3-2.5.

from seed in preceeding classes. Class I seed had the highest percentages of emergence across all but three (CERESAN M, captan-carboxinchloroneb, and carboxin 75WP + captan 75WP) fungicide treatments. In Class I, the only significant difference among seed treatments was between PCNB-ETMT 21 and thiram-carboxin. In Class II, all fungicide treatments except PCNB-ETMT L-21 and captan-chloroneb gave significantly higher total seedling emergence than the check. In Classes III, IV, and V, total seedling emergence for the check and the PCNB-ETMT L-21-treated seed was similar, but all other seed fungicide treatments performed significantly better than these.

Seedling survival in the greenhouse was related (r = 0.82*) to seed size. The percentage of seedling survival in the greenhouse test differed significantly among seed classes and followed the same trends noted for germination in the laboratory and total seedling emergence in the greenhouse (Table 1). Significant correlation coefficients were obtained for germination and seedling survival with seed in Classes III and IV and with the averages for all seed classes (Table 3); similar trends were obtained for total seedling emergence and germination. In all cases, a highly significant correlation was obtained between seedling emergence and survival (Table 3). The difference between seedling emergence and survival ranged from 3% for Class I to 12% for Class IV; values of 2, 7, and 10% were obtained for Classes II, III, and V, respectively. Thus, fungicide treatments applied to seed with a damaged seed coat increased stands.

The significant interaction of seed class × seed treatment on seedling survival was significant ($P < 0.01$). Seedling emergence and survival for each seed class generally followed the same trend among fungicide treatments (Fig. 2). However, the ratio among seed-

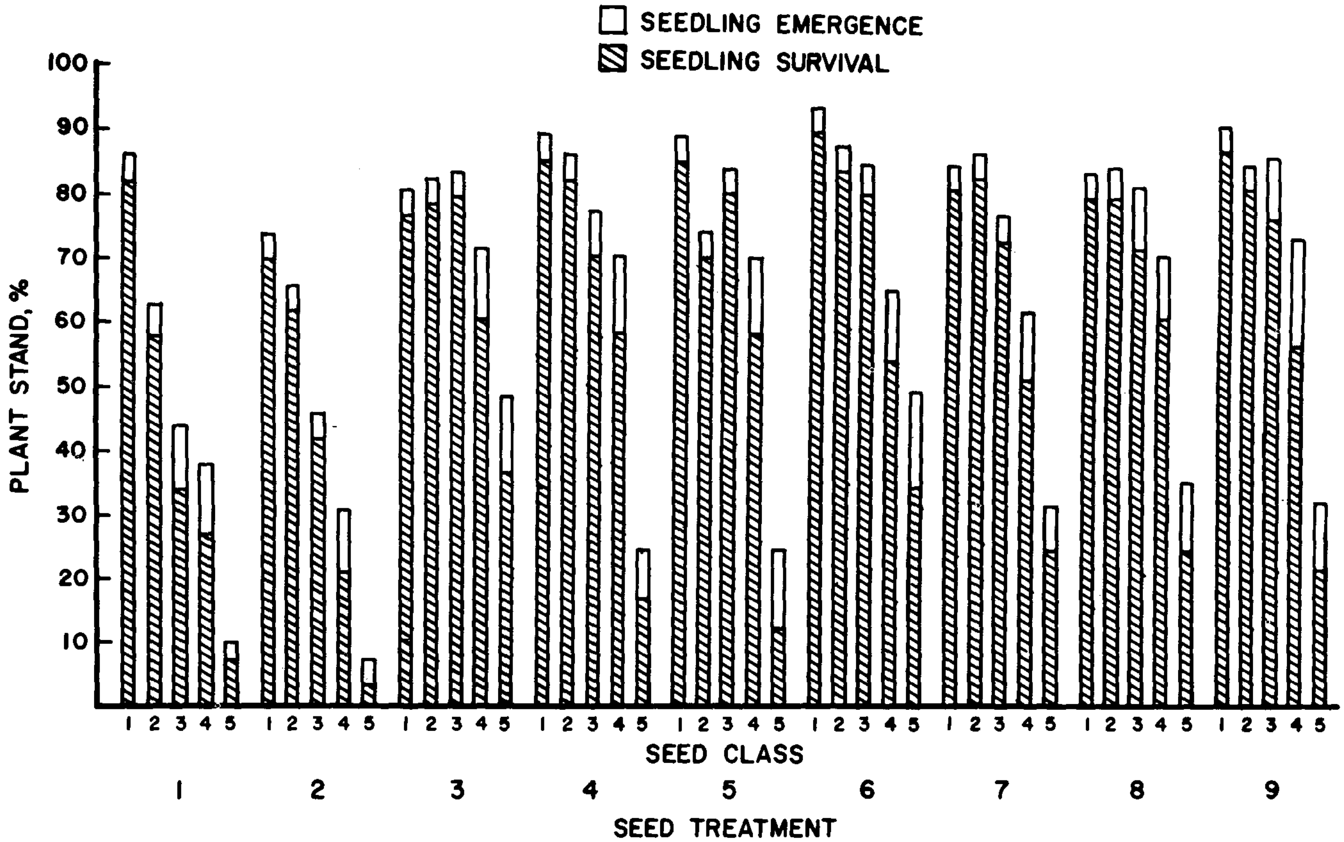

Fig. 2. Effects of seed damage and fungicide treatments on emergence and survival of Stoneville 213 cotton seedlings in the greenhouse. Seed classes: I = no visible damage; II = seed coat scratched or bruised, but not broken; III = seed coat broken, but embryo tissues not visible; IV = seed coat broken and portions of embryo visible; V = large areas of seed coat removed and embryo damaged. Fungicide treatments with rates (g/kg of seed): 1 = none (check); 2 = PCNB-ETMT L-21, 7.4; 3 = CERESAN M, 1.2; 4 = captan-carboxin, 29.5 F each, 1.8-2.5; 5 = captan-chloroneb, 29.5 F each, 1:8-4.2; 6 = thiram-carboxin, 29.5 F each, 2.5-2.5; 7 = captan-carboxin-chloroneb, 2.95 F each, 1.8-2.1-4.2; 8 = carboxin + captan, 75WP each, 2.4 + 1.2; 9 = captan-thiram-chloroneb, 29.5 F each, 1.3-1.3-2.5.

ling emergence and survival varied among seed classes and seed treatments.

Seedling Weight. Seedling weights in the greenhouse test (Table 1) were indirectly related to the extent of damage to the seed coat ($r = -0.99^{**}$). Seedling weights varied less among fungicide treatments than among seed classes. More variation occurred in seedling weight among fungicide treatments for seeds with severely damaged seed coats than for seeds that had little or no damage to the seed coat.

The cotyledons of most seedlings in Classes IV and V were small and distorted with missing areas. Most of the seedlings in these classes died in a few days or were severely stunted in both laboratory and greenhouse test. Damaged seed also produced small seedlings that would probably have been less productive than the more vigorous seedlings. Reduced root growth, which could impair the uptake of soil water and nutrients, was also associated with the small seedlings.

Our data indicate that seed fungicides can partially offset the deleterious effects associated with damaged seed coats, but previous studies did not show this response (4). However, thiram-carboxin, captan-thiram-chloroneb, carboxin 75WP + captan 75WP, and CERESAN M provided the highest germination, and seedling emergence and survival of the fungicides tested. Additional studies with other fungicides are needed to determine the most effective fungicide treatment for seed with mechanical damage. High-quality, undamaged, and fungicide-treated seed should be planted to obtain maximum germination, and seedling vigor and survival. Maximum yield and early maturity are obtained with high quality fungicide-treated cottonseed (11).

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