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Abstract. Southern pine seed coated with repellents can be stored for at least one year, even after stratification, without losing viability or becoming dormant, and with no reduction in potency of endrin in the coating.

IN DIRECT seeding, it often becomes necessary to hold stratified, repellent-coated seed for a few weeks when bad weather delays operations. Occasionally seed must be stored until the following year.

While several investigators have stored coated seed for short periods (2, 3, 4, 5), only one of the studies was maintained for a full year (2) and it was with seed coated with anthraquinone. This chemical does not exhibit phytotoxic effects, whereas the Arasan compounds that have superseded it in general use depress germination slightly. Moreover, powdered Arasan 75, used in the short-term studies cited, has been replaced by Arasan 42-S, a white liquid.¹

The study reported here included both forms of Arasan, and storage was for 1 year. The study was also designed to: (a) compare storage of repellent-treated seed at 25° and 34°F; (b) determine the necessity of drying stratified seed prior to storage; (c) investigate the effect of restratification on dried, coated seed; and (d) evaluate the potency of endrin in repellent coatings after storage.

Experimental Procedures

Longleaf, loblolly, shortleaf, and slash pine seed collected in the fall of 1961 was cleaned to approximately 100 percent soundness and dried to moisture contents of 8 to 9

percent. It was stored in moisture-proof containers at 25°F until August 1962, when the study was installed. Seed lots of each species were divided to provide for three replications, and treatments were applied as outlined below.

Slash pine seed was stratified for 30 days and loblolly and shortleaf for 60 days; longleaf seed is nondormant and hence was not stratified. Stratification consisted of placing moistened seed in cheesecloth bags between layers of wet peat moss and refrigerating at 34°F. Companion sublots were stored dry in moisture-proof containers at 25°F.

Stratified and unstratified lots were subdivided for three repellent treatments: (a) 10 percent Arasan 75 plus 2 percent Stauffer's Endrin 50W with a sticker of Dow Latex 512-R diluted 1:9 with water; (b) the new formulation containing two gallons of the liquid repellent Arasan 42-S, 4 percent Dow Latex 512-R, and 2 percent Stauffer's Endrin 50W, applied at the rate of two gallons per 100 pounds of seed; and (c) an untreated check. Aluminum powder was added to the repellent coatings to form a light overlay.

After coatings were applied, sublots were again divided for storage in sealed containers at two moisture levels. The high level was the moisture content the seed reached during stratification or repellent application. It ranged from 12 to 17 percent for unstratified, repellent-coated seed, and from 30 to 35 percent for stratified seed. The low level was obtained by drying seed to 8 or 9 percent moisture; samples of seed thus dried were restratified for 30 days before germination was

tested at the end of each storage period.

A final division of all sublots resulting from the previous treatments was made to provide for storage at 25° and 34°F.

Seed from each treatment was sampled for initial germination tests. The remainder was sealed in polyethylene bags and tested after 45, 90, 180, and 360 days of storage.

In a side test, stratified loblolly seed was treated with the standard Arasan 42-S and endrin repellent, with and without an aluminum overcoating. Samples for analyses of endrin content² were taken initially and again after each storage period, the purpose being to evaluate any possible reaction of endrin with the aluminum. Arasan contents were not analyzed, for this compound is relatively stable.

Results

Viability.—As Table 1 indicates, repellent-coated or stratified seed from pines of all four species can be stored for one year with no loss of viability. No apparent changes in viability developed up to 180 days; hence results from interim periods are not tabulated.

With a few exceptions, unstratified seed of all species kept well at all moisture contents and both temperatures. Viability declined 8 percentage points or more in only two treatments—loblolly treated with Arasan 42-S and stored with high moisture at 34°F, and longleaf treated with Arasan 75 and held at a low moisture content and 34°F.

²Chemical analyses were conducted by the Feed and Fertilizer Laboratory of the Louisiana Agric. Expt. Sta., Baton Rouge.

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¹Mention of trade names in this article is solely for necessary information, and implies no approval of products to the exclusion of others that may also be suitable.

Table 1.—Germination of Southern Pine Seed After 12 Months' Storage

Repellent	Strati- fication	Moisture content during storage	Storage tempera- ture	Strati- fication after storage	Loblolly		Shortleaf		Slash		Longleaf	
					Initial	After 1 year	Initial	After 1 year	Initial	After 1 year	Initial	After 1 year
			°F		Percent							
None	Unstrat.	Low	25	No	84	80	64	60	87	89	78	77
			34	No	86	85	66	68	91	87	72	78
	Strat.	Low	25	No	89	83	84	89	91	90	----	----
			34	No	86	89	85	76	87	87	----	----
		High	25	No	87	84	85	83	82	87	----	----
			34	No	91	76	90	77	89	79	----	----
		Low	25	Yes	88	89	94	89	92	92	----	----
			34	Yes	93	89	91	84	90	87	----	----
	Avg.				88	84	82	78	89	87	75	78
	Arasan 75 + endrin	Unstrat.	Low	25	No	73	79	61	71	88	86	43
34				No	76	75	61	61	82	83	70	56
High		25	No	78	77	61	71	84	84	50	63	
		34	No	85	86	67	65	82	86	64	60	
Strat.		Low	25	No	85	89	79	78	78	81	----	----
			34	No	85	82	77	77	81	83	----	----
		High	25	No	85	74	82	71	83	75	----	----
			34	No	82	80	83	74	81	79	----	----
		Low	25	Yes	92	75	86	82	77	63	----	----
			34	Yes	83	86	88	77	79	79	----	----
Avg.				82	80	74	73	82	80	57	59	
Arasan 42-S + endrin		Unstrat.	Low	25	No	77	77	62	56	81	87	68
	34			No	85	79	48	55	73	77	69	74
	High	25	No	77	74	55	61	77	83	75	74	
		34	No	83	73	60	54	82	83	71	79	
	Strat.	Low	25	No	85	85	76	79	87	87	----	----
			34	No	87	85	81	78	86	90	----	----
		High	25	No	87	81	82	77	82	82	----	----
			34	No	89	75	83	65	87	78	----	----
		Low	25	Yes	86	83	83	79	78	77	----	----
			34	Yes	90	87	80	76	82	79	----	----
	Avg.				85	80	71	68	82	82	71	74

Stratified seed stored at low moisture and subfreezing temperature had no substantial loss in viability. Decreases of 8 percentage points or more occurred in one-third of the treatments with stratified seed, but all involved high moisture content, the higher storage temperature, or both factors. Storage at 34°F of stratified seed with a high moisture content consistently decreased germination of all species.

Restratification after storage was not detrimental to untreated seed or that coated with liquid Arasan 42-S. Half of the lots coated with Arasan 75 and restratified, however, dropped 11 to 17 percentage points in germinability.

In general, the repellent coatings had no influence on storage ability. Restratified lots excepted, major decreases in viability occurred in four treatments with uncoated seed and four with each of the repellent coatings. The repellents lessened initial germination, especially with longleaf. This effect has been noted repeatedly in past work, and it is

usually considered to be a result of testing in small, confined germination dishes where chemicals quickly accumulate. Under field conditions, differences are negligible (1).

None of the treatments resulted in unsatisfactory germination after a year of storage. The greatest drop was 18 percentage points—in stratified shortleaf coated with Arasan 42-S and stored with high moisture at 34°F—but this lot still had 65 percent viability. The average decrease for all species and treatments was less than 2 percentage points.

Dormancy.—Storage affected dormancy (Table 2) more than viability. The criterion for assaying dormancy was the proportion of total germination that occurred within the first 11 days. For example, if total germination was 80 percent, and 40 seeds out of 100 germinated within the first 11 days of testing, the figure in Table 2 would be 50 percent.

Unstratified loblolly and short-

leaf seed exhibited the greatest degree of dormancy, and stratification greatly hastened germination. When seed of these species was stratified and dried, it entered storage more dormant than undried seed, and there was a further increase to dormancy after storage for a year.

When stratified seed was stored at high levels, however, there was little change in degree of dormancy during storage. Loblolly and shortleaf seed that was stratified, dried, and restratified after storage was slightly more dormant than freshly stratified seed—possibly because stratification was for 60 days before the initial test and for only 30 days before the test after storage.

Uncoated, unstratified loblolly seed stored at 34°F was more dormant after storage than similar seed stored at 25°F. The same was true for unstratified loblolly seed that was treated with Arasan 42-S, although the differences were less pronounced.

Table 2.—Proportion of Total Germination Occurring Within 11 Days After Start of Test

Repellent	Strati- fication	Moisture content during storage	Storage tempera- ture	Strati- fication after storage	Loblolly		Shortleaf		Slash		Longleaf		
					Initial	After 1 year	Initial	After 1 year	Initial	After 1 year	Initial	After 1 year	
					Percent								
None	Unstrat.	Low	25	No	51	56	36	16	83	86	72	70	
			34	No	46	20	50	12	90	90	72	63	
	Strat.	Low	25	No	75	54	76	37	91	93	----	----	
			34	No	78	51	75	32	88	89	----	----	
		High	25	No	93	93	94	91	86	80	----	----	
			34	No	95	90	95	99	89	86	----	----	
		Low	25	Yes	97	85	88	74	96	86	----	----	
			34	Yes	98	79	93	72	91	93	----	----	
Arasan 75 + endrin	Unstrat.	Low	25	No	12	15	22	10	46	45	18	25	
			34	No	14	12	21	13	36	48	15	23	
		High	25	No	25	14	24	14	30	47	39	30	
			34	No	12	11	22	18	44	50	36	26	
	Strat.	Low	25	No	69	68	65	27	43	48	----	----	
			34	No	52	74	69	34	49	61	----	----	
		High	25	No	92	90	78	72	36	51	----	----	
			34	No	89	99	77	89	32	71	----	----	
		Low	25	Yes	90	83	91	67	42	48	----	----	
			34	Yes	91	79	90	73	42	62	----	----	
	Arasan 42-S + endrin	Unstrat.	Low	25	No	23	36	24	12	42	56	72	49
				34	No	23	11	29	14	32	35	77	50
High			25	No	39	31	26	11	40	50	74	56	
			34	No	39	10	33	10	53	48	75	59	
Strat.		Low	25	No	75	74	62	34	73	80	----	----	
			34	No	70	56	56	35	73	82	----	----	
		High	25	No	92	92	78	73	58	68	----	----	
			34	No	96	88	62	93	73	75	----	----	
		Low	25	Yes	98	84	95	58	69	58	----	----	
			34	Yes	98	85	84	71	65	60	----	----	

The slash seed used in this study was relatively nondormant, and no benefits from stratification were apparent after 11 days of testing.

Initial germination was consistently slower for repellent-treated seed than for untreated lots, with the exception of longleaf treated with Arasan 42-S. For loblolly and slash, Arasan 75 slowed germination more than Arasan 42-S.

Stability of endrin.—The chemical analyses showed no deterioration of the endrin after one year of storage. The percentage of endrin contained in samples analyzed before storage averaged 2.6 and 2.5 percent for seed with and without the aluminum coating, respectively; percentages of endrin after storage were 2.5 and 2.9. The differences before and after storage, with and without the aluminum overcoating, were nonsignificant.

Conclusions and Recommendations

Since the only treatments that consistently reduced germination were storage with a high moisture content at 34°F, the seed user has some latitude in the storage conditions he may select for treated seed. Basically, he has two choices:

he may dry the seed before storage, or he may leave it at a high moisture content but store at 25°F. This study and previous experiences are the basis for the following recommendations for storing seed 1 year:

1. Repellent-coated, stratified loblolly and shortleaf seed may be stored at 25°F without drying. Restrification is unnecessary. Drying would provide the safest storage but would necessitate restratification, which is risky with large quantities of repellent-coated seed.
2. Stratified but uncoated loblolly and shortleaf seed should be dried to 10 percent moisture and stored at 25°F. It should be restratified after storage.
3. Stratified slash pine seed, whether coated or uncoated, should be dried to 10 percent moisture and stored at 25°F. Restrification is unnecessary.
4. Repellent-coated longleaf seed should be dried to 10 percent moisture and stored at 25°F. Although longleaf seed is never stratified, moisture is absorbed during the treating process.

Weaker seed may store less well than the lots used in this study, but it is believed all lots may be stored up to 90 days at 25°F with-

out drying or restratification. Caution should be exercised in storing seed with a high moisture content at extremely low temperatures. Although the subject requires more research, it is probable that seed with a moisture content greater than 25 percent is more likely to be damaged at 0°F than at 25°F.

Since chemical analyses showed there was no deterioration of endrin during storage, landowners can sow stored, repellent-coated seed with confidence of protection against rodents. Arasan is known to be stable also.

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