MATURITY AND CURING TEMPERATURES AND THEIR INFLUENCE ON GERMINATION OF REED CANARY GRASS SEED

by

Walter Leo Griffeth

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Farm Crops
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AN ABSTRACT

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MATURITY AND CURING TEMPERATURES AND THEIR INFLUENCE ON GERMINATION OF REED CANARY GRASS SEED
(Abstract)

In this study an attempt was made to determine some of the factors which may contribute to low germination in the production of reed canary grass seed. The seed ripens from the top of the panicle downward and shatters very readily after maturing. When harvested before shattering has started the seed and chaff is high in moisture and difficult to cure. Heating often occurs with this green material and results in lowered germination.

The investigations reported in this paper are:

1. Effect of harvest date and curing temperatures on seed germination. Heads were cut at 2 or 3 day intervals over a 2 week period and dried at several temperatures.

2. Harvest and curing methods. The combine, header, and beater were used to harvest seed. Seed was dried in an experimental drier and spread out on the floor.

3. Seed curing experiment. Combine harvested seed was dried with and without stirring when spread out 3" deep on the floor. Seed was also treated with four fungicides to determine whether mold development could be checked.

The stage of maturity, moisture content of the seed and the temperature at which the seed was dried appeared to be the

critical factors which affected the preservation or loss of viability of the seed. Seed which was harvested early had a high moisture content and germination was reduced markedly when dried above room temperature. Seed harvested when more mature was not damaged appreciably when dried at 40°C.

In the date of harvest experiments as well as in the curing experiment, early harvested seed generally had lower germination than seed from later harvest dates regardless of curing temperature or treatment.

Results from the date of harvest experiment show that for a period of approximately one week, seed losses due to shattering were compensated for by the growth of the immature seeds in the heads so that seed yields were about equal on three or four successive harvest dates. These results indicate that seed harvest with the combine may well be delayed until 5 to 10% of the seeds have shattered and 40 to 50% of the remaining seeds have turned brown.

Seed treated with Arasan germinated slightly higher than untreated seed with much less mold development. Treatment with Actidione, Cerasan M, and Dowcide B caused low germination.

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INTRODUCTION

Reed canary grass (Phalaris arundinacea L.) is native to the temperate areas of North America, Europe, and Asia. This grass species has a wide moisture adaptation but is most commonly planted as a forage crop on low-lying swampy land subject to occasional flooding. The seed ripens from the top of the panicle downward and shatters very readily after maturing. Seed harvest is often difficult because of the wet habitat and seed ripening characteristics.

When harvested before shattering has started the seed and chaff is high in moisture and difficult to cure. Heating often occurs with this green material and results in lowered germination.

In this study an attempt was made to determine some of the factors involved which may contribute to low germination in the production of reed canary grass seed. The investigation was limited to a study of the effects of several harvest methods and seed curing techniques on seed germination.

REVIEW OF LITERATURE

Wilkins and Hughes (8) harvested reed canary grass seed over an eight day period to determine the most satisfactory stage of development. They found that harvesting the seed when the seeds were 5% shattered and 40% of the remaining seeds were ripe (brown) gave the highest germination and yield per acre. In later harvests the germination was equally high but yield was reduced because of shattering loss. Seed harvested when in the late water to late hard dough stage had 45% germination. Germination increased on successive harvest dates.

Smith (7) recommends the use of a scalping device to remove coarse trash from freshly combined material and states that this will greatly speed the drying and cleaning of grass seeds. He further states that freshly harvested seed of all grasses must be spread and dried before final cleaning and storage to prevent spoilage by heating and molding.

Holden (10) found that drying of threshed seed was accomplished when seed was spread out and turned frequently resulting in 90% germination. Seed bagged immediately after threshing germinated 60-70%.

Workers at the Wisconsin Station (11) report the use of the combine to harvest reed canary seed. They suggest, raising the cutter bar high enough to get the heads but leave the stems and leaves, and reducing the cylinder speed to prevent hulling of the seeds. An earlier report from Wisconsin (9) reported the development of a modified grain binder for a header. Heads were cut by a raised cutter bar, collected in a hopper and spread out to dry before threshing.

Garman and Vaughn (4) reported that lots of Kentucky bluegrass seed, delivered to warehouses in bags within three hours after stripping, gave a range of temperature of 123.0° to 145°F. They stated that bluegrass seed allowed to heat to 140°F. even for a short time was worthless, germinating 0 to 6%. According to their work Kentucky bluegrass seed should not be allowed to reach 122°F. while drying, since heating to this temperature lowers the germination of the seeds.

Kearns and Toole (5) reported that the germination of chewings fescue seed decreased 20 to 30 per cent in 4 to 5 weeks when stored in sealed containers

at 14 percent moisture at 30°C. Storage at 10% moisture and 10°C. did not reduce germination. They concluded that relatively high moisture content and high temperatures were the cause of low germination of fescue seed.

Brentzel (2) found Arasan satisfactory as a fungicide for seed treatment and an overdose caused no apparent injury to the seed.

Dawson, et al (3) tested several compounds as to their fungicidal activity in hay. Dowcide 2 (2,4,5-trichlorophenol) and Dowcide 2S (2,4,6-trichlorophenol) at 6 to 8 pounds per ton gave complete control of molds in hay stored at 20% moisture content for 8 weeks.

Richards (6) concluded that Dowcide B (Na 2,4,5-trichlorophenol) was the most promising of several chemicals tested for inhibiting the growth of molds in curing baled hay which had a moisture content of 32 to 37% when baled.

The results of the germination tests of the samples of reed canary grass seed sent in to the seed laboratory of the Michigan Department of Agriculture during 1951 by farmers, elevator operators, and seedsmen for analysis were secured and are shown in Table 1 (12). Thirty-one of the 77 samples (40.3%) germinated less than 60% and were therefore unsaleable according to Michigan seed laws. Forty-eight of the samples

(68.8%) germinated less than 68%. Only 24 samples (31.2%) germinated over 75%. It can be seen from this data that a large proportion of reed canary grass seed offered for sale in Michigan had low germination.

TABLE 1

Distribution of germination results of 77 service samples of reed canary grass seed tested by the Michigan State Seed Laboratory in 1951.

% germination	No. of samples	% of samples
84-91	12	15.6
76-83	12	15.6
68-75	5	6.5
60-67	17	22.1
52-59	14	18.2
44-51	9	11.7
36-43	7	9.1
28-35	0	0
20-27	0	0
12-19	1	1.3
	77	

EXPERIMENTAL PROCEDURE

The methods of harvest and seed curing used by several farmers were observed during the summer of 1950. Seed samples were collected and tested for germination.

In 1951 an experiment was carried out to determine the effect of three drying temperatures on the germination of seed harvested on seven dates over a period of twenty days. Six lots of fifty heads each were cut by hand every two or three days. Three of the lots were threshed by hand and screened lightly. One lot each of threshed and unthreshed seed was dried at each of the three drying temperatures, 55°C, 40°C, and room temperature (approximately 25°C). Seed from a seventh lot was threshed and immediately tested for germination on each harvest date. The experiment was repeated in 1952 with seed from another field and with the addition of two drying temperatures, 70°C., and 10°C. for four weeks followed by 25°C.

During 1951, seed was harvested from a ten acre field by three methods. A conventional 6 foot combine

was modified to cut as high as 50 inches, Figure 1. The combine was also used as a header by removing the concaves and collecting the heads in a canvas which were threshed with the combine when dry. The third method used was a beater device designed to knock the ripe seeds out of the heads without collecting the green seed and chaff. Seed from these harvest methods was dried and later tested for germination.

In 1952, seed harvested with a combine on three dates from a field planted in 1950 was used for drying experiments. The seed from each harvest date was divided into two lots. One lot was run over the fanning mill to remove the chaff and straw. The other lot was used as it came from the combine. Four pound lots of the scalped (cleaned) and the field-run seed were weighed out and placed in boxes approximately 9½ x 11 x 5 inches. This quantity of seed was approximately three inches deep in the boxes. The boxes of seed were arranged on the floor in a semi-circle with an oscillating 12" electric fan circulating the air over the seed, Figure 2.

Two experiments were set up using this seed. Seed from the June 26 and June 30 harvests was used to determine whether frequent stirring of the seed would affect germination. The lots were stirred at 1, 2, 4,

Figure 1. Combine with attachment to raise axle and thereby increase cutting heighth.

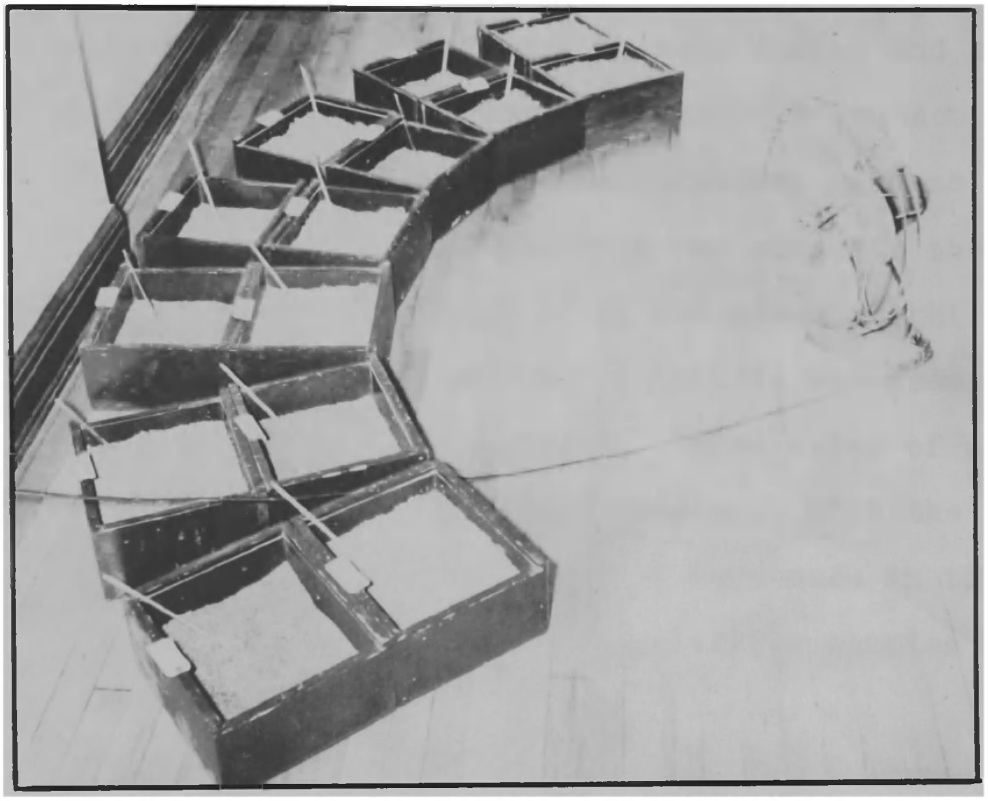

Figure 2. Arrangement for seed drying experiment.

6, and 12 hour intervals along with a check which was not stirred. On June 26, seed was also placed 5 inches deep in boxes and 12 inches deep in grain bags. Temperature readings and germination samples were taken at frequent intervals during the experiment.

Seed from the June 30 and July 2 harvests was used for a fungicide experiment to determine the effect of four selected fungicides on seed curing and seed germination. Arasan, Cerasan M, Dowcide B and Actidione were used as fungicides.[1] Methocel was used as a carrier and sufficient quantity was added to the fungicides to make a total of 1% of the green weight of the seed lots. One rate of each fungicide was used with seed from the June 30 harvest. Three rates of each fungicide (except Dowcide B) were used with the July 2 seed lots. Temperature readings were made in the morning and evening of each day and germination samples were taken after two weeks.

Germination of all samples was performed in duplicate according to the method adopted by the Association of Official Seed Analysts (1) using light, alternating temperatures and KNO_3.

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[1]Arasan and Cerasan M are fungicides recommended for treating agricultural seeds. Dowcide B is sodium 2,-4, 5-trichlorophenol manufactured by Dow Chemical Company. Actidione is a fungicide produced by the Upjohn Company. Methocel is Methyl cellulose produced by Dow Chemical Company.

EXPERIMENTAL RESULTS

Observation of practices used by farmers.

Several farms in Central Michigan were visited in 1950 to observe the methods used in reed canary grass seed harvest. Most of the farmers used the combine to harvest the seed and dried their seed spread out 2-3 inches deep on the barn floor, stirring the seed at intervals to hasten drying. Samples which were collected direct from the combine and carefully dried ranged in germination from 48 to 81%, Table 2. Head samples which were cut from two fields and threshed when dry germinated 93 to 98%.

Two farmers used bin-type driers with unheated forced air to reduce the moisture in the seed. The results were unsatisfactory, the final germination being low. Another farmer attempted to dry his seed in burlap sacks in a corn drier without success.

The most unusual harvest method observed was the use of a beater device mounted on a truck which knocked the ripe seeds out of the heads. The farmer

TABLE 2

GERMINATION OF SEED COLLECTED IN 1950
(ave. of duplicate tests)

Sample No.	Harvest Method and Drying Conditions	Sampled at harvest	Sampled after drying
		% Germ.	% Germ.
3	Combined, spread out 2-3" deep, stirred frequently	72	72
4	Same as 3	65	59
5	" " "	81	66
7	" " "	-	64
8	" " "	-	52
11	" " "	-	79
10	Same as 3 but also cleaned before drying	-	86
2	Combined, dried in improvised bin drier using forced air	48	8
9	Same as 2	-	57
6	Harvested with beater Stored in bags	98	97
1	Heads cut June 29, Dried in head		93
12a	" " July 6, " " "		97
b	" " July 12, " " "		96
c	" " July 12, " " "		98

who made this machine harvested 2000 pounds of clean seed from 25 acres. This seed was harvested late, that is, a large part of the seed had shattered from the heads. The seed germinated 97% when tested by the State Seed Laboratory.

Date of harvest experiment. The data obtained from the date of harvest experiment conducted in 1951 and 1952 are shown on Tables 3 and 4. Germination of fresh seed (seed placed in the germinator on the date of harvest) was somewhat lower than that of seed cured at 25°C. indicating the possibility of primary dormancy particularly at the earlier dates of harvest. Drying at temperatures above room temperature (approximately 25°C.) materially reduced the percent germination of seed of the earlier dates of harvest. As the seed approached maturity there was less reduction of germination by drying at temperatures over 25°C. The lowered germination was probably due to the combined effects of high moisture and high temperature. The lots which were held in the moist cool storage (10°C.) before drying at 25°C. germinated virtually the same as the seed dried immediately at 25°C. This seems to indicate that moisture content alone did not effect seed viability.

Seed yields increased rapidly then remained approximately level for a period of about one week during

TABLE 3. DATE OF HARVEST EXPERIMENT - 1951

Harvest dates	Moisture content	Ave. yield /50 heads	% Germination (ave. of duplicate tests)						
				Drying Conditions					
				55°C.		40°C.		25°C.(1)	
			Fresh seed	H(2)	T	H	T	H	T
	%	gms.	%	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.
6-21	56	6.4	39.0	69.5(3)	37.5(3)	64.5(3)	33.5(3)	71.0	56.5
6-23	47	11.1	64.0	5.5	6.5	74.5	58.0	75.0	67.5
6-25	46	10.4	76.0	8.5	4.0	72.5	55.0	68.0	85.5
6-28	40	10.9	82.5	26.0	36.0	81.5	84.0	91.0	72.0
6-30	36	11.4	89.0	56.5	55.5	92.5	88.5	91.0	93.5
7-3	33	5.8	89.0	74.5	78.5	98.5	97.5	91.0	99.0
7-5	25	3.0	-	67.0	89.5	93.0	-	96.0	96.5

(1) Average room temperature.
(2) H = seed dried in heads, then threshed. T = seed threshed, then dried.
(3) Furnace supplying heat was temporarily out of order.

Field estimate of maturity.

6-21 All heads closed after blossoming. Seed green.
6-23 1% brown seed.
6-25 5-10% brown seed.
6-28 30-40% brown seed. Some shattering.
6-30 60% brown seed. Considerable shattering.
7-3 90% brown seed. " "
7-5 All seed brown. Most of the seed shattered.

TABLE 4. DATE OF HARVEST EXPERIMENT - 1952

Harvest date	Moisture content	Ave. yield /50 heads	% Germination (ave. of duplicate tests)									
				Drying Conditions								
				70°C.		55°C.		40°C.		25°C.(1)		10°C.-25°C.(2)	
			Fresh seed	H(3)	T	H	T	H	T	H	T	H	T
	% H_2O	gms.	%	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.	% Germ.
6-24	66	1.24	0.0	1.0	0.0	0.0	0.0	4.0	8.0	31.0	8.0	20.0	28.5
6-26	48	5.89	30.5	1.0	0.0	2.0	5.0	36.5	39.0	53.0	71.0	38.5	49.5
6-28	33	18.64	61.0	1.0	3.5	12.0	14.5	66.5	76.0	88.5	94.0	75.0	74.0
7-1	26	24.38	78.0	13.5	21.5	44.5	42.0	78.0	84.0	86.0	95.5	89.0	90.0
7-4	23	22.55	65.0	54.5	58.5	58.0	62.0	83.5	91.5	88.0	94.0	86.0	83.0
7-7	25	25.78	74.5	75.5	77.5	75.5	85.0	89.5	88.0	93.0	92.5	92.0	92.0
7-10	18	8.08	80.0	90.5	89.0	83.5	89.0	91.0	91.0	86.5	93.0	94.0	95.0

(1) 25°C. = room temperature.
(2) 10°C. = in high humidity refrigerated room four weeks, then dried at room temperature.
(3) H = seed dried in heads, then threshed. T = seed threshed, then dried.

Field estimate of maturity.

6-24 50% of head still spread following antithesis, all seed green.
6-26 5-10% of heads still partially open. Approximately 1% brown seed.
6-28 5-10% brown seed. No shattering.
7-1 15-20% brown seed. Slight shattering.
7-4 60% brown seed. 10-20% shattered.
7-7 90% brown seed. 20-30% shattered.
7-10 All seeds brown. Most of seed shattered.

which time seed losses due to shattering were equalled by growth of the immature seeds, Charts 1 and 2. Later seed yields were lower due to shattering losses.

The data secured in this experiment seems to indicate that reed canary grass seed harvest should be delayed until at least 50% of the seeds are brown when examined in the field. At this stage of maturity the seed probably would be subject to little if any damage by moderate temperatures which might occur in the curing process.

Harvest and curing methods experiment - 1951.

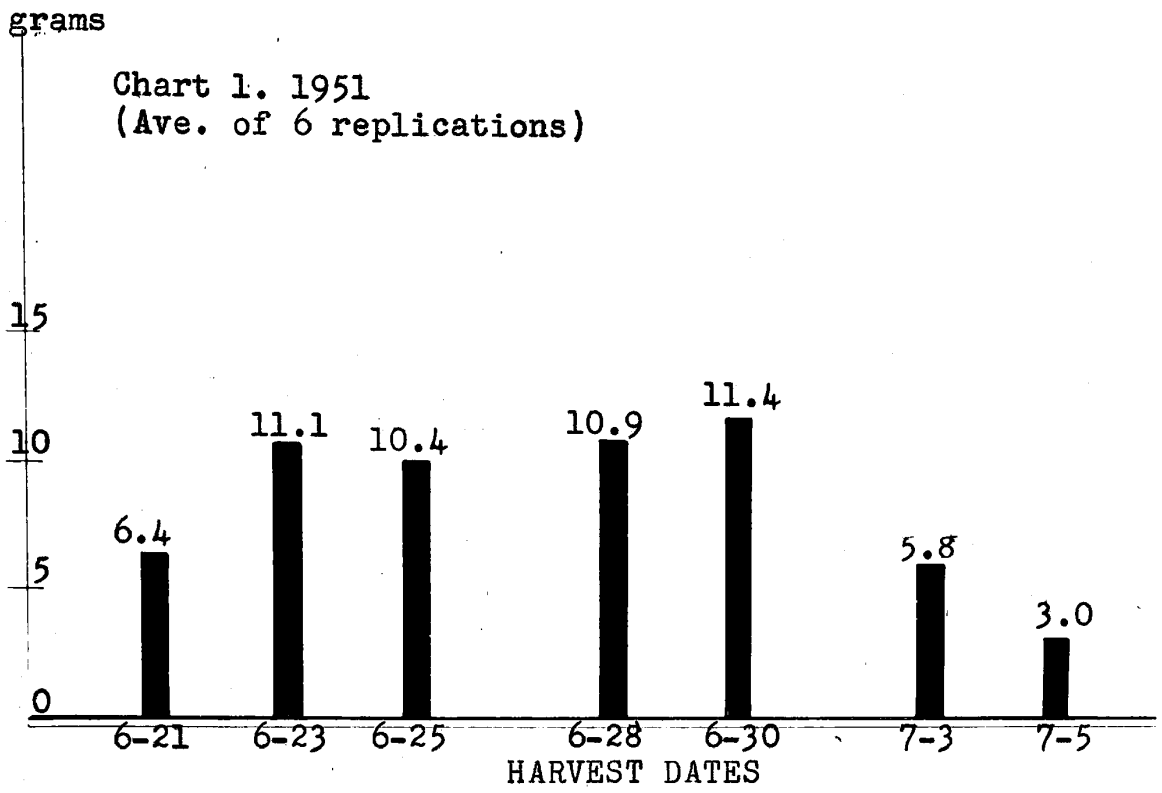
The average seed yields and germination percentages for three harvest methods are shown in Table 5. Seed yields were low because of a poor stand but the data are included for comparative purposes. The header was the most satisfactory method of harvest from the standpoint of yield. An experimental drier which forced unheated air up through a slatted floor was used to dry the heads.

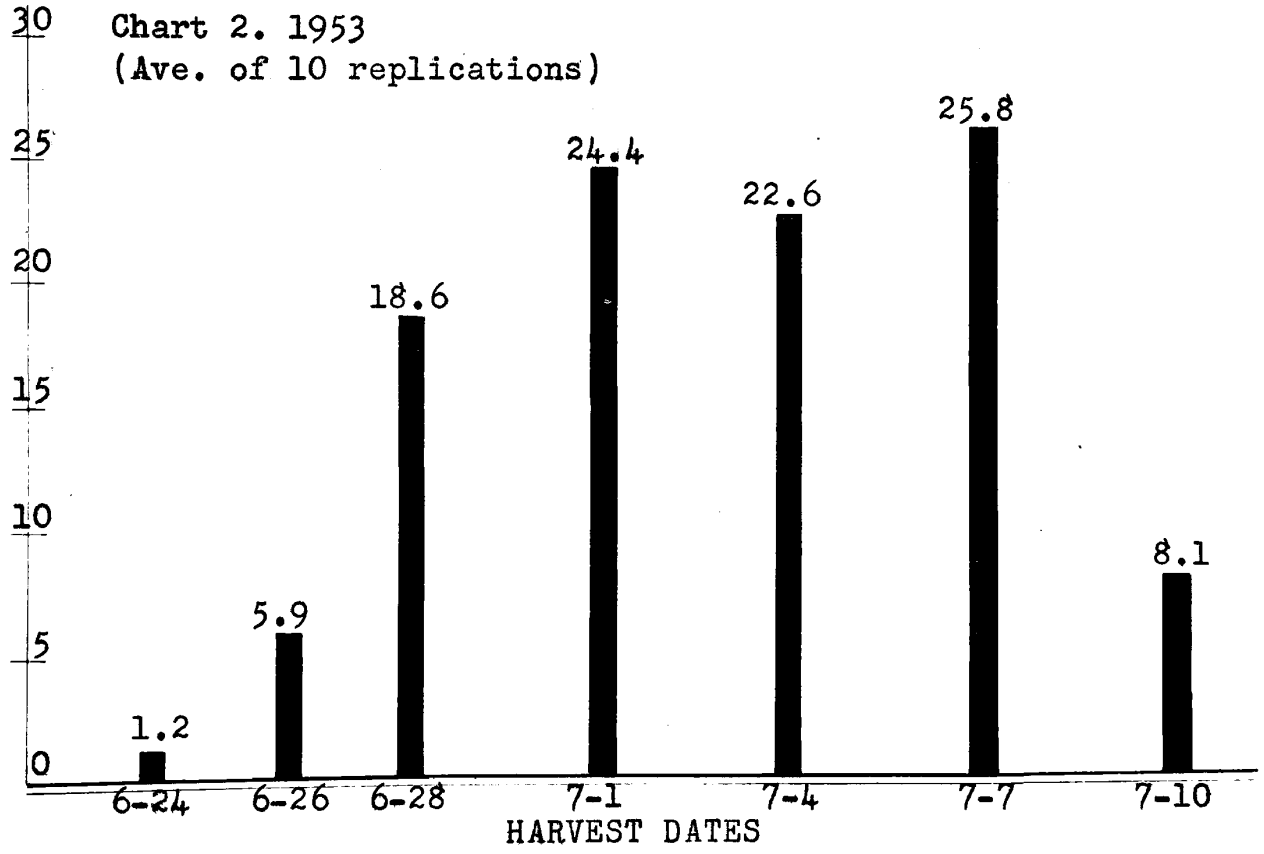
TABLE 5

HARVEST METHODS (FOUR REPLICATIONS)

Method	Yield # per acre	Average Germination %
Header	79	74
Combine	45	67
Beater	15	99

Yield of seed per 50 heads on 7 harvest dates.





The combined seed which was dried in the experimental drier germinated 64% and seed which was dried by being spread out 2 to 3 inches deep on the floor averaged 69% germination. The seed harvested with the beater was stored without drying and averaged 99% germination when tested. The idea behind the use of the beater was the possibility of harvesting dry, ripe seed only two or three times during the season. The beater was tractor mounted and knocked down so much of the grass that it was not practical to go over the area more than once.

Seed curing experiment. The germination of reed canary grass seed harvested on June 26 and June 30 of 1952 is shown in Table 6. Stirring the seed had no apparent effect on the germination. Seed which was not stirred germinated as well as seed which was stirred frequently while drying. Treatment 7, in which seed was 5 inches deep and not stirred, and Treatment 8, in which seed was placed in canvas bags and allowed to stand undisturbed, caused severe injury. Chart 3 shows the temperature curves for treatments 6, 7, and 8 on field run seed harvested June 26. Chart 4 shows the temperature and germination curves for a lot of combine harvested seed allowed to stand in a grain bag in 1951.[1] Appar-

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[1] Bemis A seamless grain bag.

TABLE 6. GERMINATION OF REED CANARY GRASS SEED HARVESTED JUNE 26 AND JUNE 30, 1952
(average of duplicate tests)

Treatment No.	Stirring interval	Depth of seed	Harvested 6/26		Harvested 6/30	
			Field run	Scalped	Field run	Scalped
			% Germ.	% Germ.	% Germ.	% Germ.
1	1 Hr.	3"	22.5	27	59	66
2	2 Hrs.	3"	18.0	32	63	62
3	4 Hrs.	3"	28.5	25.5	59.5	63
4	6 Hrs.	3"	21.5	33	59.0	63
5	12 Hrs.	3"	14.5	22.5	57.5	66
6	Check not stirred	3"	27.5	29.5	61.0	57
7	Check not stirred	5"	4.5	8	-	-
8	In Bemis bag, not stirred	12"	2.0	15.5	-	-
	% H_2O when test began		53	45	47	42.5

Chart 3. Temperatures developed in reed canary seed while curing

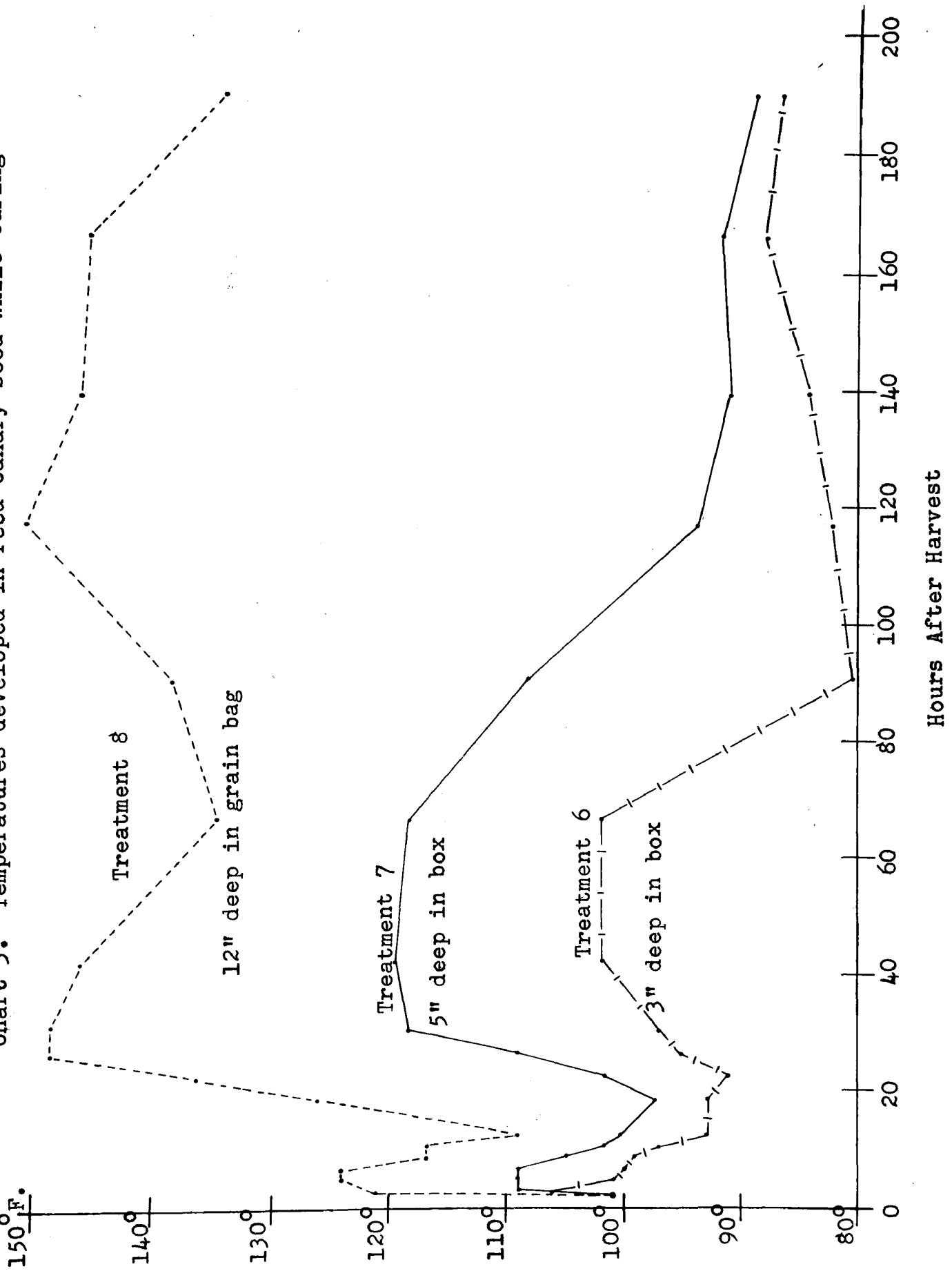
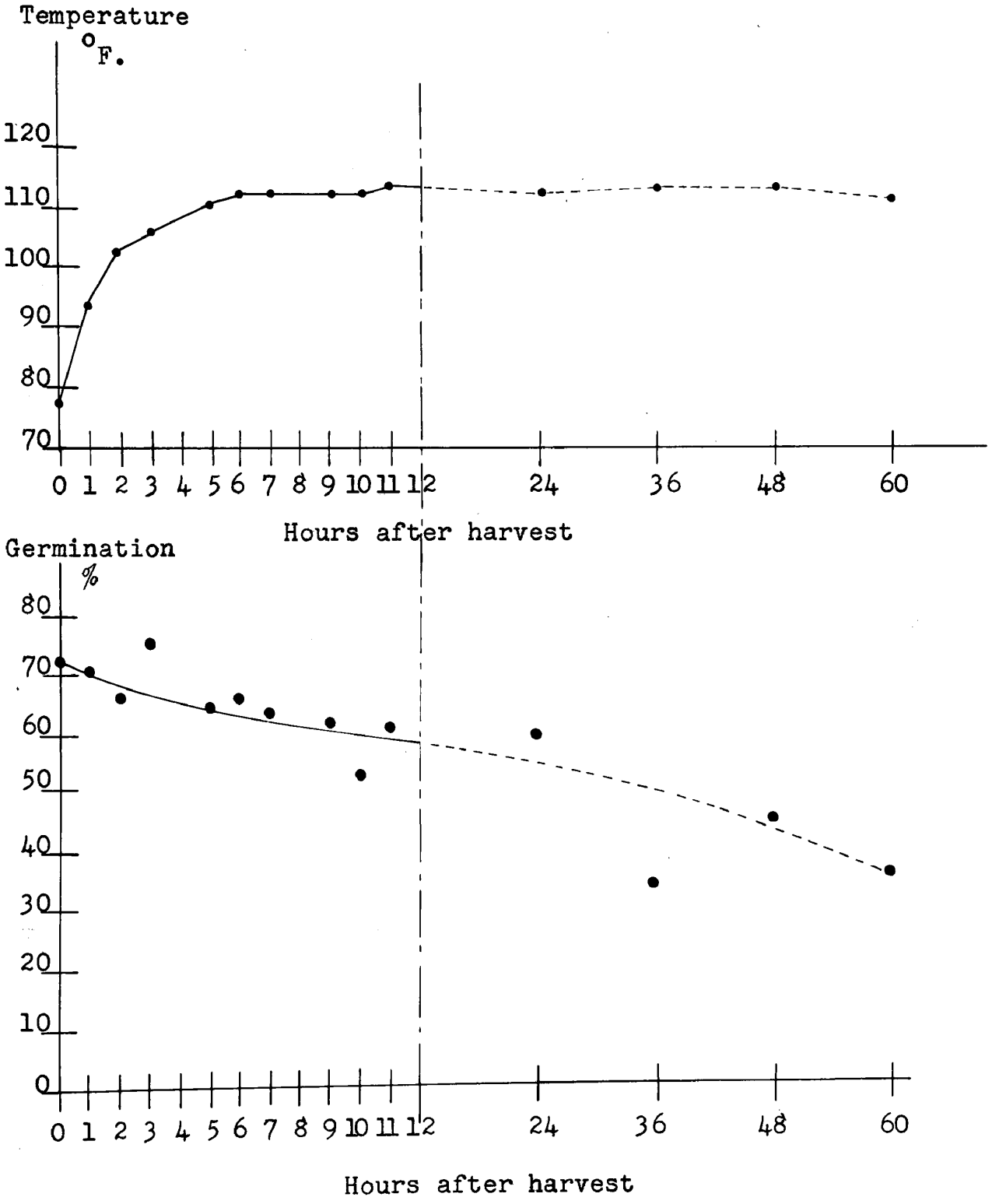


Chart 4. Temperatures developed in bag following harvest and germination of samples taken at same time.



ently the embryos of high moisture seed are quickly affected by temperatures slightly above 100°F. The data for 1951 particularly points out that reed canary grass seed is quickly injured by heating during the curing process.

It is also of interest to note that the germination of seed harvested on June 30 was much higher than that harvested June 26 regardless of treatment.

Seed curing as affected by fungicides. The addition of fungicides, Table 7, appreciably reduced visible evidence of mold development as compared to the check in all treatments except Arasan-(June 30 harvest,) Arasan-(field-run July 2,) and the lower rates of the other fungicides on the field run seed of July 2. Cerasan M, Dowcide B, and Actidione caused reduced germination in all cases. The amount of damage increased with the rate of application of the fungicides. Arasan tended to reduce mold development without reducing germination. Methocel alone apparently had no effect on germination or mold growth. Scalped seed tended to mold less than field run seed probably because of lower moisture content.

When seeds which had been treated with fungicides were germinated it was apparent that Dowcide B, Cerasan M, and Actidione caused abnormal seedling growth. Figure 3

shows representative individual seedlings from each seed treatment. Figure 4 shows ten representative seedlings from seeds treated with Cerasan M which show abnormal plumules.

TABLE 7. GERMINATION OF REED CANARY GRASS SEED TREATED WITH FUNGICIDES BEFORE CURING 3" DEEP IN BOXES WITHOUT STIRRING (Average of duplicate tests)

Treatment	Rate(1)	Harvested 6/30		Harvested 7/2			
		Scalped		Scalped		Field-run	
		% Germ.	Mold(2)	% Germ.	Mold	% Germ.	Mold
Arasan	1/4 %			79	2	74.5	4
	1/2 %	68	3	78	2	79	3
	3/4 %			76	1	76.5	3
Cerasan M	1/8 %			60	0	54	3
	1/4 %	26	0	21.5	0	20.5	0
	1/2 %			15.5	0	1.5	0
Dowcide B	1/4 %			49.5	2	40	3
	1/2 %	8.5	0	14	0	7.5	0
Actidione	1/20 %			66.5	2	66.5	4
	1/10 %	26	1	15.5	1	21.5	1
	3/20 %			14	1	20	1
Methocel	1 %	66	4	77.5	4	73	4
Check		57	4	73	4	73	4

(1) Rate is % of total weight of seed material. Methocel was added as a carrier to make a total of 1 % added material.

(2) Mold rating scale.
0 = no apparent mold
1 = slight sticky feeling
2 = soft clumps of seed
3 = soft caked
4 = mycelia clearly visible, seed caked together

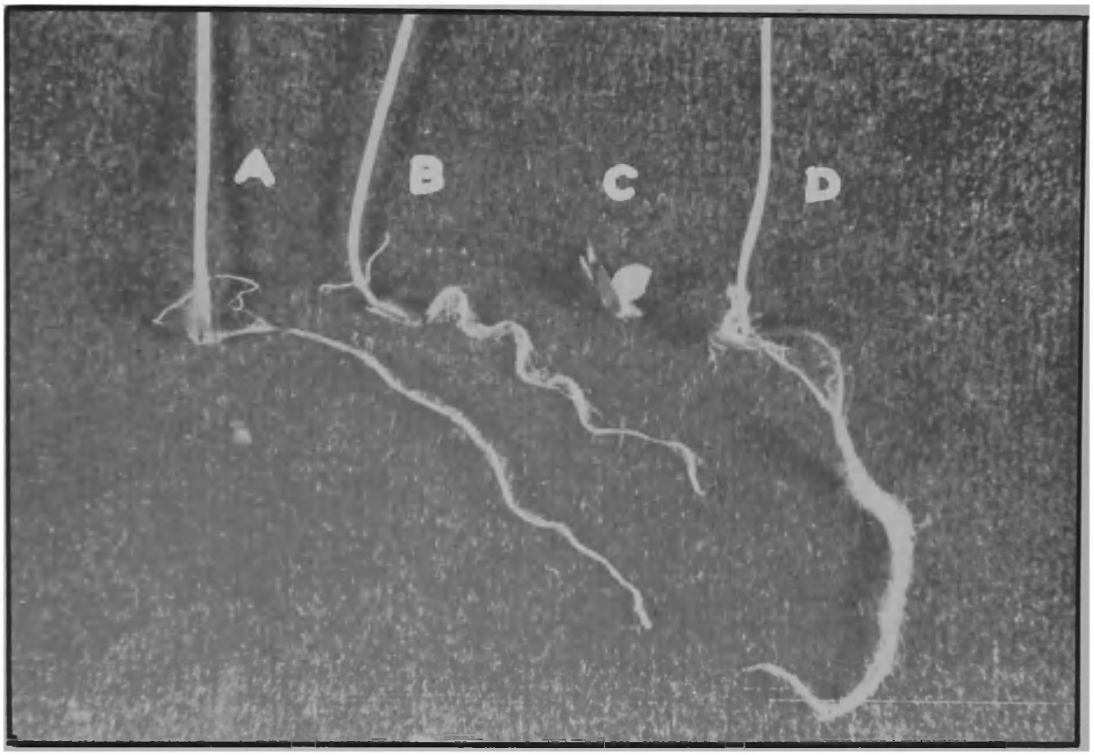


Figure 3. Seedlings from fungicide treated seed.

A. Treated with Arasan - normal seedling.

B. Treated with Dowcide B - curly root.

C. Treated with Cerasan M - stubby plumule.

D. Treated with Actidione - prolific root hair development.

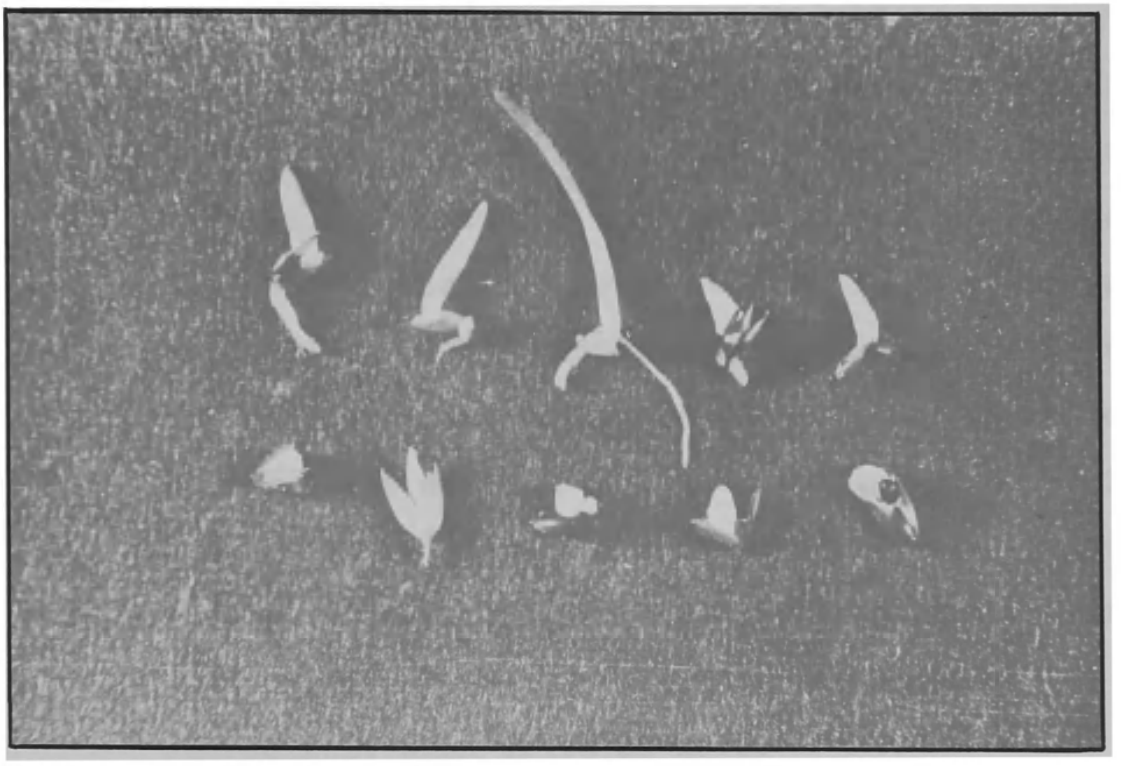


Figure 4. Seedlings from seed treated with Cerasan M.

DISCUSSION

An examination of the data presented in this study indicates that low germination of reed canary grass seed is often due to faulty curing techniques. The stage of maturity and moisture content of the seed and the temperature at which the seed was dried appeared to be the critical factors which affected the preservation or loss of viability of the reed canary grass seed. Seed which was harvested early had a high moisture content and the germination was reduced markedly when dried above room temperature. Seed harvested when more mature was not damaged appreciably when dried at 40°C.

In the date of harvest experiments as well as in the curing experiment, early harvested seed generally had lower germination than the seed from later harvest dates regardless of curing temperature or treatment.

Results from the date of harvest experiment show that for a period of approximately one week seed losses due to shattering were compensated for by the growth of the immature seeds in the heads so that seed

yields were about equal on three or four successive harvest dates. These results indicate that seed harvest with the combine may well be delayed until 5 to 10% of the seeds have shattered and 40 to 50% of the remaining seeds have turned brown. This is in agreement with conclusions reached by Wilkins and Hughes (8) who said that maximum yield was reached when the seeds were 5% shattered and 40% of the remaining seeds were brown.

CONCLUSIONS

1. The germination of reed canary grass seed is often reduced by a combination of high moisture and high temperature during curing.
2. Seed lots which contain more than 30% moisture should not be dried at a temperature above 100°F.
3. Reed canary grass seed which matures on the plant usually has a high germination.
4. Seed yields on successive dates of harvest increase rapidly until shattering starts. Yields remain relatively constant during the period that seeds in the base of the head are ripening. Apparently seed losses due to shattering are equalled by growth of the immature seeds.
5. Seed harvest with the combine should be delayed until 40 to 50% of the seeds are brown when examined in the field.
6. Seed piled over 3" deep or allowed to remain in bags was damaged quickly by heating.
7. In this experiment stirring the seed frequently, while drying at the 3" depth, had no apparent effect on germination as compared to seed which

was not stirred. However, stirred seed dried faster than seed which was not stirred.

8. Seed scalped before drying had slightly higher germination than seed dried as it came from the field.

9. Arasan mixed with wet seed tended to reduce mold development without lowering germinations.

10. Cerasan M, Dowcide B, and Actidione inhibited the development of molds and reduced germination seriously.

11. Treatment of seed with Arasan before curing shows promise as insurance against mold development during the curing process.

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