EFFECTS OF SEED TREATMENT ON THE VIABILITY OF TOUGH AND DAMP CEREAL AND FLAX SEED[1]

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Abstract

Wheat, barley, oat, and flax seed with high natural moisture contents, and untreated or treated with fungicidal or dual-purpose seed treatment chemicals were sealed in jars and stored in an unheated room (-3.5C to 23.5C). Germination tests were made on filter paper immediately after treatment, and on both filter paper and in soil after storage for 42–47 days and 192–264 days. Germination of tough and damp grain was higher in soil, especially cold soil (9.0C and 15.5C), than on filter paper. It is recommended that germination tests on all such grain be made in soil just prior to seeding because of possible dormancy or deterioration by fungi. Deterioration of tough and damp grain by fungi is usually retarded or prevented in the winter months by cold weather. Therefore seed from the crop of the previous fall can be sown providing results from germination tests made in soil are satisfactory. Tough and damp seed of flax generally responded to seed treatments, but cereals did not. Although tough and damp seed more than 1 year old tends to be infected by storage molds, germination of untreated seed was not reduced at 192–264 days if the original moisture content of the cereals was below 19.0% and of flax below 14%. It is recommended that cereal seed containing more than 19.0% moisture not be sown, because germination will be reduced by storage molds against which seed treatments are usually ineffective. However, there are indications that compounds that contain maneb can reduce storage molds.

Introduction

It has been estimated that 72% of the grain harvested in Alberta, Saskatchewan, and Manitoba in 1968 was tough or damp (3). Although the entire area is rarely so generally affected, excessive rainfall occurs in small areas nearly every year. Each year, therefore, the question is asked, "Can damp grain be used for seed?" Information on the effect of chemical seed dressings on such grain is needed. Koehler and Bever (6) found that volatile mercury compounds reduced germination as the dosage, contact time, or moisture content of the grain increased. Campbell (2) showed that wheat, barley, and oats with moisture contents of 16% or more could not be stored for 2 years without deterioration, and his results indicated that treatment of such seed with fungicides did not improve storage qualities. Machacek et al. (8) found that seed containing 18.5% moisture molded when stored for 14 weeks at room temperature and the percentage germination declined to a low level irrespective of whether mercurial, insecticidal, or dual-purpose treatments were used. Because artificially moistened seed was used in these tests the workers did not encounter the prolonged dormancy phenomenon which often occurs in naturally damp grain.

The present study on effects of seed treatment materials on naturally damp grain was undertaken because formulations have changed in recent years; non-mercurials and drill box treatments that require no storage are now commonly used.

Materials and methods

Seed of wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), and flax (*Linum usitatissimum* L.) grading either tough or damp and produced in 1968 within 50 miles of Winnipeg, Manitoba, was used. Moisture determinations were made on each sample according to AACC Method 44–18 (1).

Grains are graded tough when seed contains the following moisture levels: wheat 14.6–17.0%, barley 14.9–17.0%, oats 14.1–17.01, flax 10.6–13.5%. Wheat, barley, and oat seed is graded damp when the moisture content exceeds 17.0%, and flax seed is graded damp at levels exceeding 13.5%.

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Sixteen seed treatment dressings were used. The manufacturers of these compounds* and the active ingredients, where known, are as follows:

Chipman Chemicals Ltd.: Agrox DB (1.79% phenyl mercuric acetate + 0.25% ethyl mercuric chloride [1.25% Hg equivalent]); Mergamma DB (1.79% phenyl mercuric acetate + 0.25% ethyl mercuric chloride + 18.75% gamma BHC from lindane [1.25% Hg equivalent]); Agrox NM (37.5% maneb + 10.0% hexachlorobenzene); and Mergamma NM (37.5% maneb + 18.75% .gamma BHC from lindane).

Du Pont of Canada Ltd.: Ceresan M (7.7% ethyl mercury-p-toluene sulfonanilide [3.20% Hg equivalent]).

Green Cross Products: Res-Q (20.0% hexachlorobenzene + 20.0% captan + 15.0% maneb) and Res-Q Dual Purpose (16.0% hexachlorobenzene + 16.0% captan + 12.0% maneb + 30.0% gamma BHC from lindane).

Niagara Brand Chemicals: Polyram (53.5% zinc activated polyethylene thiuram disulphide); Polyram + aldrin (26.7% Polyram + 25.0% aldrin); and Polyram + lindane (26.7% Polyram + 25.0% lindane).

Nor-Am Agricultural Products Ltd.: Panogen PX (0.9% methyl mercuric dicyandiamide [0.60% Hg equivalent]); Panogen 15B (3.7 oz/gal methyl mercuric dicyandiamide [2.5 oz/gal Hg equivalent]); Pandrinox PX (0.72% methyl mercuric dicyandiamide + 20.0% heptachlor [0.48% Hg equivalent]); Pentadrin A (1.6 lb/gal quintozene + 2.6 lb/gal aldrin); and Pentadrin PX (13.2% quintozene + 20.0% heptachlor).

Uniroyal Ltd.: Vitavax (75% 5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide).

For each treatment 200 g of seed and an appropriate quantity of fungicide were placed in a sealed 1-liter glass jar and shaken thoroughly; the fungicide:grain ratio used was that recommended for field application (Table 1). The tightly sealed jars were stored in a room where the temperature during the storage period (December 16, 1968 to September 6, 1969) ranged from -3.5C to +23.5C. Samples of both treated and untreated grain were taken at time of treatment and 21, 42, and 192-264 days after treatment. Effects of treatment material and storage time on the microflora and percentage germination of the seed and on plant development were determined.

Table 1. Formulation and dosage of seed treatment materials

Treatment	Form*	Dosage (g/kg)			
		Wheat	Barley	Oats	Flax
Agrox DB	Du	2.10	2.60	3.70	4.40
Mergamma DB	Du	2.10	2.60	3.70	4.40
Agrox NM	Du	2.10	2.60	3.70	4.40
Mergamma NM	Du	2.10	2.60	3.70	4.40
Ceresan M	WP	0.52	0.65	0.92	1.10
Res-Q	Du	1.05	2.60	3.70	4.40
Res-Q Dual Purpose	Du	1.30	2.60	3.70	4.40
Polyram	Du	1.05	1.30	1.85	2.22
Polyram + aldrin	Du	2.10	2.60	3.70	4.40
Polyram + lindane	Du	2.10	2.60	3.70	4.40
Panogen PX	Du	2.10	2.60	3.70	4.40
Panogen 15B	Sn	0.80	0.98	1.20	1.70
Pandrinox PX	WP	2.60	3.25	4.60	5.55
Pentadrin A	Sn	2.10	2.60	3.70	4.40
Pentadrin PX	Du	2.60	3.25	4.60	5.55
Vitavax	WP	2.10	2.60	3.70	4.40

* Formulation code: Du = dust, Sn = solution, WP = wettable powder.

*Sources: Chipman Chemicals Ltd., Hamilton, Ontario; Du Pont of Canada Ltd., Toronto, Ontario; Green Cross Products, CIBA Co. Ltd., Montreal, Quebec; Niagara Brand Chemicals, Burlington, Ontario; Nor-Am Agricultural Products Ltd., Woodstock, Illinois; Uniroyal Ltd., Elmira, Ontario.

To determine the microflora on the seed, a No. 3 Whatman filter paper disc (9 cm) in a petri dish was moistened with 5 ml distilled water, and 25 seeds were placed on it in a circular pattern near the periphery. The plates were exposed to daylight at room temperature (ca. 23C) for 7 days, after which

the microflora of each seed was examined microscopically.

Evidence for phytotoxicity was obtained by sowing seeds 4 cm deep in a mixture of soil, sand, and peat (3:1:1) (7). Phytotoxic effects were shown by abnormalities of the seedling root and plumule. To determine the effect of temperature on germination and phytotoxicity, seeds were planted in moist soil in pots and kept at 9.0C, 15.5C and 27.0C with 16 hr/day fluorescent light. Replicates consisting of two pots each containing 25 seeds were sown 2 weeks apart and the seedlings were examined for phytotoxic symptoms upon emergence (7–21 days after sowing).

Results and discussion

Untreated seed

Germination of seed on filter paper immediately before storage varied from 17% in flax to 86% in one oat sample (Table 2); germination percentages tended to be slightly higher after 42 days storage. For samples stored for 192–264 days, the germination percentages of all the wheat samples and two of the three flax samples were considerably higher than for earlier tests, but for oat sample no. 4, both barley samples, and flax sample no. 10, germination percentages were much lower. No storage fungi were found on the seed plated on filter paper immediately before storage, suggesting that the low initial germination was due to dormancy. High moisture content of the seeds together with long storage periods favor development of storage fungi, which may have contributed to the depressed germination in some of the samples stored for prolonged periods.

Percentage germination of untreated seed in soil was always higher than on filter paper, and it was higher in cold soil (9C and 15.5C) than in warm soil (27C), suggesting that seeding in cold soil reduced dormancy.

Treated seed

Most fungicides had little effect on percentage germination of cereals on filter paper (Table 3) or in soil. However, Agrox NM increased germination of wheat, and most treatments increased the percentage germination of flax. Vitavax decreased germination of all four crops.

Addition of an insecticide to the fungicide, as in the dual purpose seed dressings, sometimes increased and sometimes decreased germination. However, lindane, unlike heptachlor or aldrin, produced phytotoxic effects in roots and plumules of seedlings on filter paper, but not in soil, after 42–47 days post-treatment storage. After 200 days post-treatment storage, lindane-treated wheat samples No. 1 and No. 2 showed a marked reduction in germination in soil in some instances, but no symptoms of

Table 2. Percentage germination* and microflora of untreated seed after different intervals in sealed storage

Type of test	Days stored	WHEAT Sample no. 1	2	3	OATS Sample no. 4	5	BARLEY Sample no. 6	7	FLAX Sample no. 8	9	10
Moisture content (%)	0	19.6	19.9	17.3	19.2	16.4	19.6	19.6	11.7	11.6	14.2
Grade (moisture)**	0	D	D	D	D	T	D	D	T	T	D
Filter paper test											
Germination	0	18	22	80	86	83	15	60	71	17	48
	42	30	22	94	84	90	18	75	83	7	65
	192-264	62	59	98	45	79	5	0	86	43	25
Aspergillus spp.	0	0	0	0	0	0	0	0	0	0	0
	42	0	0	0	0	0	0	0	0	0	0
	192-264	88	76	82	48	0	100	100	0	8	68
Penicillium spp.	0	0	1	0	0	0	0	0	0	0	1
	42	0	0	0	0	0	0	0	0	0	9
	192-264	28	20	0	20	4	40	8	0	0	76
Soil test											
Germination % at:								[a]			
9.0C	47	78	91	97		92		97			29
15.5C	47	71	77	97		94		91			49
27.0C	47	52	43	90	98	90	31	78	67	44	37

* Mean percentage of four replicates of 25 seeds.
** Grade (moisture): D = damp, T = tough.

Table 3. Percentage germination* on filter paper of untreated seed and treated seed immediately after treatment

Treatment	WHEAT Sample no. 1	2	3	OATS Sample no. 4	5	BARLEY Sample no. 6	7	FLAX Sample no. 8	9	10
Check (untreated)	18	22	80	86	83	15	60	71	17	48
Mercurials										
Panogen 15B	20	22	80	87	90	19	62	85	20	75
Panogen PX	26	14	86	93	85	19	49	85	19	70
Agrox DB	31	19	93		86		41			84
Ceresan M	16	9	85	93	90	18	50	90	40	69
Non-mercurials										
Agrox NM	53	41	94		87		56			77
Res-Q	24	21	89	43	80	11	58	86	22	59
Polyram	22	20	87	91	94	18	55	81	15	77
Vitavax	6	2	42	81	77	4	27	52	11	17
Dual purpose with heptachlor										
Pandrinox PX	14	9	84	92	89	12	54	84	25	79
Pentadrin PX	22	9	84	90	85	23	59	83	4	55
Dual purpose with aldrin										
Pentadrin A	21	28	96	89	83	14	62	62	6	47
Polyram + aldrin	13	25	87	84	94	17	50	73	13	63
Dual purpose with lindane										
Mergamma DB	27+†	11+	46+		74+		27+			91
Mergamma NM	53+	32+	95+		86+		35+			74
Res-Q Dual	31+	26+	84+	59+	79+	10+	46+	87	24	52
Polyram + lindane	18+	27+	79+	89+	89+	10+	42+			78

* Mean percentage of four replicates of 25 seeds.
† + indicates phytotoxicity as shown by short clubbed roots and short swollen shoots.

phytotoxicity were evident. Flax seedlings did not show phytotoxic symptoms from any of the formulations.

Because freauency of occurrence of the storage molds Penicillium spp. and Aspergillus spp. on seed lots No. 3 (wheat), Nos. 4 and 5 (oats), and Nos. 8 and 9 (flax) was low, data for these samples have been omitted from Table 4. The lots excluded are those for each crop with the lowest moisture contents. Lots graded tough, therefore, are of less importance in the occurrence of storage molds; cereal samples with over 19% moisture and flax with 14% moisture were heavily infested by storage molds. Wheat sample No. 3, which was intermediate in moisture content between the tough and the other damp cereal samples, carried a heavy infestation of Aspergillus spp. but, unlike the other damp samples, germination of this seed was unaffected, probably because of delayed infection. The results from the tough and damp cereal samples suggest that tough grain and perhaps even damp cereal grain with moisture contents below 19% could be safely maintained until the following summer under the cold winter conditions prevailing in Western Canada.

After 200 days post-treatment storage none of the chemicals had completely Drevented infestation by storage molds of all 'the seed lots tested (Table 4). Aspergillus spp. and Penicillium spp. developed on all lots of untreated seed, indicating that inoculum was present at the start of the experiment. Agrox NM and Res-Q were the most effective in preventing fungus infestation; mercurials and Polyram were the least effective. Insecticides often altered the effectiveness of the fungicide in dual-purpose compounds. For example, control of Aspergillus and Penicillium was sometimes increased or decreased when an insecticide was added to the fungicide. Generally, fungus infestation of treated or untreated grain tended to reduce germination.

It is known (5) that in dormant grain representatives of all staqes of dormancy are usually found; hence germination tests show uneven responses with time. We found that uneven germination was most evident with seed on moist filter paper, apparently due to "water sensitivity" (4), and least evident with seed sown at cold soil temperatures.

Table 4. Occurrence* of Aspergillus spp. and Penicillium spp. on wheat, barley and flax seed plated on filter paper 192-264 days after treatment

Treatment	Wheat				Barley				Flax	
	Sample no. 1		Sample no. 2		Sample no. 6		Sample no. 7		Sample no. 10	
	Asp.†	Pen.†	Asp.	Pen.	Asp.	Pen.	Asp.	Pen.	Asp.	Pen.
Check (untreated)	88	28	76	20	40	0	100	8	68	76
Mercurials										
Panogen 15B	0	28	96	32	0	0	0	0	4	40
Panogen PX	92	20	0	0	0	0	0	12	0	60
Pandrinox PX	0	0	24	0	0	0	0	0	0	100
Agrox DB	0	100	64	60			0	76	0	96
Mergamma DB	0	80	80	8			0	8	20	84
Non-mercurials										
Agrox NM	0	0	12	0			4	0	0	0
Mergamma NM	16	0	44	0			0	0	20	4
Res-Q	0	0	8	4			0	0	0	0
Res-Q Dual	4	0	4	0			0	0	0	0
Polyram	8	12	20	16	0	0	76	28	4	80
Polyram + aldrin	32	12	32	36	12	4	96	32	0	20
Polyram + lindane	0	0	68	16	4	0	28	0	52	24
Vitavax	0	0	0	0	4	0	80	0	16	0
Pentadrin PX	12	4	0	0	0	44	68	44	4	40
Pentadrin A	12	4	4	0	0	0	0	20	80	12

* Percentages are based on one replicate of 25 seeds; three other replicates of 25 seeds were examined for agreement.

† Asp. = Aspergillus, Pen. = Penicillium

Conclusions

Germination of tough and damp grain was higher in soil, especially cold soil, than on filter paper. It is recommended that germination tests on all such grain be made in soil just prior to seeding because of possible dormancy or deterioration by fungi. Deterioration of tough and damp grain by fungi is usually retarded or prevented in the winter months by cold weather. Therefore seed from the crop of the previous fall can be sown providing results from germination tests made in soil are satisfactory. Treatment of such seed, with the exception of flax, does not affect germination. Tough and damp seed more than 1 year old tends to be infected by storage molds, although in this study germination of untreated seed was not reduced after 192–264 days when the original moisture content of the cereals was below 19.0% and of flax below 14%. It is recommended that damp cereal seed containing over 19.0% moisture not be sown because germination will be reduced by storage molds against which seed treatments are usually ineffective. However, there are indications that compounds that contain maneb can reduce storage molds.

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