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LOW COST MERCURY REPLACEMENT CEREAL SEED TREATMENT

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by

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ABSTRACT

Since the withdrawal of organo-mercury, and with the introduction of the new generation products, seed treatment costs have risen dramatically. As a low cost alternative, dithiocarbamate based products were used to treat a range of infected cereal seed. In a series of trials between 1992 and 1995, these low cost treatments proved to be effective at controlling *Michrodochium nivale* (seedling blight) in winter wheat and *Pyrenophora graminea* (leaf stripe) in spring barley. This control was similar to that provided by commercial treatments tested alongside. The low cost treatments also produced useful suppression of *Tilletia caries* (bunt) and *Ustilago nuda* (loose smut). This project demonstrates that there is potential to provide competent, cheaper cereal seed treatments from amongst the range of currently available products.

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INTRODUCTION

Since March 1992, when organo-mercurial seed treatments were withdrawn from the market, the costs of dressing cereals have increased significantly. Growers have been left with the choice of using considerably more expensive proprietary products or take the risk of sowing untreated seed.

This project was instigated in response to concerns that, with the continuing trend of lower cereal prices, and no cheap alternatives to organo-mercury, more growers would question the need for routine treatment of cereal seed. In a survey of seed health in Scotland during 1992-95 (Cockerell and Stoddart, 1996) it was found that infection levels of a number of seed pathogens were high enough to allow for a rapid escalation of disease without effective management.

The aim of this project was to identify and evaluate the performance of low cost alternative seed treatments from the range of cleared active ingredients currently available for use in cereals. Dithiocarbamate based products were identified as promising candidates for seed treatment purposes, as they are relatively low-cost and are used as seed treatments on a range of non-cereal crops. They are also extensively used as seed treatments on cereals in a number of other countries, notably Canada (Evans, 1995). The addition of benzimidazole (MBC) products was also investigated, but at higher rates than previously used in seed treatments because of evidence of reduced efficacy of these compounds against *Michrodochium nivale* (Koch *et al.*, 1992).

The project covers the results obtained from seed treatment trials on winter wheat, winter barley and spring barley during the period 1992-95.

MATERIALS AND METHODS

Trials were undertaken using naturally infected seed stocks, with infection levels verified by the Official Seed Testing Station for Scotland (OSTS), East Craigs, Edinburgh. The crops and diseases investigated were:-

Winter wheat	*Michrodochium nivale* (Seedling blight)
	Tilletia caries (Bunt)
Winter / spring barley	*Pyrenophora graminea* (Leaf stripe)
	Ustilago nuda (Loose smut)

Trials were established throughout Scotland, with details given in Table 1.

Table 1 Seed infection, variety and sowing dates of trials included in this project

Season	Location	Sowing Date	Variety	Disease and infection level	
1992-93	Forfar	1 Oct	Manitou	*U. nuda*	7%
	Banff	4 Oct.	"	"	7%
	Kelso	7 Oct.	"	"	7%
	Forfar	9 Oct.	Haven	*M. nivale*	60%
	Banff	13 Oct.	Norman	"	20%
	Kelso	15 Oct.	Norman	"	20%
	Kelso	9 Mar.	Blenheim	*P. graminea*	60%
	Forfar	15 Mar.	"	"	60%
	Portsoy	17 Mar.	"	"	60%
1993-94	Coupar Angus	30 Sept.	Gaulois	*P. Graminea*	6%
	Kelso	5 Oct.	"	"	6%
	Portsoy	27 Oct.	"	"	6%
	Coupar Angus	30 Sept.	Manitou	*U. nuda*	6%
	Kelso	5 Oct.	"	"	6%
	Portsoy	27 Oct.	"	"	6%
	Kelso	22 Oct.	Riband	*M. nivale*	28%
	Coupar Angus	23 Oct.	Riband	"	41%
	Portsoy	29 Oct.	Riband	"	41%
	Portsoy	29 Oct.	Beaver	"	61%
	Coupar Angus	23 Oct.	Beaver	*T. caries*	10,000 spores/g
	Kelso	19 Mar.	Blenheim	*P. graminea*	16%
	Portsoy	31 Mar.	Blenheim	"	16%
	Coupar Angus	5 Apr.	Alexis	"	14%
1994-95	Kinross	2 Nov.	Hunter	*M. nivale*	60%
	Kinross	3 Oct.	Beaver	*T. caries*	10,000 spores/g

The treatments used were dithiocarbamate based products selected from currently available formulations, plus copper oxychloride and a selection of commercial treatments (Table 2). A polymer was added to selected treatments to evaluate any improvement in efficacy. The experimental treatments were applied to the seed as a slurry using a water volume of 5 litres / tonne. The slurry was injected by syringe onto small batches of seed in a small industrial mixer. All commercial treatments were applied to the same seed stock by either OSTS or the relevant manufacturer.

Trials were all of a randomised block design with four replicates. Plot size was 1.8m x 10-12m, and the drill used was a Hege 80. All trials were sown by seed number; winter wheat at 450 seeds/ m2, and winter and spring barley at 400 seeds/ m2.

Establishment counts and tiller/ear assessments were undertaken to determine the effect of seed borne disease. Crop establishment was assessed by counting plants in 4 x 1m row lengths per plot. Tiller/ear assessments were made by counting 4 x 0.1m2 quadrats per plot. All trials, apart from those on *T. caries*, were harvested using a Claas Compact plot combine and yields were corrected to 15% moisture content. Where appropriate, Duncan's Multiple Range Test (Duncan, 1955) was used to analyse yield and yield component differences. Values which share a common letter are not significantly different at p = 0.05. Where the test is not used, differences are not significant.

Table 2 Seed treatment details

Code	Active Ingredient(s)	Product	Rate (g a.i. /t)
1	Maneb	Headland Spirit	480
2	Maneb	Headland Spirit	960
3	Maneb (+ Polymer)	H. Spirit + Crown Red Polymer	960 + (2 l/t)
4	Maneb + Carbendazim (MBC)	H. Spirit + Stempor WG	480 + 100
5	Maneb + MBC	H. Spirit + Stempor WG	480 + 250
6	Maneb + MBC	H. Spirit + Stempor WG	960 + 125
7	Maneb + MBC (+ Polymer)	H. Spirit + Stempor WG + Crown Red Polymer	480 + 250 + (2 l/t)
8	Maneb + copper oxychloride	H. Spirit + Cuprokylt L	960 +1350
9	Copper oxychloride	Cuprokylt L	1350
10	Fenpiclonil	Beret	200
11	Carboxin + thiabendazole (TBZ)	Cerevax	900 + 50
12	Carboxin + TBZ + imazalil	Cerevax Extra	600 + 50 + 40
13	Carboxin + TBZ + maneb	Cerevax + H. Spirit	900 + 50 + 960
14	Fuberidazole + triadimenol	Baytan Flowable	45 + 375
15	Fuberidazole + triadimenol + maneb	Baytan Fl. + H. Spirit	45 + 375 + 960
16	MBC	Stempor WG	125

RESULTS

Michrodochium nivale

Trials on the control of *M. nivale* spanned 3 seasons and encompassed 8 separate trials on winter wheat. Seed infection ranged from 20% to 61%. There was little evidence of phytotoxic effects from any of the treatments - either commercial or experimental.

The results from season 1992/93 are presented in Tables 3 and 4. In the trial on the more highly infected seed stock (Table 3) the maneb treatment showed a significant increase in establishment, ear population and yield compared to the untreated. The addition of MBC to the maneb gave an additional improvement in establishment and ear population, without a further yield response.

Table 3 Effect on establishment and yield from control of *M. nivale* on winter wheat, Forfar 1992/93, cv. Haven, 60% infection

Treatment	Rate (g a.i./t)	Establishment (plants/m2)	Ears/m2	Yield (t/ha)
untreated		137 a	345 a	7.94 a
1 maneb	480	277 b	432 b	9.93 b
4 maneb + MBC	480 + 100	294 b	457 b	9.83 b
5 maneb + MBC	480 + 250	302 b	442 b	9.89 b

The infection level was lower on the seed stock used for the Kelso and Banff trials. All treatments gave an improvement in establishment compared to the untreated. The addition of a polymer gave no significant additional increase in establishment, but markedly reduced the dustiness of the dressing. The improvements in plant establishment were not reflected in any significant yield increases over the untreated. Plant growth compensation in the untreated was good, with ear populations reaching the same levels as in the other treatments.

Table 4 Effect on establishment and yield from control of *M. nivale* on winter wheat, Kelso (A) Banff (B) 1992/93, cv. Norman, 20% infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)		Ears/m2		Yield (t/ha)	
			A	B	A	B	A	B
	untreated		303	277 a	521	434	10.57	7.14
1	maneb	480	311	309 b	515	417	9.89	7.78
5	maneb + MBC	480 + 250	317	305 ab	535	443	10.22	7.53
7	maneb + MBC + polymer	480 + 250	337	319 b	551	453	10.18	7.53

Trials carried out in season 1993/94 compared the performance of selected commercial seed treatments with experimental treatments. A straight MBC treatment was included in three out of the four trials to observe the degree of control of *M. nivale* provided by these compounds in the light of widespread reports of resistance. Results from the Kelso trial (Table 5) show that all maneb based treatments gave an improvement in establishment compared to the untreated. There was a significant increase in establishment from the higher rate of maneb, and this was comparable to results from the commercial treatments. The straight MBC treatment resulted in a reduction in plant establishment compared to the untreated. The addition of MBC to the higher rate of maneb also resulted in a lower establishment compared to maneb alone. There was no significant response to the addition of maneb to the commercial treatments.

Table 5 Effect on establishment and yield from control of *M. nivale* on winter wheat, Kelso 1993/94, cv. Riband, 28% infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)	Ears/m2	Yield (t/ha)
	untreated		265 ab	454	9.13
1	maneb	480	272 ab	438	9.00
2	maneb	960	336 c	490	9.15
6	maneb + MBC	960 + 125	309 b	452	9.27
10	fenpiclonil	200	369 cd	465	9.29
11	carboxin + TBZ	900 + 50	350 c	472	9.26
13	carboxin + TBZ + maneb	900 + 50 + 960	369 cd	478	9.27
14	fuberidazole + triad.	45 + 375	320 bc	409	8.95
15	fuberidazole + triad. + maneb	45 + 375 + 960	316 bc	433	8.97
16	MBC	125	238 a	406	8.77

Results from the trials using 41% infected seed are presented in Table 6. All treatments, apart from MBC, produced an increase in plant establishment. There was again a benefit in increased establishment from the higher rate of maneb compared to the lower, and this performance was comparable to the carboxin + TBZ and fuberidazole + triadiminol. The fenpiclonil was the most effective commercial product, however, the addition of maneb to the other commercial treatments produced comparable results in establishment and yield. The addition of MBC to the maneb depressed both establishment and yield. Yield increases over the untreated were significant, apart from the MBC, lower maneb rate, and maneb + MBC treatments.

Table 6 Effect on establishment and yield from control of *M. nivale* on winter wheat, Coupar Angus (A) Portsoy (B) 1993/94, cv. Riband , 41% infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)		Ears/m2		Yield (t/ha)	
			A	B	A	B	A	B
	untreated		183 a	79 a	216 a	318 ab	8.32 b	9.40 a
1	maneb	480	224 ab	166 b	330 b	358 b	8.82 bc	9.77 ab
2	maneb	960	276 b	268 c	343 bc	446 cd	9.46 cde	10.52 bcd
6	maneb + MBC	960 + 125	240 ab	211 bc	336 b	440 cd	9.02 bc	10.31 bc
10	fenpiclonil	200	340 cd	328 d	382 cd	513 def	10.10 de	11.16 d
11	carboxin + TBZ	900 + 50	281 b	268 c	353 bc	436 cd	9.43 cd	10.31 bc
13	carboxin + TBZ + maneb	900 + 50 + 960	347 cd	327 d	402 d	503 de	10.33 e	10.33 bc
14	fuberidazole + triad.	45 + 375	312 bc	279 c	370 bcd	423 c	10.09 de	10.58 cd
15	fuberidazole + triad. + maneb	45 + 375 + 960	323 bcd	293 cd	374 cd	484 d	9.99 de	10.65 cd
16	MBC	125	158 a	94 a	230 a	289 a	7.45 a	9.27 a

The results from a second trial on the Portsoy site using very highly infected seed are presented in Table 7. The maneb treatment produced an increase of almost 150% in establishment over the untreated. The fenpiclonil was the most effective treatment, giving a significant increase in establishment, ear numbers, and yield over the untreated and the maneb treatment. Again, the addition of the maneb to the fuberidazole + triadimenol improved its performance.

Table 7 Effect on establishment and yield from control of *M. nivale* on winter wheat, Portsoy 1993/94, cv. Beaver, 61% infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)	Ears/m2	Yield (t/ha)
	untreated		63 a	291 a	9.35 a
2	maneb	960	155 b	402 b	9.81 a
10	fenpiclonil	200	339 d	510 c	11.27 c
14	fuberidazole + triad.	45 + 375	173 bc	424 b	10.57 b
15	fuberidazole + triad. + maneb	45 + 375 + 960	215 c	435 b	11.00 bc

In season 1994/95, in a trial carried out using 60% infected seed, the maneb treatment produced a comparable performance to the commercial treatments (Table 8). All treatments gave a significant improvement in establishment and yield over the untreated.

Table 8 Effect on establishment and yield from control of *M. nivale* on winter wheat, Kinross 1994/95, cv. Hunter, 60% infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)	Ears/m2	Yield (t/ha)
	untreated		193 a	463	7.58 a
2	maneb	960	332 b	528	9.88 b
10	fenpiclonil	200	346 b	509	9.63 b
11	carboxin + TBZ	900 + 50	348 b	493	9.68 b
14	fuberidazole + triad.	45 + 375	356 b	523	10.02 b

Tilletia caries (bunt)

Trials were carried out on very highly contaminated wheat seed over two seasons. In season 1994, maneb alone, and maneb + copper oxychloride treatments gave a very high degree of control of *T. caries.* This control was equal to that provided by the commercial controls (Table 9).

Table 9 Control of *Tilletia caries* on winter wheat, Coupar Angus 1994, cv. Beaver, 10,000 spores / gramme infection

	Treatment	Rate (g a.i./t)	Establishment (plants/m2)	% Control
	untreated		332	(10. 0) *
2	maneb	960	368	99.7
8	maneb + copper oxychloride	960 / 1350	330	99.9
10	fenpiclonil	200	345	99.9
11	carboxin + TBZ	900 + 50	334	100
14	fuberidazole + triad.	45 + 375	358	100

* % ears infected in untreated

In the trial in 1995 on similarly infected seed (Table 10), the experimental treatments were less effective in controlling the disease. None of the treatments provided acceptable levels of control, although the addition of a polymer to the maneb increased control by over 10%. There were no commercial treatments for comparison in this trial.

Table 10 Control of *Tilletia caries* on winter wheat, Kinross 1995, cv. Beaver, 10,000 spores / gramme infection

Treatment	Rate (g a.i./t)	Establishment (plants/m2)	% Control
untreated		318	(10. 7) *
2 maneb	960	342	81.3
3 maneb + polymer	960	332	91.6
10 copper oxychloride	1350	328	91.6

* % ears infected in untreated

Pyrenophora graminea (leaf stripe)

Spring barley

In a series of trials over two seasons (1993 & 1994) on spring barley, maneb based treatments provided a very high degree of control of *P. graminea.* The trials in 1993 (Tables 11 & 12) also produced significant yield increases over the untreated.

Table 11 Control of *Pyrenophora graminea* on spring barley, 1993, cv. Blenheim, 60% infection

Treatment	Rate	% Control			
	(g a.i./t)	Kelso	Forfar	Portsoy	Mean
untreated		(8.9)*	(8.5)*	(8.4)*	(8.6)*
1 maneb	480	96.7	86.6	90.8	91.4
4 maneb + MBC	480 + 100	98.8	90.1	93.3	93.4
5 maneb + MBC	480 + 250	93.3	87.5	92.0	90.9

* % infected tillers in untreated

Table 12 Yield response from the control of *Pyrenophora graminea* on spring barley, 1993, cv. Blenheim, 60% infection.

Treatment	Rate	Yield (t/ha)			
	(g a.i./t)	Kelso	Forfar	Portsoy	Mean
untreated		6.75 a	5.48 a	6.15 a	6.13
1 maneb	480	7.43 b	5.81 b	6.72 b	6.65
4 maneb + MBC	480 + 100	7.45 b	5.68 ab	6.68 b	6.60
5 maneb + MBC	480 + 250	7.39 b	5.82 b	6.77 b	6.66

The trials in 1994 included two commercial treatments; fenpiclonil, and carboxin / TBZ / imazalil. The maneb treatment provided effective control of *P. graminea*, which was comparable to the commercial products. All treatments produced yield increases over the untreated on all three sites. Results are presented in Tables 13 & 14.

Table 13 Control of *Pyrenophora graminea* on spring barley, 1994, cv. Blenheim, 16% infection (Coupar Angus site cv. Alexis 14%)

	Treatment	Rate (g a.i./t)	Kelso	% Control Coupar Angus	Portsoy	Mean
	untreated		(5.4)*	(3.2)*	(9.5)*	(6.0)*
2	maneb	960	93.2	100	97.2	96.8
10	fenpiclonil	200	97.5	89.6	88.4	91.8
12	carboxin + TBZ + imazalil	600 + 50 + 40	97.7	100	91.8	96.5

* % infected tillers in untreated

Table 14 Yield response from the control of *Pyrenophora graminea* on spring barley, 1994, cv. Blenheim 16% infection (Coupar Angus site cv. Alexis, 14%)

	Treatment	Rate (g a.i./t)	Kelso	Yield (t/ha) Coupar Angus	Portsoy	Mean
	untreated		4.38 ab	5.45 a	6.39 b	5.41
2	maneb	960	4.73 bc	5.51 a	6.71 cd	5.65
10	fenpiclonil	200	4.48 abc	5.62 a	6.91 d	5.67
12	carboxin + TBZ + imazalil	600 + 50 + 40	4.83 c	5.54 a	6.61 bc	5.66

Winter barley

Trials were carried out in 3 locations in 1993-94, using seed with an infection level of 6%. The performance of maneb was compared to that of two commercial treatments. Maneb gave comparable control of *P. graminea* to carboxin / TBZ / imazalil in two of the three trials. Fenpiclonil proved to be the most effective treatment in all three trials (Table 15). When taken to yield, the maneb treatment produced a higher yield than the untreated in all three trials. Overall, the maneb treatment produced the highest yield (Table 16).

Table 15 Control of *Pyrenophora graminea* on winter barley, 1993-94, cv. Gaulois, 6% infection

	Treatment	Rate (g a.i./t)	Kelso	% Control Coupar Angus	Portsoy	Mean
	untreated		(7.2)*	(5.4)*	(7.6)*	(6.7)*
2	maneb	960	52.3	75.0	65.9	64.4
10	fenpiclonil	200	95.1	95.8	93.3	94.7
12	carboxin + TBZ + imazalil	600 + 50 + 40	54.3	54.8	100	69.7

• % infected tillers in untreated

Table 16 Yield response from the control of *Pyrenophora graminea* on winter barley, 1993-94, cv. Gaulois 6% infection

	Treatment	Rate (g a.i./t)	Yield (t/ha) Kelso	Coupar Angus	Portsoy	Mean
	untreated		7.63 abc	6.44 ab	8.16 a	7.41
2	maneb	960	7.92 bc	6.88 b	8.58 a	7.79
10	fenpiclonil	200	8.06 c	6.08 a	8.73 a	7.62
12	carboxin + TBZ + imazalil	600 + 50 + 40	7.87 bc	6.07 a	8.71 a	7.55

Ustilago nuda (loose smut)

Using the same infected seed stock, trials were carried out in winter barley on three sites in 1993-94. Maneb seed treatment reduced symptoms of *U. nuda* by around one third on two out of three sites. On the third site maneb treatment gave no control (Table 17). Carboxin / TBZ / imazalil treatment gave more reliable control of the disease. The maneb treatment produced an increase in yield over the untreated on all three sites, with a significant increase on the Coupar Angus site (Table 17).

Table 17 Control of *Ustilago nuda* on winter barley, 1993-94, cv. Manitou, 6% infection

	Treatment	Rate (g a.i./t)	% Control Kelso	Coupar Angus	Portsoy	Mean
	untreated		(4.8)*	(4.4)*	(4.7)*	(4.6)*
2	maneb	960	- 1.3	35.3	32	22.0
12	carboxin + TBZ + imazalil	600 + 50 + 40	68.7	59.9	85.5	71.4

* % infected tillers in untreated

Table 18 Yield response from the control of *Ustilago nuda* on winter barley, 1993-94, cv. Manitou, 6% infection

	Treatment	Rate (g a.i./t)	Yield (t/ha) Kelso	Coupar Angus	Portsoy	Mean
	untreated		8.32 a	7.78 a	9.43 a	8.51
2	maneb	960	8.45 a	8.59 b	9.60 a	8.88
12	carboxin + TBZ + imazalil	600 + 50 + 40	8.36 a	7.85 a	9.44 a	8.55

DISCUSSION

The results achieved from this project give a strong indication that dithiocarbamate fungicides applied as seed treatments can be effective at controlling or suppressing a range of cereal seed borne pathogens.

Michrodochium nivale is one of the most damaging seed infections, especially so in winter wheat. The risk of crop damage tends to be particularly high in northern Britain as the progress of the disease is associated with high rainfall and low soil temperatures during establishment (Hewett, 1965). The trial results indicate that at lower infection levels, maneb can be equally as effective as commercial treatments in controlling *M. nivale*. On seed with very high infection levels, maneb provides useful suppression, but in this series of trials is not as effective as the best commercial treatments which were included. Based on the evidence of the rate response to the higher application rate of maneb used, it would be reasonable to expect that an even higher loading of maneb may provide more effective control of the disease, perhaps equalling that of the best commercial standards.

When added to the commercial controls, maneb gave an increase in establishment compared to the commercial treatment alone, indicating the potential benefit the addition of a cheap dithiocarbamate product could provide in increasing the spectrum of control of existing products.

The addition of an MBC fungicide to the maneb in 1992-93 resulted in enhanced control of *M. nivale*, but the results from later trials show a reduction in both establishment and yield. This effect, plus the definite suppression of establishment and yield from the use of a straight MBC treatment, tends to verify other widespread evidence of reduced efficacy of these compounds against this disease.

In the case of bunt, effective control of the disease is particularly important because of the speed at which the disease can build up in the crop (Davis *et al*, 1987). In the first seasons' trials, maneb proved to be as effective as the commercial treatments in providing a high level of control. In the second season, using similarly infected seed, control was poorer using the maneb and copper treatments. Unfortunately, there were no commercial treatments included in this trial, so a question mark remains on whether these products would have provided more reliable control than the cheaper experimental treatments.

The control of leaf stripe in spring barley by maneb seed treatment was consistently good in the series of trials in 1993 and 1994. When directly compared with commercial treatments, maneb provided an equal, if not better, degree of control. The control of the same disease in winter barley by maneb was less reliable, and generally not as effective as commercial treatments, although still providing at least 50% control of the disease.

The expectancy on the trials on loose smut was that maneb treatments were unlikely to be effective, due to their non-systemic nature. It was found that they did seem to provide some degree of suppression of the disease, albeit inconsistently throughout the three trials.

The decision to use flowable water-based dithiocarbamate products, as opposed to powder, was taken firstly, because of their more uniform quality, and secondly, because most of the commercially available seed treatments are water-based solutions. Polymer solutions were added to some of the maneb treatments to improve the coverage on the seed, and to make the treatment more user friendly by reducing the dustiness of the dressing. The addition of the polymer generally appeared to improve the efficacy of the treatment.

A recent survey on seed health undertaken by the Official Seed Testing Station, Edinburgh (Rennie & Cockerell, 1995) concluded that a significant proportion of cereal seed could potentially be sown without treatment, and not incur a yield loss. However, there is a serious risk of rapid build-up of disease between years if adequate testing procedures are not carried out.

With future expected increases in economic pressures, the likelihood is that there will be more area sown to untreated seed. This project has shown that, used in conjunction with appropriate testing procedures, dithiocarbamate based seed treatment could greatly reduce the risks associated with sowing undressed seed, and provide an effective, cheap alternative to commercial dressings in the control of low level seed infection.

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