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INCREASING THE EFFECTIVENESS OF SEED-TREATED FUNGICIDES BY THE PELLETING METHOD[1]

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Abstract

Four fungicides were used in this study. Seedling emergence and growth as determined by dry weight in soil infested with *Drechslera sorokiniana* (Sacc.) Subrain & Jain, *Fusarium culmorum* (W.G. Smith) Sacc. and *Rhizoctonia solani* Kühn were improved by pelleting seed with either thiram, captan+HCB, PCNB or carboxin. Mixing fungicides with silica or polyvinyl alcohol binder prior to pelleting was more effective than dusting seed with fungicides prior to pelleting or dusting without pelleting.

Introduction

Most of the fungicides presently recommended for seed treatment are formulated as dusts or wettable powders. These can be applied either by mixing or as slurries. Several compounds, such as captan-HCB 20-20, captan and maneb, are suggested for use in the drill box immediately prior to planting. Most growers buy seed which has already been treated by the seed company. Non-uniform coverage of the seed coat and inhalation by operators are the most serious problems encountered when fungicides are applied as dusts. Except in the case of systemic fungicides, incomplete coverage results in incomplete control (Purdy, 1967). Lack of tenacity is another important shortcoming of the application of powdered fungicides. To investigate the possibilities of improving current application techniques and to obtain more uniform coverage and better tenacity of fungicides on seeds are the purposes of this study.

Materials and Methods

Foundation seed of Orbit oats and Arrow wheat, used in this study, was

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obtained from the New York Seed Improvement Cooperative, Inc., Ithaca, New York.

For evaluation of seed treatment, the fungi for infesting soil were *Drechslera sorokiniana, Fusarium culmorum*, and *Rhizoctonia solani*. Soil contained in each 5 inch diameter clay pot was infested with 27±2 g of fungal culture (8.5–9.5 g of fungal culture of each of the above mentioned pathogens). Fungi were mixed with soil in areas where seeds were sown.

The following seed treating fungicides were selected for evaluation at the rates indicated.

Common name	Trade name	Formulation	Rate (oz/bu)		Manufacturer
			Oat	Wheat	
thiram	Arasan 42 S	4 F	4	2	DuPont
captan + HCB	Captan-HCB 20-20	40% WP	4	2	Stauffer
PCNB	Terra Coat LT-2	24% EC	4	2	Olin Mathieson
carboxin	Vitavax	75% WP	2 2/3	1 1/3	Uniroyal

The basic coating employed in these studies was composed of a 200 mesh sand filler and a binder of polyvinyl alcohol (2.5% Elvanol 7130 G, DuPont). Seeds which had been sprayed with binder were rolled in sand to coat the seed with a layer of sand and binder. In all the following pelleting procedures, 50 ml binder/300 g sand was used for pelleting 100 g wheat and 70 ml binder/400 g sand was used for 100 g oats.

Arasan 42 S, Captan-HCB 20–20, Terra Coat LT-2, and Vitavax were applied to seed in several ways; (1) measured amounts of fungicide were mixed with polyvinyl alcohol binder followed by the addition of 200 mesh sand; (2) fungicides were mixed with sand followed by the addition of the binder; (3) seeds were coated with fungicide and then pelleted by the addition of sand and binder. Pelleted seeds without fungicides served as control. Seeds dusted with fungicides were compared to untreated seeds.

The treated seeds were sown in artificially infested soil in pots maintained in the greenhouse and in soil tanks. Pots of both oats and wheat were placed in a greenhouse with day and night temperatures of 18°C and 15°C, respectively. A soil tank was used to maintain constant soil temperatures of 8°C for oats and 15°C for wheat. Four pots were used for each treatment, with 25 seeds per pot. After one month, treatments were evaluated by calculating the percent germination and determining seedling dry weight.

Results

In most instances, pelleting oat and wheat seeds by mixing Areasan 42 S

with binder or sand increased emergence, dry shoot weight and total seedling dry weight under both greenhouse and soil tank conditions (Table 1). In the case of wheat, this fungicide, when mixed with binder, did not increase seedling emergence under greenhouse conditions, nor emergence and dry weight of seedlings under soil tank conditions. Application of Arasan 42 S to oat seeds before pelleting increased percent emergence and total dry weight only under soil tank conditions. Conventional dusting of seeds with Arasan 42 S or pelleting without fungicide had no positive effect on emergence and total dry weight as compared to the untreated control seed.

For both oat and wheat seeds, prior mixing of Captan-HCB 20–20 with the binder increased emergence, dry shoot weight and total dry weight under both greenhouse and soil tank conditions (Table 2). Pelleting oat and wheat seeds by first mixing this funicide with sand increased emergence and total dry weight under greenhouse conditions and increased wheat emergence and total dry weight of wheat seedlings under soil tank conditions. In most tests, Captan-HCB 20–20, when applied to oat or wheat seeds before pelleting or without pelleting, caused no positive effect as compared to pelleting without fungicicide and no treatment. In contrast, this fungicide, when applied to oat seeds before pelleting, increased total dry weight under soil tank conditions and, when dusted on wheat seeds without pelleting, increased emergence and dry root weight under soil tank conditions.

Prior to mixing of Terra Coat LT–2 with binder before pelleting positively increased emergence, dry root weight and total dry weight of oats under greenhouse conditions, whereas mixing with sand only inereased emergence under soil tank conditions (Table 3). Pelleting wheat seeds by first mixing this fungicide with binder or sand increased dry weight of plant tissues under greehnouse conditions and increased emergence, dry shoot weight and total dry weight under soil tank conditions. However, in the soil tank test, this fungicide when mixed with sand, had no effect on dry shoot weight and total dry weight as compared to the pelleted contol. No beneficial effects were achieved by application of the fungide to seeds prior to pelleting as compared to the pelleted or untreated controls.

The Vitavax-sand mixture when used for pelleting oat seeds increased dry root weight under greenhouse conditions and emergence under soil tank conditions. Vitavax mixed with binder or sand gave greater dry root weight and total dry weight of wheat seedlings than either the pelleted control or no treatment under greenhouse conditions. Dusting this fungicide onto oat or wheat seeds before pelleting, conventional dusting, and pelleting seeds without Vitavax, did not produce results significantly different from those obtained with untreated seeds (Table 4).

Table 1. *Effect of various methods of application of Arasan 42 S on seedling development*[1]

Treatment	Oats[2]								Wheat[2]							
	Greenhouse				Soil tank				Greenhouse				Soil tank			
	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)
In binder	97a	.15	.76a	.91a	97ab	—	—	1.29a	91ab	.17a	.56a	.73a	76ab	.13	.60bc	.73bc
In sand	99a	.17	.81a	.98a	98a	—	—	1.19ab	98a	.18a	.62a	.80a	89a	.25	.80a	1.05a
Dusting before pellet	86ab	.13	.67ab	.81b	98a	—	—	1.03bc	83b	.12ab	.38b	.50ab	58bc	.19	.54cd	.73cd
Dusting	83b	.17	.66ab	.83ab	82bcd	—	—	.81cd	90ab	.13a	.44ab	.57ab	44c	.24	.46cd	.70cd
Pellet control	71b	.12	.56b	.67b	60d	—	—	.68d	74b	.08b	.34b	.42b	50bc	.13	.44cd	.57cd
No treatment	79b	.12	.58b	.70b	74cd	—	—	.79d	71b	.06b	.31b	.37b	34c	.07	.25d	.32d

(1) Values, which are averages of 4 replicates, followed by common letters in the same column do not differ significantly at the 5% level by the hsd test.

(2) Total number of treated seeds=25/replicate, 4 replicates.

Table 2. *Effect of various methods of application of Captan-HCB 20-20 on seedling development*[1]

Treatment	Oats[2]								Wheat[2]							
	Greenhouse				Soil tank				Greenhouse				Soil tank			
	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)
In binder	95a	0.17	.75a	.92a	96a	—	—	1.11a	87a	.19a	.51a	.70a	88a	.31a	.73a	1.04a
In sand	94a	0.19	.69ab	.88a	93ab	—	—	1.06ab	86a	.15ab	.47ab	.62a	82a	.20ab	.61ab	.81bc
Dusting before pbllet	82ab	0.17	.55b	.72b	88ab	—	—	1.11a	73b	.13ab	.34ab	.47ab	30c	.10bc	.25d	.35e
Dusting	88ab	0.14	.66ab	.80ab	78ab	—	—	.87bc	83ab	.10ab	.37ab	.47ab	60b	.25a	.59bc	.84cd
Pellet control	71b	0.12	.56b	.68b	60c	—	—	.68c	74b	.08b	.34ab	.42b	50c	.13b	.44cd	.57de
No treatment	79b	0.12	.58b	.70b	74bc	—	—	.79c	71b	.06b	.31b	.37b	34c	.07c	.25d	.32e

(1) Values, which are averages of 4 replicates, followed by common letters in the same column do not differ significantly at the 5% level by the hsd test.

(2) Total number of treated seeds=25/replicate, 4 replicates.

Table 3. *Effect of various methods of application of Terra Coat LT-2 on seedling development*[1]

Treatment	Oats[2]								Wheat[2]							
	Greenhouse				Soil tank				Greenhouse				Soil tank			
	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Tatal dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)
In binder	97a	.28a	.71	.99a	87ab	—	—	.91	84	.16a	.48a	.64a	82a	.17	.72a	.89a
In sand	90ab	.17b	.68	.85ab	96a	—	—	1.01	78	.15a	.42a	.57a	77a	.20	.67ab	.87ab
Dusting before pellet	74b	.16b	.58	.74b	72bc	—	—	.89	76	.09ab	.31b	.40b	38b	.09	.31c	.40c
Dusting	79b	.15b	.56	.71b	82ab	—	—	1.07	72	.10ab	.30b	.40b	42b	.10	.31c	.41c
Pellet control	71b	.12b	.56	.68b	60c	—	—	.68	74	.08b	.34a	.42b	50b	.13	.44bc	.57bc
No treatment	79b	.12b	.58	.70b	74bc	—	—	.79	71	.06b	.31b	.37b	34b	.07	.25c	.32c

[1] Values, which are averages of 4 replicates, followed by common letters in the same column do not differ significantly at the 5% level by the hsd test.

[2] Total number of treated seeds=25/replicate, 4 replicates.

Table 4. *Effect of various methods of application of Vitavax on seedling development*[1]

Treatment	Oats[2]								Wheat[2]							
	Greenhouse				Soil tank				Greenhouse				Soil tank			
	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)
In binder	86	.18ab	.66	.84ab	60b	—	—	.75	88a	.15a	.48a	.63a	61	.12	.51	.63
In sand	92	.19a	.75	.99a	91a	—	—	.93	87ab	.15a	.46a	.61a	76	.13	.63	.76
Dusting before pellet	75	.13ab	.59	.72ab	82ab	—	—	.92	75ab	.09b	.32b	.41b	50	.24	47	.71
Dusting	78	.18ab	.59	.77ab	78ab	—	—	.88	71b	.07b	.27b	.34b	37	.09	.28	.37
Pellet control	71	.12b	.56	.67b	60b	—	—	.68	74ab	.08b	.34ab	.42b	50	.13	.44	.57
No treatment	79	.12b	.58	.70ab	74b	—	—	.79	71b	.06b	.31b	.37b	34	.07	.25	.32

(1) Values, which are averages of 4 replicates, followed by common letters in the same column do not differ significantly at the 5% level by the hsd test.

(2) Total number of treated seeds=25/replicate, 4 replicates.

In order to determine the best method of application of fungicides to both wheat and oat seeds, mean values for the four fungicides were calculated for each method (Table 5). In the case of wheat, prior mixing of the fungicides with sand or binder before pelleting was found to be more effective in increasing percent emergence and total dry weight than was direct application of the fungicides to seeds with or without subsequent pelleting under both greenhouse and soil tank conditions. However, in the case of oats, this benefit occurred only under greenhouse conditions. Under soil tank conditions, there were no differences between the treatments in the total dry weight of oat seedlings, and fungicides mixed with binder were no more beneficial to emergence of oats than conventional dusting with or without pelleting.

Discussion

Low seeding rates of wheat, e. g., 0.3 and 0.6 bu/A, have been shown to produce significantly more grain than the higher seeding rates currently used, i. e., 2–4 bu/A (Clark, 1971; Pelton, 1969). Presumably, this difference is the result of the availability of optimum space for development and growth of roots, shoots and tillers, and reduced competition within the crop. Low seeding rates obviously demand maximum emergence and uniform spacing of seedlings. Pelleted seeds offer promise since they can be machine sown with a high degree of accuracy. Theoretically, improved emergence should be obtained by sowing pelleted seeds in which suitable materials such as growth regulators and pesticides have been incorporated.

In this study, the addition of fungicides to the binder or to sand during pelleting resulted in greater seedling emergence than direct application of fungicides to the seed coat whether or not the seed was subsequently pelleted. The experimental results indicate no differences in the percent emergence or dry weight of plant tissues from seeds treated without pelleting. In other words, there was no effect of pelleting after dusting fungicide on seeds. The inferiority of the two direct methods of applying fungicides compared to mixing the fungicides with a binder or sand was likely due to uneven distribution and loss of fungicide from seeds. This suggests that pelleting provides a protected area for the susceptible root and leaf primordia. During imbibition as the seed enlarges, the pellet swells noticeably—thus increasing the protective area around the developing seedling. Therefore, seedlings grown from pelleted seeds have a relatively pathogen-free micro-environment for their very early development and growth as compared to non-pelleted seed. Garrett (1970) has indicated that all the tissues of a young seedling are juvenile and lack mature-plant resistance, so that they are susceptible to infection by parasites. Pelleting wheat or oat seed with fungicides may be similar in

Table 5. *Summary of the effects of various methods of application of fungicides on seedling development*[1]

Treatment	Oats[2]								Wheat[2]							
	Greenhouse				Soil tank				Greenhouse				Soil tank			
	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)	Emergence (%)	Dry root weight (g)	Dry shoot weight (g)	Total dry weight (g)
In binder	93.75a	.19a	.72a	.91a	85.00bc	—	—	1.01	87.50a	.17a	.50a	.67a	76.75a	.18	.64a	.82a
In sand	93.75a	.18ab	.73a	.91a	.94.50a	—	—	1.05	87.25a	.16a	.49a	.65a	81.00a	.19	.68a	.87a
Dusting before pellet	79.25b	.15b	.60b	.75b	85.00bc	—	—	.99	76.75b	.11b	.34b	.45b	44.00b	.15	.39b	.54b
Dusting	82.00b	.16ab	.62b	.78b	80.00c	—	—	.91	79.00b	.10b	.34b	.44b	45.75b	.17	.41b	.58b

(1) Values, which are averages of 4 replicates, followed by common letters in the same column do not differ significantly at the 5% level by the hsd test.

(2) Total number of treated seeds=25/replicate, 4 replicates

action to the treatment of papaya seed in virgin soil. Ko (1971) effectively protected the young and succulent plant tissues from infection by growing papaya seedlings in small quantities of pathogen-free virgin soil prior to transferring them to a *Phytophthora palmivora*-infested soil. After the roots had emerged from the virgin soil, they were all capable of resisting infection by this pathogen.

In summary (Table 5), the new method of applying fungicides to oat seeds was only effective under greenhouse conditions. The was probably due to oat seedlings being more susceptible to infection under low temperatures in the soil tank and/or pathogens being more aggressive in the soil tank condition than under the greenhouse condition.

Literature Cited

CLARK, R. V. 1971. Influence of chemical fungicide treatment of oat seed on seedling emergence, seed yield, and kernel weight. Can. Plant. Dis. Surv. **51**: 71-75.

GARRETT, S. D. 1970. Pathogenic root-infecting fungi. Cambridge University Press, London, England. 294 p.

KO, W. H. 1971. Biological control of seedling root rot of papaya caused by ***Phytophthora palmivora***. Phytopathology **61**: 780-782.

PELTON, W. L 1969. Influence of low seeding rates on wheat yield in southwestern Saskatchwan. Can. J. Plant Sci. **49**: 607-614.

PURDY, L. H. 1967. Application and use of soil-and seed-treatment fungicides. ***In*** Fungicides and advanced treatise. Vol. I: 195-237. Academic Press, New York.

增進殺菌劑藥效的丸衣種子處理法

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處理過 thiram, captan+HCB, PCNB 及 carboxin 的丸衣種子 (pelleted seed), 在染有 *Drechslera sorokiniara* (Sacc.) Subrain & Jain, *Fusarium culmorum* (W. G. Smith) Sacc. 及 *Rhizoctonia solain* Kühn 三種病原菌的土壤中，具有增進幼苗出土及其生長的特性。製造丸衣種子前，將殺菌劑與矽 (Silica) 或聚乙烯醇 (polyvinyl alcohol) 混合，然後所製出之丸衣種子比種子在製成丸衣種子之前粉衣 (dusting) 或只有粉衣的種子具有更有效的預防病原菌的效能。