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Comparison of safflower fungicide seed treatments

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Abstract
Ten fungicide seed treatments were evaluated in 2006 and 2007 for effects on stand, test weight, oil content, seed and oil yield per hectare. Fungicides evaluated included: carboxin + thiram, fludioxonil, azoxystrobin, tebuconazole + metalaxyl + imazalil, mefenoxam + fludioxonil + mancozeb, azoxystrobin + mancozeb, mefenoxam + thiram, difenoconazole + mefenoxam, and mefenoxam + fludioxonil + azoxystrobin. Seed lots of the cultivars Nutrasaff and Montola 2004 with 10-20% infection with *Alternaria carthami* were planted at the Montana State University Eastern Agricultural Research Station at Sidney, MT, USA. For the cultivar Nutrasaff, no fungicide treatment statistically increased stand, test weight, oil content, seed yield or oil yield per hectare over untreated seed ($P<0.05$). For the cultivar Montola 2004, no fungicide treatment statistically increased stand, test weight, or percent oil over untreated seed ($P<0.05$). Seed treatment with mefenoxam + thiram and difenoconazole + mefenoxam statistically increased total seed yield and oil yield per hectare over untreated seed ($P<0.05$) for the cultivar Montola 2004. Treatment with mefenoxam + fludioxonil + mancozeb and azoxystrobin + mancozeb increased total seed yield and oil yield per hectare over untreated seed ($P<0.1$) for the cultivar Nutrasaff. Stand establishment averaged 81.7% and 85.3% for untreated seed for the cultivars Nutrasaff and Montola 2004 respectively. All seed treatments reduced detectable seed infection by *Alternaria carthami* ($P<0.05$).

Key words: fungicide seed treatment - soilborne pathogens - *Alternaria* seed infection-safflower - *Carthamus tinctorius*

Introduction

Fungicide seed treatments are used on safflower to control pre and post emergent damping-off caused by soilborne fungi such as *Pythium ultimum* Trow, *P.aphaidermatum* (Edson) Fitz, *P. debaryanum* Hess, *P. splendens* Braun, *P. acanthium* Drechsler, *P. myriotylum* Drechsler, *Rhizoctonia solani* Kuhn, *Phytophthora drechsleri* Tucker, *P. cryptogea* Pethyb. and Laff., and *P. parasitica* Dast (Mündel and Huang, 2003). In addition, fungicide seed treatments are recommended for control of two seedborne pathogens, Puccinia carthami Cda and *Alternaria carthami* Chowdhury (Mündel and Huang, 2003). Damping–off pathogens typically cause greatest losses where conditions do not favor rapid germination and seedling establishment. Ideally, a single fungicide would control both soil and seedborne pathogens, however no single available fungicide will control the full spectrum of pathogens affecting safflower. In these studies, combinations of fungicides that control the full spectrum of pathogens were investigated. Carboxin, thiram and mancozeb were selected because they have proven activity on seedborne safflower rust and in addition will control seed decay caused by Pythium and Rhizoctonia. Tebuconazole, difenconazole, and axoxystrobin were selected because of activity on Rhizoctonia and Alternaria. Fludioxanil was selected because of its activity on pre and post damping-off pathogens such as Pythium and Rhizoctonia. Metalaxyl / mefenoxam was selected because of its excellent activity on Pythium and Phytophthora (Lyr, 1995). In addition azoxystrobin has some activity on Pythium species. At the time of this writing only thiram, carboxin, fludioxanil and mancozeb are labeled for use on safflower in the USA. Other products evaluated are registered on small grains and would appear to have potential for control of important safflower diseases affecting safflower seeds.

Materials and Methods

Safflower seeds of the cultivars Montola 2004 and Nutrasaff were treated with the fungicides by shaking in a plastic bag with 60 ml water / kg of seed. Fungicide treatments and rates are given in Table 1. Seeds were air dried following treatment on paper towels and repackaged for planting. Experiments were planted on 18 May in 2006 and 1 May in 2007 using a seeding rate of 22.4 kg/h pure live seed. Plots were four rows wide (61 cm row width) by 9.2 m with the center 6 m of the center two rows harvested. The plot design for all experiments was a randomized complete design with four replications. The previous crop in each year was sugarbeet and the soil type was Savage slit loam. Plots were fertilized to achieve a total available nitrogen supply (residual N plus applied) of 200kg/ha, phosphorous to achieve a minimum of 16 ppm and potassium to achieve a minimum of 250ppm. The herbicide Sonolan 3EC (ethalfluralin, Dow Agrosciences LLC, Indianapolis, IN) was applied at 1590 ml product/ha in 2002 and in addition the herbicide Eptam 7E (EPTC, Gowan, Yuma, AZ) at 1590 ml product/ha was applied in both years. To maintain optimal soil moisture, plots were furrow irrigated in May, June and August of both years. Stand counts were done and percentage emergence calculated based on a pure live seed basis. Seed germination for Montola 2004 were 93% in 2006 and 87% in 2007. Germination for Nutrasaff was 90% in 2006 and 84% in 2007.

Table 1. Seed treatment fungicides and rates tested

Fungicide-Common Name	Fungicide Trade Name	Rate ml product / 100 kg seed
untreated	untreated	-
carboxin-thiram	Vitavax 200	260
fludioxanil	Maxim	30
azoxystrobin	Dynasty	111
tebuconazole+ metalaxyl+ imazalil	Raxil MD Extra	148
mefenoxam + Fludioxanil+ mancozeb	ApronMaxx + Mancozeb	148 + 118
mefanoxam +thiram	Apron-Thiram	148
azoxystrobin + mancozeb	Dynasty + mancozeb	111 + 118
difenoconazole+ mefenoxam	Dividend XL RTA	295
mefenoxam + Fludioxanil+ azoxystrobin	ApronMaxx 50z + Dynasty	148 + 111

In a separate trial, seeds of a seed lot of Montola 2004 that was 22% infected with *A. carthami* and that had a germination of 68% were treated with the same fungicide seed treatments. Percentage seeds showing *A. carthami* infection and germination were measured after 7 days germination at 25 ^{0} C on cellulose pads. Experimental design was a four replication randomized complete block design.

Results

Yields and stands are given in Tables 2 and 3. Plots were harvested with a plot combine at approximately 8% moisture on 9, October in 2006 and 21 October in 2007 and yields were all corrected to 8% moisture. Oil content was determined using the protocol for simultaneous determination of oil and moisture contents of oilseeds using pulsed nuclear magnetic resonance spectrometry using a known safflower seed standard (Flynn and Bergman, 2001).

Table 2. Stand, grain yield and oil yield of Nutrasaff safflower treated with fungicides grown at Sidney, MT in 2006 and 2007.

Treatment	Percent stand-45 days post plant	Yield kg/h	Oil yield kg/h
untreated	80.2 a	2174 abc	1075 abc
Vitavax 200	73.0 c	2039 c	1009 c
Maxim 4FS	74.2 c	2220 ab	1103 ab
Dynasty	80.8 a	2303 ab	1141 ab
Raxil MD extra	77.5 abc	2241 ab	1106 ab
ApronMaxx Mancozeb	80.0 a	2350 a	1169 a
Apron-Thiram	78.7 ab	2159 bc	1064 bc
Dynasty + mancozeb	79.2 a	2222 ab	1095 abc
Dividend XL RTA	81.7 a	2352 a	1172 a
ApronMaxx + Dynasty	78.3 ab	2261 ab	1111 ab
Flsd 0.05	4.5	175.0	92

Table 3. Stand, grain yield and oil yield of Montola 2004 treated with fungicides grown at Sidney, MT in 2006 and 2007.

Treatment	Percent stand 45 days post planting	Yield kg/h	Oil yield kg/h
untreated	81.7 abc	2528 abc	947 abc
Vitavax 200	81.7 abc	2398 c	889 c
Maxim 4FS	80.0 bc	2542 abc	956 abc
Dynasty	79.0 c	2484 bc	923 bc
Raxil MD extra	85.3 a	2446 abc	936 abc
ApronMaxx Mancozeb	82.5 abc	2622 ab	990 ab
Apron-Thiram	80.0 bc	2748 a	1049 a
Dynasty + mancozeb	81.7 abc	2635 ab	993 ab
Dividend XL RTA	79.3 c	2782 a	1042 ab
ApronMaxx + Dynasty	84.2 ab	2609 abc	982 abc
Flsd 0.05	4.5	219.0	96

Table 4. Effect of fungicide seed treatment on *Alternaria carthami* infection and seed germination on Montola 2004 safflower

Treatment	Percent germination after 7 days	Percentage seeds or seedlings with visible Alternaria after 7 days
untreated	68	22
Vitavax 200	77	17
Maxim 4FS	79	19
Dynasty	82	0
Raxil MD extra	78	12
ApronMaxx Mancozeb	83	9
Apron-Thiram	77	15
Dynasty + mancozeb	89	0
Dividend XL RTA	84	7
ApronMaxx + Dynasty	83	0
Flsd 0.05	6	3

Discussion

For the cultivar Nutrasaff, no fungicide treatment statistically increased stand, test weight, oil content, seed yield or oil yield per hectare over untreated seed ($P<0.05$). For the cultivar Montola 2004, no fungicide treatment statistically increased stand, test weight, or percent oil over untreated seed ($P<0.05$). Seed treatment with mefenoxam + thiram and difenoconazole + mefenoxam statistically increased total seed yield and oil yield per hectare over untreated seed ($P<0.05$) for the cultivar Montola 2004. Treatment with mefenoxam+ fludioxonil + mancozeb and azoxystrobin + mancozeb increased total seed yield and oil yield per hectare over untreated seed ($P<0.1$) for the cultivar Nutrasaff. Mefenoxam/ metalaxyl containing seed treatments had numerically higher but not statistically improved stands over untreated seeds indicating that stand reduction by Pythium species was likely a factor in these trials. Seeds used in these trials had 10-20% *A. carthami* infection. The lack of improved germination with either mancozeb or azoxystrobin indicates that stand reduction by this pathogen was not important in these field trials.

Seed treatments containing mancozeb difenconazole and azoxystrobin improved germination and reduced *A. carthami* infection more than all other seed treatments although all treatments provided improved germination and reduced *A. carthami* infection over untreated seeds. These seed treatments may be beneficial to safflower producers when *A. carthami* reduces germination.

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