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EFFECTS OF FUNGICIDES ON RUST SEVERITY AND YIELD IN SUNFLOWER

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SUMMARY

Field experiments were conducted in 1991 and 1992 at Morden, Manitoba, on the efficacy of eight fungicides to control sunflower rust. Fungicides were applied either once at flowering or twice, at flowering plus 2 weeks later. Two applications of mancozeb resulted in the highest reduction in rust severity over the two years of this study followed by two applications of propiconazole. One application of mancozeb or propiconazole significantly reduced rust severity over the two-year period. One and two applications of fluazinam, and two applications of chlorothalonil significantly reduced rust severity in 1991; while one and two applications of myclobutanil, and two applications of RH-7592 significantly reduced rust severity in 1992. Most fungicides increased yield over the control, however, significant increase in yield resulted only from one application of myclobutanil or benomyl in 1991.

Key words: ***Helianthus annuus*, *Puccinia helianthi*, rust, fungicides, disease control.**

INTRODUCTION

Rust caused by *Puccinia helianthi* Schw. is a major disease affecting sunflower (*Helianthus annuus* L.) in the Red River Valley in Canada and the United States (Putt & Sackston 1955; Hoes & Huang, 1976). Severe epidemics in Manitoba caused yield reductions up to 60% (Putt & Sackston, 1955). Epidemics occurred in North Dakota in 1971-73 and in 1988-89 (Gulya *et al.*, 1989). Similar epidemics occurred in the eastern Canadian Prairies in 1988-89, where rust was present in 57-86% of fields surveyed with a range in severity of 1-60% leaf area affected (Rashid, 1991).

Sunflower rust can be effectively controlled by genetic resistance. Specific resistance genes to races 1 and 2 of this rust are present in commercial sunflower hybrids. However, race-specific resistance often breaks down due to the high pathogenic variability and the development of new virulent races. In Canada, two of the four races of *P. helianthi* (Sackston, 1955) predominated until recently when 12 new virulent races were identified and widely isolated (Rashid, 1991). Sunflower hybrids lack effective resistance genes to the new races, and there are no fungicides registered in Canada to control the disease. In India, benodanil, vitavax, dithane S-31, and dithane M-45 significantly reduced sunflower rust when applied at the seedling stage before or after infection (Lal & Singh, 1977); two applications of benodanil and vitavax gave 46-68% control of rust and increased yield by 51% (Lal Thakore *et al.*, 1980). In Kenya, five applications of oxycarboxin, zineb or sulphur effectively controlled sunflower rust and increased yield by 94-154% (Singh, 1975). In Israel, tebuconazole (Folicur) suppressed rust development for 14 days and resulted in yield increases of 0.86-1.15 t ha^{-1} (Shtienberg & Zohar, 1992). The objective of this study was to evaluate the efficacy of fungicides in reducing rust severity and improving the yield and yield components of sunflower.

MATERIALS AND METHODS

Field experiments were conducted at the Agri-Food Diversification Research Centre, Morden, Manitoba in 1991 and 1992. The rust susceptible hybrid MRS 42 was used in both years. Eight fungicides were evaluated for efficacy: benomyl, methyl 1-(butylcarbamoyl)-2-benzimidazole-carbamate 50% WP (Benlate); myclobutanil, a-butyl-a-(4-chlorophenyl)-1*H*-1,2,4-triazole-1-propanenitrile 40% WP (RH-3866); mancozeb, ethylene bisdithiocarbamate 80% WP (Dithane M-45); RH-7592, an experimental triazole fungicide 2F 23% (from ROHM and HAAS Canada); fluazinam, 3-chloro-N-(3-chloro-2,6-dinitro-4-trifluoromethyl)-phenyl-5-trifluoromethyl-2-pyridinamine 50% F; chlorothalonil 50% FL (Bravo); propiconazole 25% F (Tilt); and SAN 371 F 25% WP 01, an experimental fungicide (from Zeneca, formerly Chipman). RH-7592 was applied with Triton XR adjuvant (octylphenoxypolyethoxyethanol 70% F) at 0.5 l ha^{-1} as recommended by the manufacturer.

Experimental design was a randomized complete block with 17 treatments (Table 1) and four replicates. Plots consisted of four rows, 6.5 m long with 0.75 m row spacing. Plots were seeded on June 3 in 1991 and on May 27 in 1992, and were harvested on October 3 in 1991 and October 6, in 1992. One row of each of the highly susceptible cultivars Commander and S-37 were planted as rust spreaders every four plots. All rows of the two rust-spreader cultivars were inoculated with rust at the seedling stage using 0.1% urediospore suspension in water and applied with a knapsack sprayer on a humid evening to ensure favourable conditions for infection. Fungicides were applied either once at flowering or twice, at flowering plus two weeks later using application doses recommended by the manufacturer (Table 1). The fungicides were applied in 200 l ha^{-1} water using a knapsack sprayer equipped with TeeJet 8004SS nozzle. Control plots were sprayed with water.

Plots were assessed for rust severity during the first week of September. Severity was estimated visually using the percentage leaf area affected (% LAA) on all leaves in the plot (Gulya *et al.*, 1990), and disease severity indices were calculated on a scale of 1 to 10 as follows: 1= 1%; 2= 5%; 3= 10%; 4= 15%; 5= 20%, 6= 25%, 7= 30%, 8= 35%, 9= 40%, and 10= >40% LAA. The two middle rows per plot were harvested, the seed dried to 10% moisture content and cleaned, and the seed yield (kg ha^{-1}) was calculated. Oil content (% of kernel), kernel weight (g 1000^{-1} seed), and kernel density (g l^{-1}) were also determined. Data from individual years and two years combined were analyzed using the analysis of variance procedure (SAS Statistics, Version 6, SAS Institute, Cary, NC.). When F values were significant, the treatment means were compared using the least significant difference (L.S.D) at P=0.05%.

RESULTS AND DISCUSSION

Rust was observed in 95% of commercial fields in 1991 with mean severity index of 2-3 (8% LAA), but only in 56% of fields in 1992 with mean severity index of 2 (3% LAA). In this study, rust severity index in the control treatment was 4.2 in 1991 but only 0.6 in 1992 (Table 1). The difference in rust severity between 1991 and 1992 is attributed to the normal seasonal temperatures in 1991 which favoured rust development in comparison with the exceptionally low temperatures in 1992 with the May to September mean temperature of 2.3° C lower at Morden than the 30-year average.

In both years, most of the fungicides tested reduced rust severity and increased yield, especially when applied twice (Table 1). In 1991, one and two applications of mancozeb significantly reduced the rust severity index from 4.2 to 3.0 and 0.9, respectively. Similarly, one and two applications of fluazinam significantly reduced the severity index from 4.2 to 2.9 and 1.7, respectively. For propiconazole and chlorothalonil, only two applications significantly reduced the rust severity index to 2.7 and 2.9, respectively. Yields in 1991 were higher in most of the fungicide applications but only the early applications of myclobutanil and benomyl yielded significantly more than control plots (14-15%) in spite of the insignificant reduction in rust severity index. Oil content was significantly increased only by two applications of chlorothalonil. Kernel weight was significantly increased only by two applications of myclobutanil and propiconazole; while kernel density was significantly increased only by two applications of fluazinam and propiconazole.

In 1992, in spite of the lower rust severity, severity index was significantly reduced by one and two applications of mancozeb, myclobutanil, and propiconazole, and by two applications of RH-7592 (Table 1). Yields were equal or higher in all fungicide treated plots except those treated with one application of propiconazole. In spite of up to 11% higher yield in some plots treated with fungicides, the yield was not significantly different from the control due perhaps to the low impact of rust severity in 1992 in reducing yield. Similarly there was no significant effect of fungicides on oil content, kernel weight, and kernel density in 1992.

This study demonstrated that sunflower rust can be effectively controlled by two applications of mancozeb and propiconazole, while rust severity can be

Table 1: Effect of fungicides on sunflower rust, yield and yield components in sunflower

Fungicide	No. of applications	Dose (a.i. kg ha^{-1})	Rust severity[#] Index		Yield (kg ha^{-1})		Oil content %		Kernel weight (g 1000^{-1})		Kernel density (g L^{-1})	
			1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
Control			4.2	0.6	3490	2828	47.9	46.6	56.6	63.4	391	373
Mancozeb	1	1.6	3.0*	0.3*	3736	2990	48.6	46.7	57.0	62.9	392	366
Mancozeb	2	1.6	0.9*	0.1*	3914	2970	48.1	46.4	61.1	64.2	400	374
Myclobutanil	1	0.3	4.2	0.3*	4030*	2922	47.9	46.7	57.6	62.6	391	378
Myclobutanil	2	0.3	3.5	0.3*	3522	3060	47.4	47.0	62.6*	62.4	396	375
RH-7592	1	0.15	4.7	0.4	3804	3121	47.2	46.7	59.8	62.8	397	377
RH-7592	2	0.15	3.6	0.3*	3612	3114	47.7	46.9	60.8	62.3	400	377
Fluazinam	1	1.0	2.9*	0.4	3503	2969	46.7	46.6	61.2	64.6	386	377
Fluazinam	2	1.0	1.7*	0.4	3462	2862	48.1	46.8	58.2	63.4	405*	386
Propiconazole	1	0.12	3.3	0.2*	3666	2759	47.7	46.8	61.7	60.5	390	377
Propiconazole	2	0.12	2.7*	0.1*	3954	2924	47.9	46.4	62.4*	64.9	406*	379
SAN 371	1	0.2	3.5	0.5	3492	3137	47.5	46.9	56.5	62.4	392	372
SAN 371	2	0.2	4.1	0.6	3245	2979	48.3	46.3	55.9	66.2	394	379
Benomyl	1	1.0	4.3	0.5	3988*	3046	48.4	47.4	58.7	62.0	391	374
Benomyl	2	1.0	3.4	0.6	3689	2956	48.1	45.5	54.9	66.9	397	383
Chlorothalonil	1	1.0	3.7	0.5	3468	2993	48.1	45.0	56.0	65.5	386	371
Chlorothalonil	2	1.0	2.9*	0.5	3700	2821	49.2*	45.7	56.3	65.6	394	376
C.V.			21.2	50.8	9.5	8.0	1.4	2.7	6.9	5.8	1.9	3.0
L.S.D.			1.0	0.3	496	337	1.0	1.8	5.7	5.3	10.9	15.8

Rust severity index is based on percentage leaf area affected (%LAA), see materials and methods

* Significantly better than the control at the 5% level of probability

reduced by one application of mancozeb. These treatments proved effective in both years of this study. Other treatments such as one or two applications of myclobutanil, one or two applications of fluazinam, one application of propiconazole, and two applications of RH-7592 or chlorothalonil were effective in reducing rust severity in one of the two years of this study.

Most fungicide applications improved yield, however, only the treatments with mancozeb, myclobutanil, and propiconazole increased yield by 11-16% and significantly reduced rust severity in at least one of the two years. One application of RH-7592 or benomyl resulted in 8-14% increase in yield in both years in spite of the insignificant effects on rust severity. The modest effects of the fungicides used on yield improvement were attributed to the low levels of rust severity particularly in 1992 where rust did not have a major impact in reducing yield yet the fungicides reduced rust severity measured by %LAA and expressed in severity indices. Timing of fungicide application is very important to achieve effective rust control, and should coincide with the occurrence of initial stages of infections. Under warm humid conditions, primary infections occur early in the growing season, prior to the bud stage, and two fungicide applications may be required to control the disease and significantly increase yield. Only one application may be sufficient to control rust and increase yield in years when primary infections occur late or when weather conditions are unfavourable for rust development. The economical control of rust has to be assessed based on the growth stage of the crop when primary infections occur, prevailing weather conditions and anticipated severity of epidemics, subsequent yield losses and market prices, and the net returns from higher yields obtained by applying fungicides.

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REFERENCES

Gulya, T., Miller, J. and Rashid, K.Y., 1989. Rust races occurring in North America in 1988 and resistance of sunflower hybrids to races 1 and 3. In: Proceedings of the Sunflower Research Workshop, Fargo, North Dakota, January 9-10, 1989, USA National Sunflower Association, Bismark, ND, USA. PP.19-20.

Gulya, T., Venette, R., Venette, J.R., and Lamey, H.R., 1990. Sunflower rust. NDSU Extension Service, North Dakota State University, Fargo, ND, USA. pp. 1-4.

Hoes, J.A. and Huang, H.C., 1976. Importance of disease to sunflower in Manitoba in 1975. Can. Plant Dis. Surv. 56:75-76.

Lal Thakore, B.B.T., Mathur, S., Chakravarti, B.P., Singh, R.B. and Singh, R.D., 1980. Increase in sunflower yield by controlling rust with systemic and non-systemic fungicides. J. Turkish Phytopath. 9:89-96.

Lal, B.B. and Singh, R.D., 1977. Control of sunflower rust by pre- and post-infection spraying of systemic and non-systemic fungicides. Pesticides 11:24-25.

Putt, E.D. and Sackston, W.E., 1955. Rust resistance in sunflower (*Helianthus annuus* L.). Nature 176:77.

Rashid, K.Y., 1991. Incidence and virulence of *Puccinia helianthi* on sunflower in western Canada during 1988-1990. Can J. Plant Pathol. 13:356-360.

Sackston, W.E., 1962. Studies on sunflower rust. III. Occurrence, distribution, and significance of cultures of *Puccinia helianthi* Schw. Can. J. Bot. 40:1449-1458.

Shtienberg, D. and Zohar, D., 1992. Fungicidal disease suppression and yield losses associated with sunflower rust in Israel. Crop Protection 11:529-534.

Singh, J.P., 1975. Field evaluation of fungicides for the control of sunflower rust in Kenya. Plant Dis. Reptr. 59:200-202.

CONTROL DE LA ROYA DE GIRASOL CON FUNGICIDAS

RESUMEN

Se llevaron a cabo experimentos en campo en 1991, 1992 en Morden, Manitoba, sobre la eficacia de ocho fungicidas para controlar la roya de girasol. Dos aplicaciones de mancozeb dieron luger a la mayor reducción en la severidad de la roya durante los dos años de este estudio seguida por dos aplicaciones de propioconazole. Una aplicación de mancozeb o propiconazole redujo la severidad de la roya en los dos años. Una y dos aplicaciones de fluacinan, y dos demiclobutanil y dos aplicaciones de clorotalonil redujeron significativamente la severidad de roya en 1991, mientras que una y dos aplicaciones de miclobutanil, y dos aplicaciones de RH-7592 redujeron significativamente la severidad de roya en 1992. La mayoria de los fungicides incrementaron el rendimiento respecto al control, pero un incremento significativo del rendimiento solo tuvo lugar con una aplicación de miclobutanil o benomil en 1991.

CONTRÔLE DE LA ROUILLE DU TOURNESOL PAR FONGICIDES

RÉSUMÉ

Des expérimentations ont été conduites en 1991 et 1992 à Morden, Manitoba, sur l(efficacité de huit fongicides pour contrôler la rouille du tournesol. Les fongicides ont été appliqués soit en un seul passage à la floraison soit en deux fois: à la floraison et deux semaines plus tard. Deux applications de mancozèbe conduisent à la plus forte réduction de la gravité de l'attaque sur les deux années de cette étude, suivie par une moindre efficacité du propiconazole en deux applications. Une seule application de mancozèbe ou de propiconazole a réduit significativement l'attaque de rouille durant les deux années. Une et deux applications de fluazinam et deux applications de chlorothalonil ont significativement réduit la gravité de l'attaque en 1991, alors qu'une et deux applications de myclobutanil et deux applications de RH-7592 ont réduit significativement la gravité de l'attaque en 1992. La plupart des fongicides ont augmenté le rendement par rapport au témoin, cependant, des augmentations significatives de rendement ont résulté d'une application unique de myclobutanyl ou de benomyl, en 1991.