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CHEMICAL CONTROL OF FOOT ROT OF WHEAT CAUSED BY *SCLEROTIUM ROLFSII* SACC.

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The effects of four fungicides on germination and growth of *Sclerotium rolfsii* and on the intensity of foot rot of wheat seedlings are reported. Campogram M and Benodanil showed significant inhibition of germination and growth from sclerotia in *in vitro* tests. Soil drench with Benodanil and seed treatment with Campogran M were highly effective in reducing the seedling mortality caused by the pathogen, under controlled conditions. Calixin caused acute phytotoxicity when used as a seed dressing.

INTRODUCTION

Foot rot of wheat (*Triticum vulgare* L.) is caused by several pathogenic fungi. Occurrence of foot rot caused by *Sclerotium rolfsii* Sacc. has been recorded in various parts of the world (Epps *et al.*, 1951; Chattopadhyay, 1953). The disease appears at any stage of crop growth when the soil temperature is above 25°C (Kilpatrick & Merkle, 1967). But losses are more severe when infection occurs at the seedling stage. The authors noted extensive seedling mortality in West Bengal. Similar record has been made in Madhya Pradesh (Agarwal & Singh, 1968). Various control measures have been recommended from time to time. These included high level of nitrogenous fertilizers (Agarwal & Singh, 1968), seed treatment with panogen [Cyano (methylmercuri) guanidine] (Kilpatrick & Merkle, 1967), brassicol (pentachloronitrobenzene) and TMTD (tetramethylthiuram disulphide) (Mishra & Chand, 1970), arasan (TMTD) and captan [N-(trichloromethylthio)-3α, 4, 7, 7α-tetrahydronaphthalimide] and soil drench with Rhizoctol (methylarsenic sulphide) (Agarwal & Singh, 1969). These fungicides when tested in the laboratory and field gave variable results.

The fungitoxicity of four new fungicides, including three systemics, towards germinability and growth from sclerotia of *S. rolfsii* were tested along with their effects on preventing foot rot of wheat in an attempt to develop an efficacious control method for this disease.

MATERIALS AND METHODS

Sclerotium rolfsii was isolated from infected wheat seedlings, on potato-dextrose-agar (PDA) medium.

Fungicides tested were Benodanil 50 WP (2-iodobenzoic acid anilide), Campogran M [a mixture of 50% 2, 5-dimethyl-furan-3-carbonic acid anilide+

32% (zinc) manganese ethylene-bis-dithiocarbamate], Calixin 75 EC (N-tridecyl-2, 6-dimethyl-morpholine) and Busan 60 EC [2-(thiocyanomethylthio) benzothiazole]. Dilutions of 160, 80, 40, 20 and 10 ppm were prepared on the basis of the formulated products. Lower dilutions were used, where necessary, for determining the E_D 50.

Mature sclerotia were harvested from 30-day old culture of the test fungus in PDA and soaked in different concentration of the fungicides in replicated sets for 24 and 48 hrs., respectively. After specified period one-half sclerotia were repeatedly washed in sterile distilled water. Germination of the washed and unwashed batches of treated sclerotia was studied on glucose-impregnated moist filter paper in petri dishes incubated at 28 ± 1°C. Parallel controls were run for comparison.

Growth studies were conducted by the conventional poisoned-food technique. Required amount of fungicide was incorporated aseptically into molten PDA medium and 20 ml poured into 8 cm diameter sterilised plates. The plates were inoculated with single viable sclerotia. In others, inoculation was done with 5.0 mm discs of mycelial felt taken from a 3-day old culture on PDA. Each treatment was replicated four times and maintained at 28°C. Changes in colony diameter, colony character, hyphal growth and sclerotia production were recorded. ED_{50} was determined on a log-probit scale.

The effect of these fungicides on seed germinability and seedling health was studied by treating seeds with 0.8 ml Busan, 3.0 g Campogran M, 3.0 g Benodanil and 2.5 ml Calixin per Kg seed in a slurry treater. Twenty treated seeds were placed in replicated sterilised petri dishes on moist blotting paper and incubated at 25°C. Germination (%), root and shoot growth were recorded after 7 days.

The effectiveness of these fungicides *in vivo* was studied by raising seedlings of wheat (var. *Sonalika*) in wooden trays in natural soil mixed with requisite amount of fertilizers. Seed treatment was done as mentioned above. Inoculum of *S. rolfsii* was raised in sand maize meal medium at 28°C for one month and the sclerotia subsequently air dried. The sclerotia so obtained were mixed with sand in proportion of 1 : 5 and placed in bands along seedlings after their emergence. For studying the effect of soil drench, untreated seeds were sown and inoculation of soil was followed by drenching. For this 1000 ppm Calixin and Campogran M, 2000 ppm Benodanil and 300 ppm Busan were used. Inoculated controls were maintained. All treatments were replicated thrice. Number of dead seedlings was counted after 3 weeks and results statistically analysed after necessary angular transformation.

RESULTS

Effect of fungicides on germination of sclerotia

The results (Table I) showed that soaking for 48 hrs. in Benodanil and Campogran M (160 ppm) reduced germination of sclerotia significantly. However, the response with the two chemicals was different in that while in Benodanil washing the sclerotia following soaking eliminated its effect, such washing had no effect

TABLE I

Effect of different concentrations of four fungicides on the germination of sclerotia of Sclerotium rolfsii *after two periods of soaking*

Chemical	Concentration (in ppm)**	Percent germination of sclerotia*			
		24 hrs.		48 hrs.	
		washed	unwashed	washed	unwashed
Benodanil	40	100	100	100	80
	80	100	100	100	70
	160	100	100	90	40
Campogran M	40	100	70	100	90
	80	90	70	90	80
	160	30	30	40	30
Calixin	40	100	90	100	90
	80	90	90	100	100
	160	100	90	100	100
Busan	40	90	90	90	60
	80	100	90	90	40
	160	100	100	100	40

*Hundred sclerotia were used in each treatment replicated thrice
**At 0, 10 and 20 ppm there was nearly 100% germination in each treatment.

TABLE II

Effect of four fungicides on the percent reduction in growth of Sclerotium rolfsii

Fungicide concentration (ppm)	% reduction in growth*			
	Benodanil	Campogran M	Calixin	Busan
10	78·0	100·0	0·0	0·0
20	85·9	100·0	8·0	4·2
40	95·9	100·0	27·1	24·4
80	100·0	100·0	74·1	46·7
160	100·0	100·0	93·75	70·0
E_D 50 (ppm) (Sclerotial inoculum)	14·0	<10·0	60·0	100·0
E_D 50 (ppm) (mycelial inoculum)	0·22	0·14	155	120

*Results are an average of four replications using sclerotia as inoculum

on the inhibitory activity of Campogran M. A response similar to Benodanil was noted when sclerotia were soaked for 48 hr in Busan. Calixin had no effect on the germination of sclerotia.

Bioassay by poisoned food technique

The results showed that Benodanil and Campogran M were highly effective in preventing mycelial growth. Campogran M caused complete inhibition of growth at 5 ppm and Benodanil at 10. The E_D 50 of these compounds were 0.22 and 0.14, respectively. E_D 50 for Busan and Calixin were 120 and 155, respectively. When sclerotia were used as inoculum (Table II) the ED_{50} was found to be higher for Benodanil (14 ppm).

Effect of fungicides on fungal growth and sclerotia formation

Benodanil and Campogran M induced thin, sparse mycelial growth. Sclerotia were light brown in colour at lower concentrations and at higher concentrations sclerotia production was completely inhibited. Calixin-treated colonies developed sectors in all concentrations. At low concentrations sclerotial initials developed in a month. At higher concentrations sclerotia production was completely inhibited. Treatment with Busan resulted in progressive reduction in sclerotia production and at 160 ppm no sclerotia were produced.

Effect of fungicides on seed and plant health

No significant change in germinability was noted, although at times germination was delayed. Most prominent in this respect was Calixin. This was reflected in the initial reduction of root and shoot length (Table III). Calixin treated seedlings showed burning of root tips. Leaves became thicker, broader and dark green and the surface became rough. After 12–15 days water soaked lesions appeared on leaves, irregular in shape and arrangement, and developed progressively from tip downwards. Spots coalesced, ultimately blighting the whole leaf, and plants withered in 20–25 days from the date of emergence. Campogran M also produced mild leaf tip burn in some plants.

TABLE III

Per cent reduction in root and shoot growth of wheat seedlings due to fungicidal treatment

Treatment	Concentration (per kg seed)	Per cent reduction in growth*	
		shoot	root
Benodanil	3·0 g	24·19	35·04
Campogran 'M'	3·0 g	5·18	45·96
Calixin	2·5 ml	68·68	71·77
Busan	0·8 ml	43·84	37·30

*Results are an average of 20 measurements in each of the four replications after 7 days of germination

Chemical control of foot rot of wheat

The results (Table IV) showed that soil drenched with 2000 ppm Benodanil was most effective in reducing seedling mortality (65·1%), followed by seed

TABLE IV

Effect of seed treatment and soil drenching with four fungicides on the incidence of foot rot of wheat caused by Sclerotium rolfsii

Treatment	Doses	Per cent mortality
SOIL DRENCH		
Benodanil	2000 ppm	34·87 (36·15)*
Campogran M	1000 ppm	65·37 (53·97)
Calixin	1000 ppm	85·49 (67·66)
Busan	300 ppm	69·06 (56·31)
SEED TREATMENT		
Benodanil	0·3%	52·39 (46·37)
Campogran M	0·3%	38·33 (38·24)
Calixin	0·25%	**
Busan	0·08%	46·05 (42·73)
Control (inoculated)	—	83·23 (65·91)
CD at 5%	—	4·24

*Figures in parentheses indicate angular transformed values
**Percentage mortality not recorded due to acute phytotoxicity

treatment with Campogran M, Busan and Benodanil. Soils drenched with Campogran M, Busan and Calixin were ineffective. Seed treatment with Calixin caused acute phytotoxicity resulting in death of most seedlings.

DISCUSSION

The action of anilides on the germination of sclerotia of *S. rolfsii* is of interest. On soaking for 48 hr in graded fungicide suspensions, inhibition was recorded in either case at 40 ppm and above. However, washing the sclerotia after soaking reversed to a great extent the inhibitory action of Benodanil. This basic difference in activity can be explained if we assume that Benodanil is not able to penetrate the rind wall of sclerotia while Campogran M is able to do so.

Claims of the *in vitro* effectivity of Benodanil and the furane anilide derivative on *S. rolfsii* has been made earlier (Pommer & Zwick, 1974). However, the present results showed that Benodanil is far more effective in preventing mycelial growth than in preventing germination of sclerotia. It would appear that the intrinsic energy of a sclerotium is able to counterbalance to limited extent the inhibitory activity of the toxophore.

The effect of these chemicals on the seed germinability and seedling health showed that Calixin and Busan have to be used with caution. While no significant effect on germination was noted, Calixin was highly phytotoxic to wheat seedlings emerging from treated seed. Sequential N-(n-alkyl) substitutions with 9–18 carbon atoms on the fungicidal activity of 2, 6-dimethylmorpholine against barley mildew showed that effectiveness increases with chain length, reaching a maximum for $C_{13}H_{27}$ (Calixin) but the tendency for phytotoxicity increases at the same time (Konig Pommer, 1965). There were indications of some phytotoxicity on certain winter wheat varieties (Pommer & Kradel, 1967). Present results showed that Calixin was unsuitable for seed treatment of wheat. Campogran M also caused mild phytotoxic symptoms in wheat. Similar sensitivity has been noted earlier by Pommer *et al.* (1971) for some varieties of barley under certain climatic conditions.

Pot trials confirmed the results obtained through bioassay and seed health studies. Soil drench with Benodanil and seed treatment with Campogran M were most effective in reducing the intensity of foot rot of wheat and may provide some new avenues for the control of this ubiquitous plant pathogen. It was noted that while bioassay studies revealed Campogran M to be more effective than Benodanil, the reverse was recorded in pot trials. The explanation possibly lies in the relative translocability of the two compounds. Pommer (1972) observed that transport of the furane anilide inside the plant is relatively slow and during translocation part of the active material may be fixed in the tissue of the stem. When applied to the soil, during uptake of the substance via the roots, there may be a decrease in the concentration inside fast growing plants to a point where it becomes too low for the control of the pathogenic fungi. This also will explain the better control of this disease with Benodanil as soil drench and Campogran M by seed treatment.

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References

Agarwal, S. C. & Singh, S. P. (1968). A survey of foot rot disease of wheat in Madhya Pradesh. *PANS*, **14**, 147–151.

Agarwal, S. C. & Singh, S. P. (1969). Efficiency of some fungicides in controlling foot rot of wheat. *Indian Phytopathol*, **22**, 476–479.

Chattopadhyay, S. B. (1953). Root rot and foot rot of wheat caused by *Sclerotium rolfsii* and *Curvularia specifera* Boedju (*Helminthosporium tetramera* Mckinney). *Sci. Cuet.*, **19**, 101–102.

Epps, W. M., Paterson, J. C. & Freeman, I. E. (1951). Physiology and parastitism of *Sclerotium rolfsii*. *Phytopathology*, **43**, 245–256.

Kilpatrick, R. A. & Merkle, D. G. (1967). Seedling disease of wheat caused by *Sclerotium rolfsii*. *Phytopathology*, **57**, 538–540.

Konig, K. H. & Pommer, E. H. (1965). N-substituted tetrahydro-1, 4-oxazines : a new class of fungicidal compounds. *Angew, Chem*, **4**, 336.

Mishra, R. P., Chand, J. N. (1970). Efficacy of different fungicides against foot and root rots caused by *Sclerotium rolfsii*. *PANS*, **16**, 327–330.

Pommer, E. H. (1972). The systemic activity of a new fungicide of the Furane carbonic acid anilide group (BAS '3191' F), In : *Pesticide Chemistry*, Vol. V, 397–404. (Ed. A. S. Tahori) Gordon Breach Science Publishers, New York, London and Paris.

Pommer, E. H. & Kradel, J. (1967). Substitutierte dimethyl-morpholin derivate als neue fungizide zur bekamfung echter mehltanpize. Mededel. Rijksfaculteit Landbouw. *Wateten-schappen Gent.*, **32**, 735.

Pommer, E. J. & Zwick, W. (1974). Efficacy of systemic fungicides against basidiomycetes. *Indian Phytopathol.*, **27**, 53–58.

Poomer E. H., Hampel, M. and Locher, F. (1971). Results with BAS '3270'F. *Proc. 6th Br. Insectic. Fungic. Conf.*, **2**, 587.