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INVESTIGATIONS ON DOWNY MILDEW OF SUNFLOWER IN INDIA

M.A. PATIL and C.D. MAYEE
Oil Seeds Research Station
Marathwada Agricultural University, Parbhani 431 402 , India

SUMMARY

Plasmopara halstedii, the pathogen inducing downy mildew of sunflower was for the first time detected to occur in India. Presently it is endemic in a pocket of 0.1 million ha in central India. Since 1984, when it was first found to occur, the natural incidence of the disease has increased from 8% to 30%. In artificial inoculations, the pathogen induced variety of symptoms typical of the disease. Radical inoculation with active zoosporangia successfully produced the disease. Downy mildew was found to be nearly 7.0% seed transmissible. The disease reduced drastically the growth parameters, yield and oil content of the seed. Infected plant material containing oospores incorporated in soil also served as inoculum. The natural occurrence of the disease was dependent on rainfall pattern and high incidence occurred in crops sown from June to October Sunflower susceptibility to zoosporangial inoculation declined with host growth. Race 1 to 2 but certainly not race-3 appears to have been introduced in India as the isolate was able to infect cv. Progress. Sunflower germplasm lines available in the country were screened for resistanee successively for three years and sources of resistance amongst cultivar, male restorers and CMS-lines were identified. Chemical seed treatment with metalaxyl was found effective. However, emphasis has been given to develop downy mildew resistant hybrids, the yield performance and acceptability of some has encouraged to adopt this method of control.

INTRODUCTION

The cultivation of sunflower is fast increasing in the semi-arid regions of Central India comprising the states of Maharashtra, Andhra Pradesh and Karnataka. We detected by chance the occurrence of downy mildew caused by **Plasmopara halstedii** on cv. Morden popularly grown by farmers in September 1984 in the region called Marathwada which extends between 75° and 78° longitude East and 17° and 20° latitude North (Mayee and Patil, 1986, 1987). The disease remained confined largely in this tract for three years but now there are reports of its occurrence from adjoining Karnataka states and below 17° lat itude North. With large scale exchange of seed material it would not be suprising if downy mildew of sunflower spreads to all sunflower growing areas of country and pose a major threat to the crop cultivation. The entry of disease into India, likely again due to unchecked seed in qurantine, nececiated urgent studies in the Indian context. The present paper reports the results of experimentation carried out for the last three years on the disease.

MATERIAL AND METHODS

Plasmopara halstedii zoosporangial inoculum in the form of downy growth was multiplied on seedlings of cv. Morden at Oilseeds Research Station, Latur in September, 1984 and since then the disease has been maintained by periodical inoculations on potted plants by providing congenial conditions round the year. The infective of zoosporangia, oospores was checked by inoculation on to zoosporangia, healthy seedlings. Oosporescollected from infected stem and roots were separately harvested and added to soil to develop a downy mildew-sick plot of 0.5 ha. Morden sunflower was repeatedly grown in three seasons and infectedplants incorporated to improved the level of infectivity. Radical inoculation technique (Henning and Franca Neto, 1985) was largely adopted for zoosporagial inoculation in many experiments.

Replicated pot and field experiments were carried out to examine the efficacy of oomycetes-sensitive fungitoxicants for three years under artificial inoculation. Similarly, resistance screening was initiated in early 1985 in the sick plot and simultaneously in pots.. The zoosporangia inoculated seedlings were raised in earthen pots and exposed in humidity chamber where 12 hr cycle of high humidity was provided by humidifiers. Each genotype was subjected to field and pot testing for three years. In the sick plot suitable infector row technique was adopted to ensure high infection.

Out of the male restorers found resistant, crosses were executed using RHA 274, RHA 265, RHA-587, RHA 801, RHA 273, MRHA-1, MRHA-2 with CMS -lines such as, CMS-207 A, CMS-338A, CMS-300 A, CMS-234A and CMS-821A. MRHA-1 and MRHA-2 were developed as new male restorers by the method given by

Fick (1978). A series of hybrids were developed and evaluated for downy mildew resistance and yield. Promising hybrids from the series designated as LDMRSH were tested for their performance at many locations for a period of two years in Maharashtra state.

RESULTS AND DISCUSSION

Roving surveys were conducted between September and November being from 1984 for recording the natural incidence of downy mildew in farmers field in a belt comprising of nearly 0.3 to 0.35 million ha. The disease was found confined only in the area where sunflower was grown continuously in irrigated conditions in the post rainy season. The incidence varied from 3 to 35% and appears increasing every yeaar excepting in 1986. when general drought conditions prevailed (Table 1).

The zoosporangia were highly infective and using the radical inoculation method induced damping off symptoms (Table 2). However, the potted grown plants appeared less susceptible to sporangial inoculation by spray with the growth of seedling. The fungus produced abundent sexual oospores embeded in the root, stem and foliar tissues. They too when incorporated in the sterilized soil served as good source of inoculum. The soil on which infected plants grew when used for planting the healthy seeds acted as an agent for disease transmission indicating the possibility of inoculum survival in the soil. Infected seeds were found to transmit the disease to the tune of 7% when grown in isolation chambers under sterilized soil conditions. These characteristics of infection and perpetuation have been well known for downy mildew of sunflower (Zimmer and Hoes, 1978). Similarly, in artificial inoculation, the pathogen induced variety of symptoms like, damping off, stunting, yellowing of the first pair of true leaves along the mid rib, downy growth basal gall and errect head in susceptive cv. Morden. Occasional floret malformation noticed in nature could not be confirmed in artifaicial inoculation. The characteristic stunting of the infected plants were found accompanied with reduced fibrous root growth (Table 3).

The influence of downy mildew on plant growth and yield was examined in two separate experiments in a paired plot of infection and healthy, the disease reduced yield by nearly 84% by reducing the growth parameters, seed weight and oil content. Table 4 depicts the results obtained in this regards.

A study was carried out for a period of three in a replicated blocks for finding out the relationship between dates of planting, rainfall pattern and disease incidence conditions. It was revealed that under the optimum conditions of inoculum availability and susceptible host rainfall immediately following planting and number of rainy days governed that- initial incidence of downy mildew in sunflower (Table 5). Highest primary infection of downy mildew was evident in sick plots when the first fortnight after sowing had highest rainfall and more number of rainy days. This confirms the results of Zimmer (1975), who reported that the incidence of systemically infected plants in field associated with occurrence and intensity of rainfall during seeding time.

Henning and Franca Neto (1985) used breeding line AD 66 (resistant to European race 1) RHA 271 and RHA 274 (resistant to Euyropean race 1 and American race 2) and cultivar Issanka for determining race flora of **Plasmopara halstedii** in Brazil. RHA 273 and RHA-274 have also been shown resistant to Red River race 2 but susceptible to new ra ce 3 (Fick and Auwarter, 1982). Cultivar progress is susceptible to race 3 (Abdallah, 1985, Henning and Franca Neto, 1985). We could not obtain Issanka, AD 66 and other differential lines. However, based on the reactions of the Indian isolate on RHA-271, 265, 273, 274, 271 and progress, it is inferred that probably races 1 or 2 are present in the country but certainly not race 3 as cv. progress known to be resistant to race 3 has been found susceptible in artificial inoculations.

Several oomycetes- sensitive chemicals have been introduced in recent years in India for testing against downy mildews. Metalaxyl and fosetyl-Al have shown promise against downy mildew of pearl millet, cucurbits, grapes and therefore seed treatment trials were carried out using six treatments in a randomized block design over a period of three years. The data in Table 7 depicted a clear response of metalaxyl seed treatment to downy mildew of sunflower. Fosetyl-Al was also at par with metalaxyl while others though inhibitory were not inferior to the best ones. Nikolov (1981) and Melero-Vara et al. (1982) reported inhibition of P. halstedii with metalaxyl seed dressing. Phytoalexin (Chemical marketed by West Coast International, Bombay) which the manufacturers claim to induce disease resistance against non-septate fungi has been found to reduce systemic infection of fdowny mildew when sprayed at 0.7% product. However, the lower levels were not very effective (Table 8).

Resistance breeding being the best method for management of downy mildew, a comprehensive resistance screening programme was initiated in 1985. Nearly all the available germplasm lines were tested for

Table 1. Incidence of downy mildew of sunflower since the first occurrence in Central India (Maharashtra) in 1984

Year	Total area (M.ha)	Area infected (ha.)	Incidence (%)	Rance (%)
1984	0.30	10,000	12	7-20
1985	0.35	21,000	25	20-30
1986*	0.30	1,500	4	3-5
1987	0.30	25,000	25	15-35

(*) Severe drought occurred in the sunflower belt.
Surveys carried out during September to November.

Table 2. Infectivity of downy mildew oospores and zoosporangia in artificial inoculation.

Mode of inoculation	Incidence (%)	Mortality (%)
Zoosporangia as inoculum		
radicle dip	80	25
seed dip	78	3
Cotyledon spray	75	0
Spray on first true leaves	50	0
Oospores as inoculum mixed in soil		
from stem	6	0
from root	49	0
Previously infected soil (oospores)	22	0
Seeds collected from infected plants	7	0

Table 3. Range of downy mildew symptoms in natural and artificial infection

Type	Frequency (%)	
	In nature	In artificial infection
Damping off	0.5	20.0
Stunting	95.0	95.0
Veinal chlorosis	60.0	95.0
Downy mildew	20.0	100.0
Basal gall	25.0	5.0
Errect head	95.0	95.0
Floret malformation	Trace	0.0

Table 4. Influence of downy mildew on growth and yield of sunflower cv. Morden*

Source	Plant height (cm)	Root Length (cm)	Days to Maturity	Head diameter (cm)	1000 seed wt.(g)	Oil (%)	Germination (%)	Yield[1] Kg/ha
Healthy (un-inoculated)	116	38	95	20	46	35	78	1200
Infected (inoculated)	32	20	81	7	20	31	23	190

(*) Based on 1000 plants randomly selected in 2 ha plot
1 Based on paired plot techniques

Table 5. Downy mildew primary infection in relation to date of planting and rainfall during the first forthnight after planting in a sick plot

Date of planting	1985			1986			1987		
	Rainfall (mm)	Rainy days	% Incidence	Rainfall (mm)	Rainy days	% Incidence	Rainfall (mm)	Rainy days	% Incidence
June 1	63	6	30	71	5	15	22	4	20
15	53	8	25	21	2	10	113	8	50
July 1	5	2	10	37	4	35	55	4	40
15	147	8	55	77	7	30	49	4	29
Aug. 1	38	4	15	90	11	35	83	5	57
15	19	3	18	0	0	5	94	3	54
Sept. 1	27	4	20	13	1	10	2	1	5
15	56	3	34	29	2	15	16	1	4
Oct. 1	167	5	58	0	0	5	80	6	30
15	0	0	25	0	0	0	33	1	21

Table 6. Reactions of some differentials to downy mildew isolate of India

Differential cultivar	Know reactions to races		Reaction in India
	1 and 2	3	
RHA-271	R	S	R
RHA-265	R	S	R
RHA-273	R	S	R
RHA-274	R	S	R
RHA-801	R	S	R
Progress	S	R	S

R = Resistant S = Susceptible

Table 7. Influence of fungicidal seed treatment on the incidence of downy mildew.

Chemical	Trade Product	Rate per kg.	% incidence		
			1985	1986	1987
Fosetyl-Al Fosetyl-Al 44% + Mancozeb 26%	Aliette 80 WP Rodax	5 6	24 11	29 10	17 11
Oxadixyl	SAN 371 F 2-5	5	22	17	23
Thiophanate methyl	Topsin M70 WP	3	35	33	34
Metalaxyl	Apron 35 SD	6	4	5	4
Control	-	50	50	54	53
CD 5%			13.5	7.8	

Table 8 . Efficacy of phytoalexin in controlling downy mildew.

Spray Concentration (%)		Downy mildew incidence (%) 28 DAP	Plant Recovery (%)
0.3	PI	40.0	0.0
	AI	48.7	0.0
0.5	PI	40.2	5.5
	AI	44.3	3.5
0.7	PI	33.5	28.5
	AI	36.0	25.9
Control (Water spray)		56.9	0.0
CD 5%		4.5	-

resistance to downy mildew in field and pots. A good range of sources of resistance are found in cultivars and male lines. However, only one CMS-line was found to be resistant. Several hybrids derived at the research centres in India have knowing or unknowingly the male component as resistant to downy mildew and therefore the hybrids have largely shown moderate to high level of resistance (Table 9 and 10). The presently recommended hybrids BSH-1, MSFH-1, and MSFH-8 have been found to be moderately resistant to susceptible. Therefore, a separate breeding programme was started at Latur (maharashtra) for developing downy mildew resistant hybrids using the resistant restorers. A series of hybrids designated as LDMRSH were evolved through the hybridization involving RHA-274, RHA 265, RHA-801, RHA-273, RHA-587 , MRHA-1 and MRHA-2 as male restorers and CMS-207A, CMS-338A. CMS-300A , EMS 234A and CMS -821 A as female parents. Out of the 32 hybrids developed only 4 have shown promise interms of yield and other agronomic characters. Their performance was evaluated at four locations in two seasons during 1986and at 12 locations in one season during 1987 in Central India (Table 11). The yield of LDMRSH-12 has been often higher followed by LDMRSH-3. These hybrids have shown other acceptability traits and are being faurther tested at national level. If their performance as found better than national check hybrids, BSH-1 and MSFH-1 at national level also these hybrids will be considered for release at national level. Presently they are being considered for Maharashtra State level where downy mildew endemic area exists in the major sunflower growing belt.

CONCLUSIONS

The following conclusions can be drawn on the basis of three year studies on downy mildew of sunflower in India:

1. Downy mildew recently introduced in India is likely to become a serisous threat to sunflower cultivation. 2. Perpetuation of the pathogen occurs through infected bebris and seed. Zoosporangia bring about secondary infection. 3. The disease severity is governed by rainfall after sowing. 4. Chemical seed treatment with metalaxyl is effective. 5. Several sources of resistance are available and hybrids resistance to downy mildew can be developed in short period to minimizethe problem.

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Table 9. Screening and categorization of sunflower material against downy mildew in India

Sunflower genotypes	Total screened	Number of Entries in			
		Resistant	Moderately Resistant	Moderately Susceptible	Susceptible
Cultivars	250	3	0	2	245
Male Restorers	14	10	2	0	2
CMS-lines	15	1	1	0	13
Hybrids	150	12	80	20	38

Resistant = Below 2% , Moderately Resistant = 2.1 to 10%, Moderately susceptible = 10.1 to 25%, Susceptible = Above 25.1%

Table 10. Reactions of some selected sunflower entries to Downy mildew.

Entry	% infection (maximum)	Entry	% infection (maximum)
Cultivars:		**Male Restorers:**	
SFL-6	2.0	RHA-271	2.0
LS-51	2.8	RHA-273	1.4
LS-7	1.5	RHA-274	1.4
*Morden	94.0	RHA-299	0.0
*EC 68 414	76.0	RHA-586	1.2
Hybrids:		RHA-587	1.5
*BSH-1	15.0	RHA-801	0.0
*MS FH-1	15.0	MRHA-1	0.0
*MS FH-8	20.0	MRHA-2	2.0
+LDMRSH-1	1.6	6 D-1	12.0
+LDMRSH-3	2.0	**CMS-lines**	
+LDMRSH-12	15.0	207-A	6.0
+LDMRSH-4	0.0	338-A	12.0
		234-A	78.0
a		300-A	80.0
		822-A	60.0

* Recommended for cultivation in India

\+ Developed recently in downy mildew nursery by the authors.

Table 11 : Yield performance of the newly developed hybrids resistant to downy mildew.

Hybrid	Mean yield (kg/ha)		Plant height (cm)	Days to maturity	Oil (%)
	1986[1]	1987[2]			
LDMRSH-1	1954	1316	135	85	35-3
LDMRSH-3	2760	1962	190	95	34.2
LDMRSH-4	2298	1470	170	96	34.5
LDMRSH-12	2816	2212	170	92	34.8
BSH-1(NC)	1716	*	134	96	37.5
MSFH-1(NC)	1783	1643	160	98	34.3

* Data not available

1 Based on 4 locations and 2 seasons

2 Based on 12 locations in Central India in one season.