

SUNFLOWER BREEDING STRATEGY FOR RESISTANCE TO DOWNY MILDEW DISEASE IN INDIA

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ABSTRACT

Sunflower downy mildew disease is caused by *Plasmopara halstedii* (farlow) and was first reported in 1986 in Marathwada region of Maharashtra state (India) on well adapted cultivar Morden with 1-36 % intensity. The occurrence of disease was reported in other states of India viz., Karnataka, Andhra Pradesh and Punjab. For effective screening of the sunflower germplasm, varieties and hybrid for the downy mildew disease, under the controlled condition the sick plot technique was developed at Oilseeds Research Station Latur in 1988. Hence, the centre has been identified as facilitator for the screening of the advance material evaluated under All India Coordinated Research Project (AICRP) on Sunflower for downy mildew at National level. The results of sick plot revealed that the disease reduces sunflower seed yield up to 89 % and negatively affects the other traits. The race identification studies of Indian isolate of *Plasmopara halstedii* revealed that it belongs to race-1 (European race). Breeding for downy mildew resistance is one of the major goals in sunflower breeding programme in India. The research work carried out since 1988 to 2015 at the centre under AICRP on sunflower screened the advance breeding material in both field and sick plot condition. Till date 5408 sunflower accessions against downy mildew were evaluated and reported 1075 disease free having high level of resistance to the pathogen. This resulted into the release of 15 sunflower hybrids and populations at national level. The identified resistance sources have been effectively utilized in the introgression of the resistant genes from identified sources for the improvement of parental lines. The centre has identified 14 parental lines (8 CMS, 6 restorer lines) possessing downy mildew resistant (PI genes). The center has released three state level hybrids LDMRSH-1, LDMRSH-3 and LSFH-35 and LSFH-171 at national level for commercial cultivation.

INTRODUCTION

In India different diseases are the main limiting factor in the production of sunflower (*Helianthus annuus* L.) and they cause poor realization of genetic yield potential of sunflower hybrid. Downy mildew (DM) is an economically significant disease. It is caused by the fungus *Plasmopara halstedii* (Farl.). Downy mildew is widespread in all sunflower growing countries with the exception of Australia. With regards to India, during early 1980's Ram Nath *et al* (1981) detected oospores of *Plasmopara halstedii* on sunflower seeds imported from Bulgaria. Mayee and Patil (1986) reported its occurrence in Marathwada region of Maharashtra state on cv Modern with 10.0 percent intensity for first time. The DM occurrence was immediately brought to the notice of Oilseeds Researchers in the Annual *kharif* workshop held at Dr. Punjabrao Deshmukh Agrilculture University, Akola of Maharashtra State (Anonymous, 1985). Similarly suggestions to restrict the disease with wide publicity were given through regional and national news papers for keeping watch on disease spread. (The Hindu, January 1st 1986, Indian Express, April, 23rd 1985). A Committee was constituted to go in the details of DM occurrence and the committee felt that the disease has been introduced through infected seeds and probable failures of quarantine detection has resulted in the introduction of disease. Recently a survey was conducted during 1995-96 to find out the present status of the disease in Marathwada region of Maharashtra State in India. Sixty fields in six districts were visited and out of those, 22 fields (36.67 %) had DM incidence with

varying intensity ranging from 1 to 30.00 per cent (Shrishikar, 1995). The cv Modern was highly infected by the disease as compared to hybrids.

The extent of damage depends on infection type i.e. whether it is primary (systemic) or secondary infection, while primary or systemic infection causes significant yield reductions. Primary infection is effected during seed germination in the soil and the emergence of sunflower seedling. It may be caused by Fungus mycelium or oospores present on infected seeds or by oospores present in the infected soil in to which healthy seeds were sown. No matter if primary infection starts from seeds or soil, the causes of disease development in infected plants is identical.

The fungus develops in unison with the development of young plants. It penetrates the root, stem cotyledons and reaches the meristematic tissues at the top of young plants. The fungus develops inside the infected plants intercellular in all plant parts, pervading the young tissues and depriving the infected plants of assimilates and water. This is why infected plants lag behind healthy ones in growth and development. This way of fungus expansion inside the plant tissue is called a systemic infection. It begins with the infection of the germ and ends with the infection of the head and seeds. The fungus penetrates all parts of the seed (Husk, endosperm and germ) which then produces a new infected seedling. Infected plants in addition to having stunted growth i. e. short internodes are chlorotic and with a platform head which gives a smaller yield than the normal head. On the infected plant parts, the roots, cotyledons, the stem and especially the leaves, there occurs abundant white mycelium, which is typical for this disease. The mycelium occurs also on the reverse side of the leaves and it contains the vegetative organs of the fungus conidiophores and conidia (Zoosporangia). On the upper side of the leaf there occurs chlorotic spots. Infected plants collapse and remain in the field after harvest. Measures of protection against Downy mildew include cultivation practices, chemical measures and the use of resistant hybrids.

The most effective chemical measures of Downy Mildew control is seed treatment with metalaxyl based preparations. These measures protect the sunflower crop at the time of the primary infections i.e. early stage of development of sunflower. Breeding for downy mildew resistance is one of the major goals in sunflower breeding programme in India. The research work carried out since 1988 to 2015 at the Latur centre under AICRP on sunflower screened the advance breeding material in both field and sick plot condition. Use of genetically resistant hybrids is definitely the most effective way of controlling Downy mildew in sunflower. Therefore research work set up with the objective of developing sunflower genotype genetically resistant to dominant race of Downy mildew in India gained prime importance in sunflower breeding programme.

MATERIAL AND METHODS

To determine the variability and level of resistance available in cultivated sunflower (1988-2015) 5408 accessions which include CMS, inbreds, restorer, open pollinated varieties, germplasm lines and hybrids collected from NBPGR, IOR, Hyderabad and different AICRP (All India Coordinated Research Project) sunflower centers in India were evaluated in field along with Downy mildew sick plot unique developed at Oilseeds Research Station, Latur, Maharashtra.

Inoculation Technique

Many inoculation techniques viz. soil inoculation, seed inoculation, radical inoculation, foliar spray method, whole seedling immersion and disc method have been described for artificial screening of sunflower genotypes against DM disease. Patil *et al* (1993) have compared all these methods to find out effective technique for artificial screening of sunflower genotypes against DM under controlled conditions. The methodology for seed inoculation and Radical inoculation technique is given below

1. **Seed inoculation:** Seed of cv Modern were soaked in water for five hrs and kept in rolled towel paper. Next day these seeds were immersed in zoosporangial suspension (2.5×10^4 propagules/ml of distilled water) for five hrs and sown in pots).
2. **Radicle inoculation:** In this method the germinated seeds of cv Morden were inoculated with zoosporangial suspension, when radical was 4 to 5 mm long by spraying of sporangial suspension @ (2.5×10^4 propagules/ml of distilled water).

RESULT AND DISCUSSIONS

From the table 1 it can be conclude that the radical inoculation method is the best method for screening sunflower genotypes against DM. Similarly Wehtje and Zimmer (1978) have reported that in sunflower seedling infected with *P. halstedii*, the zoospore encystment and infections occurred primarily, within or adjacent to zone of elongation of radical and up to 1000 infection sites / mm of root length were observed.

Table : 1 Incidence of Downy mildew as influenced by different inoculation techniques (1986-89)

S.No	Method	Percent disease incidence			Mean
		1986-87	1987-88`	1988-89	
1	Soil inoculation	52	55	42	49.66
2	Seed Inoculation	52	56	60	56.00
3	Radicle inoculation	100	95	90	95.00
4	Foliage Spray	60	58	57	58.33
5	Whole seedling immersion				
	a) Cotyledon method	65	64	69	66.00
	b) First two leaf stage	64	64	69	63.66
6	Disc method	*	*	*	

- Only local lesions were observed

Race situation and sources of resistance

The fungus completes its sexual life cycle annually, affording maximum opportunity for recombination of genes responsible virulence and / or other pathogenic characters. Initially two races of the fungus were differentiated, race- 1, originally referred to as the European race and race -2, known as Red River race, referring to the Red River vally area of North Americ. However, presently a total eight races are known worldwide (Viranyi, 1990). With regards to India, Patil and Mayee (1990) conducted the studies to find out the race situation of India isolate of *Plasmopara halstedii* and study revealed that (Table 2) it belongs to race - 1. The reaction to different isolates observed on various 'R' lines which resulted in identification of five resistant restorer lines in India.

Table : 2 Reaction of *Plasmopara halstedii* Indian isolate to Downy mildew sunflower host differentials

SN	Differential Line	Percent disease incidence			Known reaction to race			Reaction to Indian isolate
		1986-87	1987-88	1988-89	1	2	3	

1	RHA-272	2.00	0.56	0.90	R	R	S	R
2	RHA-273	0.80	0.83	0.43	R	R	S	R
3	RHA-274	0.00	0.00	0.00	R	R	S	R
4	RHA-801	0.00	0.00	0.00	R	R	S	R
5	RHA-265	0.66	0.56	0.83	R	S	S	R
6	Progress	58.66	63.33	60.00	S	S	R	S

R = Resistant; S = Susceptible

The progress cultivar is known to resistant to race -3, but it is susceptible to Indian isolate, hence the Indian isolate does not belong to race -3. The cultivar RHA-265 is resistant to race -1 and susceptible to race -2 and 3. The same cultivar is also resistant to Indian isolate; hence the Indian isolate could be race -1 category. A regular field screening programme for sunflower lines is being conducted at Oilseeds Research Station, Latur (MS) to find out the reaction of sunflower lines against DM under sick soil condition, since from 1988. Two DM resistant hybrids *viz.*, LDMRSH-1 (CMS-338-A x MRHA-2) and LDMRSH-3 (CMS-207-A x MRHA-1), LSFH -35 (234 A x RHA-1-1), LSFH-171 (CMA-17A x RHA-1-1) developed at Oilseeds Research Station, Latur have been released.

Disease management

The DM disease is seed, soil and air borne in nature, it is necessary to adopt various control strategies like regulatory measures, cultural management, seed treatment and use of resistant varieties etc. to combat the disease under field condition.

Host resistance

This includes use of resistant varieties (LDMRSH-1 and LDMRSH-3) to combat DM problem (Patil et al 1992). Use of hybrid varieties should be encouraged sine they are found tolerant compared to population. Similarly at Oilseeds Research Station, Latur many DM resistant hybrids have been identified through screening in DM plot and based on yield potential and DM resistance, ICAR has released such hybrids for the commercial cultivation (Shrishikar, 2005) (Table 4).

Table 4: List of sunflower Downy mildew resistant / tolerant hybrid s identified by ICAR varietal release committee (2002- 15)

Name of sunflower hybrids / variety	Year	Remarks
Sungene – 8	1996	This variety has been released during AICRP workshop held at JNKKV, Jabalpur in April 1996
LS-11	1998	This variety released by varietal identification committee meeting held at TNAU, Coimbtore in April 1998
MSFH-47	2000	This hybrid was highly resistant to DM and it was released by ICAR varietal identification committee meeting at PAU, Ludhiana in April 2000

Pro-009 (Prosun-09)	2003	This hybrid has been releases during AICRP sunflower workshop held at TNAU, Coimbtore
SH-416	2003	This hybrid has been releases during AICRP sunflower workshop held at TNAU, Coimbtore
DRSF-108	2003	This hybrid has been releases during AICRP sunflower workshop held at TNAU, Coimbtore
PCSH – 243	2004	This hybrid has released during AICRP sunflower workshop held at ANGRU, Hyderabad
RPO-011	2004	This hybrid has released during AICRP sunflower workshop held at ANGRU, Hyderabad
SCH-35	2004	Released by M. S. State, ORS, Latur Hybrid
XF-4132	2005	This hybrid has been released during AICRP sunflower workshop held at H. P. Krishi Vishwa Vidhyala, Palampur
PAC-334	2008	This hybrid has been released during Annual Group meeting held at GAU, Junagarh on 21-23 May 2009`
LSFH-171	2012	This hybrid has been released during Annual Group meeting held at UAS, Bangaluru on 27-29 April 2012

Chemical control

Seed treatment with fungicide like Apron 35 S. D. (Metalaxy fungicide) found very effective for the control of DM disease. The efficiency of Apron 35 S.D. fungicide and they reported that the fungicide is quite effective in reducing DM incidence under field conditions when used @ 6 g / kg of seed. However, a new formulation Apron XL 35 ES- @ 3 ml / kg as seed dresser has also been recommended (Shrishikar, 2005) (Table 3).

Table 3: Management of sunflower DM disease through Apron XL 35 ES fungicide under sick plot condition 2002-04 (Pooled)

SN	Details	DM incidence (%)	Yield kg/ha	BC ratio
1	Apron1 ml / kg	20.40	726	1.81
2	Apron 2 ml / kg	14.86	861	2.14
3	Apron 3 ml / kg	5.46	1106	2.74
4	Apron 6 ml / kg	8.56	1043	2.57
5	Control	85.5	263	0.65
	SE ±	1.1	106	
	CD at 5 %	3.4	326	

CONCLUSION

The race identification studies of India isolate of *Plasmopara halstedii* confirms that it belongs to race -1 (European race). The multiyear work carried out at ORS, Latur centre under All India Coordinated Research Project on sunflower screened 5408 lines and identified 1075 disease free entries with high level of resistance to DM pathogen. This resulted into the release of 15 sunflower hybrids and populations at national level. The identified resistance sources have been effectively utilized in the introgression of the resistant genes from identified sources for the improvement of parental lines. The centre has identified 14 parental lines (8 CMS, 6 restorer lines) possessing downy mildew resistant (Pl genes). The center has released three state level hybrids LDMRSH-1, LDMRSH-3 and LSFH-35 and LSFH-171 at national level for commercial cultivation.

LITERATURE

- Anonymous, 1985. Twenty first Annual Report *kharif* Oilseeds Workshop (DOR) ICAR, New Delhi ; held at Dr. PDKV, Akola, 15th -19th April, 1985.
- Mayee, C. D. and Patil, M. A. 1986. Downy Mildew of sunflower. *Indian Phytopath.* 39:314
- Patil, M. A. and Mayee, C. D. 1990. Race identity of Indian *Plasmopara halstedii* cause of Downy mildew of sunflower. *Indian Phytopath.* 43:517-519
- Patil, M. A., Mayee, C. D. and Phad, H. B.1993. Inoculation technique for sunflower downy mildew. *Seed Tech. News* 23 : 10-12.
- Ram Nath, Lambat, A. K., Mukewar, P. M. and Indra Rani 1981. Interceptions of pathogenic fungi on imported seed and planting material. *Indian Phytopath.* 34: 282-286
- Shrishikar, S. P. 1995. Survey of sunflower downy mildew disease in the Marathwada region. *J. Maharashtra Agric. Univ.* 22(1) : 135-136
- Shrishikar, S. P. 2005. Control of downy mildew in sunflower with a new metalaxyl formulation Apron XL -35 E.S. *Helia* 28(3): 159-164.
- Viranyi, E. 1990. Downy mildew of sunflower. Pp: 328-345. In plant disease of international importance (eds. Chube et al 1990) Prentice Hall, Ingle Wood cliff, New Jersey 363 pp
- Whtje, G. and Zimmer, D. E. 1978. Downy mildew of sunflower, biology of systemic infection and the nature of resistance. *Phytopath;* 68: 1568-71.