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SCREENING OF SUNFLOWER GENOTYPES AGAINST POWDERY MILDEW

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ABSTRACT
Powdery mildew is a devastating disease of sunflower in major sunflower growing regions of India, causing considerable yield losses. Use of host plant resistance is the cheapest and effective disease management strategy. In the present investigation, 43 and 20 sunflower genotypes were screened under field and artificial epiphytotic conditions respectively, along with susceptible check Morden. Disease severity was scored using 0-9 scale by visually observing the per cent leaf area covered by powdery growth in each replication and Per cent Disease Severity was calculated. The disease severity of 23 hybrids obtained from cross between resistant with susceptible and highly susceptible genotypes were evaluated and eight hybrids were found to be resistant to powdery mildew both under field and artificial conditions.

INTRODUCTION

Sunflower is one of the important edible oilseed crops grown in the world after soybean and groundnut. It is an important source of edible and nutritious oil. Sunflower oil is a rich source of lenoleic acid (64 %) and 25-30 per cent of oleic acid which helps in washing out cholesterol in the coronary arteries of the heart and thus is good for heart patients. Presently, Karnataka is the leading state in the country contributing 64 and 54 per cent of total sunflower area and production, respectively. It is the second important oilseed crop after groundnut having an area of 0.44 million hectares with production of 0.29 million tones. However, productivity (670 kg ha^{-1}) is lesser than the national average of 791 kg ha^{-1} (Anon., 2015).

Although area under crop cultivation increased with the advent of new sunflower commercial hybrids and their wider adoptability to diverse agro-climatic conditions with low economic attention of farmers on plant protection measures, the crop has been found suffering from many diseases. The major diseases limiting sunflower cultivation in India are *Alternaria* leaf spot, downy mildew, sunflower necrosis disease and occasionally rust. During the past 2–3 years, powdery mildew caused by *Golovinomyces cichoracearum* (DC.) *V.P. Heluta* (formerly *Erysiphe cichoracearum*) has become a serious problem in major sunflower growing regions of Southern India. Since decade, disease observed regularly during *rabi-summer* seasons and under severe conditions disease is found infecting the cotyledonary leaves up to ray florets. Dinakaran and Dharmalingam (1999) observed the incidence of the disease from 35 to 40 DAS and peak incidence was observed from 65 to 75 DAS. They reported that the incidence of the disease ranged from 60 (Co-1) to 95.8 per cent (JT- 7) under unprotected conditions. Application of fungicides to manage the disease involves high cost, besides the environmental concern and the insensitivity built up in the pathogen limit their usage (Gullino and Kuijpers, 1994).

The full potential of this crop is far from being exploited due to several abiotic and biotic stresses. The crop suffers from many fungal diseases, among them foliar disease takes a heavy toll by reducing the yield to considerable extent. Among the foliar diseases powdery mildew caused by *Golovinomyces cichoracearum* DC is a potential destructive disease in recent years causing severe yield loss. The disease is prevalent in all sunflower growing states of India and in all the countries of the world wherever it is cultivated (Puscasu 1980; Docea *et al*., 1981; Singh *et al.,* 1984; Gulya *et al.,* 1991; Bhutta *et al*., 1993; Singh and Bedi, 1995; Bains *et al*., 1996 and Baiswar *et al*., 2008).

Sunflower is infected by a large number of diseases causing severe economic losses in yield. Occurrence of wide spread disease was identified as one of the major constraint for low productivity of sunflower. Powdery mildew caused by *Golovinomyces cichoracearum* is a widely distributed pathogen of cultivated sunflower, frequently causes economic losses in warmer climates (Zimmer Hoes, 1978). The development of resistant cultivars is a promising solution that may allow promising zones to be expanded. Sunflower cultivars differ in their reaction to powdery mildew, but resistant cultivars are not available and relatively little efforts have been devoted to develop resistant germ plasm. The two accessions of *H. debilis ssp debilis* has been recognised as source of

powdery mildew resistance to sun flower(Jan and Chandler, 1985; Rojas-Baross, 2004). Screening of the sunflower germ plasm lines against the disease would be of a great help to identify the resistance source. The study of epidemiology of the disease is of practical significance. Since the pathogen is disseminated through air, disease spreads very fast. Hence identification of resistant variety is one of the best management practices in development of IDM strategy.

The management of the disease through host plants resistance is the best practice in developing IDM strategy. Besides this, these resistant cultivars conserve natural resources and reduce the cost, time and energy when compared to the other methods of disease management (Badwal,1975). Therefore, an attempt was made to identify sources of resistance which can be used in developing resistant hybrids/cultivars to mitigate loss in farmer's field.

MATERIALS AND METHODS

The present investigation was carried out at MARS, University of Agricultural Sciences, Raichur. The experimental material for the study comprised of fourty three sunflower genotypes, some of them derived from *H. argophyllus* background, six commercial hybrids and one susceptible check Morden.

Field screening of sunflower genotypes against powdery mildew

The fourty three genotypes were screened against powdery mildew disease by leaf stapling method in field during *rabi* 2013. Leaves from the heavily infected plants were collected and stapled to leaves of randomly selected five healthy plants in each row at 30 and 40 DAS, in such a way that the infected part of leaf was in close contact with the surface of healthy leaf (Reddy *et al*., 2013). The percent leaf area covered by the powdery growth was recorded as per the standard 0-9 scale for powdery mildew (Mayee and Datar, 1986). Disease severity observations were recorded on five randomly chosen plants from each genotype. The mean diseverity was calculated using formula gives by Wheeler(1969).

Per cent Disease severity (PDS) was calculated for every plant using the formula.

$$PDS = \frac{\text{Sum of disease rating}}{\text{Number of plants rated} \times \text{Highest rating}} \times 100$$

Artificial screening of sunflower genotypes against powdery mildew

Nine resistant and thirteen moderate resistant entries were selected on the basis of natural screening under field conditions. These selected genotypes were again screened under green house condition by spraying conidial spore suspension. The powdery mildew infected leaves are collected from field, using camel hair brush powdery mass is dislodged into one per cent sucrose solution *i.e.* (10^6 conidia/ml prepared in 1 per cent sucrose solution) and such conidial suspension prepared was sprayed on all the genotypes at 30 and 45 days after sowing (Reddy *et al*., 2013) and observations on powdery mildew incidence were recorded at 15 days interval from 30 DAS up to 90 DAS for identification of precise resistant genotypes.

The genotypes were categorised into different classes using disease index scale calculated by following formula given by wheeler (1969).

Hybrids development/crossing to generate hybrids

The selected resistant and susceptible genotypes were used to generate F1 hybrids. Individual plant heads were treated with 100 ppm GA_3 at stage to induce male sterility. The pollen of the male lines was collected separately in petriplate with the help of camel hairbrush during morning hours (9:00 to 11:00 AM) and dusted on to the stigma of female heads to derive crossed seeds. Immediately after pollination the heads were covered with cloth bags to avoid cross contamination. Pollination was done till all the florets in the capitulum showed sign of drying. The heads of all the resultant 23 hybrids were harvested, dried and threshed separately and stored with care to maintain viability. The well filled seeds from each cross

Table 1: List of sunflower genotypes used in the disease screening

Sl. No.	Code	Genotype/prebred lines
1	PM-1	RCR-1929/3-1-1-1
2	PM-2	RCR-1929/3-1-1-2
3	PM-3	RCR-1938/3-1-1-1
4	PM-4	RCR-1938/3-1-1-2
5	PM-5	RCR-1938/2-2-2-1
6	PM-6	RCR-1938/2-2-2-2
7	PM-7	RCR-2063/1-2-1-1
8	PM-8	RCR-2063/1-2-1-2
9	PM-9	RCR-2066/1-1-1-1
10	PM-10	RCR-2066/1-1-1-2
11	PM-11	RCR-1945/T_1-2-3-1
12	PM-12	RCR-1947/2-T_2-2-2
13	PM-13	RCR-1947/2-T_2-1-1
14	PM-14	RCR-1947/1-T_1-1-1
15	PM-15	RCR-1947/2-T_2-2-1
16	PM-16	RCR-1947/2-T_2-2-2
17	PM-17	RCR-1892/1-3-1-1
18	PM-18	RCR-1892/1-3-2-1
19	PM-19	RCR-1892/1-4-1-1
20	PM-20	RCR-1892/1-5-2-1
21	PM-21	RCR-1900/1-1-1-1
22	PM-22	RCR-1900/1-1-2-1
23	PM-23	RCR-1932/2-1-2-1
24	PM-24	RCR-1934/4-5-1-3
25	PM-25	RCR-1934/4-5-1-1
26	PM-26	RCR-1885-1-1-1-1
27	PM-27	RCR-1901/1-1-1-1
28	PM-28	RCR-1901/1-1-2-1
29	PM-29	RCR-1901/2-1-1-1
30	PM-30	RCR-1904/1-1-2-1
31	PM-31	RCR-1913/1-1-1-1
32	PM-32	RCR-1913/1-1-3-2
33	PM-33	RCR-1913/1-1-4-1
34	PM-34	RCR-1913/1-1-5-2
35	PM-35	RCR-1922/1-1-1-1
36	PM-36	RCR-1926/1-1-2-1
37	PM-37	RCR-1926/1-2-2-2
38	PM-38	RCR-1977/3-5-1-2
39	PM-39	RCR-2046/1-2-1-2
40	PM-40	RCR-2046/1-1-2-2
41	PM-41	RCR-1926/1-2-2-1
42	PM-42	RCR-1932-1-1-2-1
43	PM-43	RCR-2075/2-1-1-1

were separated out for evaluation of hybrids for powdery tolerance during *kharif* 2014.

Screening of sunflower hybrids against powdery mildew

Twenty three hybrids were sown in RCBD design with three replications along with susceptible checks during late *kharif* 2014 and screening was carried out by leaf stapling method (Reddy *et al*., 2013). The powdery mildew disease incidence was recorded at 15 days interval from 30 DAS upto 90 DAS.

Ten plants in each cross were sown in pot separately and screening was conducted by spraying conidial spore suspension (10^6 conidia/ml prepared in 1 per cent sucrose solution) at 30 and 45 DAS and powdery mildew disease incidence observations were recorded at 15 days interval from 30 DAS upto 90 DAS on individual plant of each crosses.

RESULTS AND DISCUSSION

Powdery mildew is an economically important disease of sunflower in India, it has become serious and occurring regularly since three years, significantly affecting the quality and quantity of sunflower production and is observed during different crop growing seasons and under severe conditions it is found infecting the cotyledonary leaves up to ray florets .

Application of fungicides is an alternative to manage the disease but it involves high cost, besides the environmental concern and the insensitivity built up in the pathogen limit their usage (Gullino and Kuijpers, 1994) therefore genetic resistance is preferred, because it is a more sustainable means of controlling disease. Hence, there is a need for identifying reliable sources of resistance to powdery mildew. Wild *Helianthus* species

Table 2: Reaction of 44 sunflower genotypes to powdery mildew under natural conditions during *rabi*-2013

Sl. No.	Genotypes	Per cent disease severity (%) at					Scale	Host reaction
		30 DAS	45 DAS	60 DAS	75 DAS	90 DAS		
1	PM-13	0.0	0.0	1.8	2.9	6.3	3	Resistant
2	PM-14	0.0	0.7	2.3	5.6	7.2	3	Resistant
3	PM-16	0.0	0.0	1.3	4.9	7.8	3	Resistant
4	PM-17	0.2	0.8	1.7	4.8	7.0	3	Resistant
5	PM-19	0.0	0.5	1.1	3.2	8.6	3	Resistant
6	PM-20	0.0	1.0	2.4	4.1	9.8	3	Resistant
7	PM-22	0.0	0.6	1.9	3.7	8.1	3	Resistant
8	PM-23	0.0	0.8	2.0	3.9	9.2	3	Resistant
9	PM-25	0.0	0.3	1.2	4.6	9.6	3	Resistant
10	PM-2	0.0	0.2	2.7	11.0	18.2	5	Moderately resistant
11	PM-3	0.0	0.6	2.7	12.4	12.6	5	Moderately resistant
12	PM-6	0.1	1.2	4.7	15.0	22.6	5	Moderately resistant
13	PM-7	0.0	1.0	3.8	10.7	14.0	5	Moderately resistant
14	PM-8	0.5	1.7	4.5	16.9	24.7	5	Moderately resistant
15	PM-9	1.2	2.1	6.0	15.7	24.1	5	Moderately resistant
16	PM-10	1.5	3.7	6.2	12.0	21.4	5	Moderately resistant
17	PM-11	0.0	0.5	1.1	8.6	22.8	5	Moderately resistant
18	PM-12	0.4	1.7	3.6	12.7	20.7	5	Moderately resistant
19	PM-15	0.9	2.7	6.5	13.8	22.6	5	Moderately resistant
20	PM-18	0.1	1.6	2.7	11.7	22.8	5	Moderately resistant
21	PM-21	0.2	1.2	2.8	9.7	20.8	5	Moderately resistant
22	PM-24	0.6	2.1	7.1	13.4	24.3	5	Moderately resistant
23	PM-1	0.7	3.9	10.3	21.9	32.5	7	Susceptible
24	PM-4	0.5	2.6	5.8	15.7	26.3	7	Susceptible
25	PM-5	1.8	4.9	13.3	21.9	31.2	7	Susceptible
26	PM-27	1.3	3.6	6.8	13.4	26.2	7	Susceptible
27	PM-29	0.2	1.5	3.8	16.5	27.4	7	Susceptible
28	PM-30	1.0	3.8	13.2	24.4	38.9	7	Susceptible
29	PM-31	0.7	3.6	13.8	19.6	30.5	7	Susceptible
30	PM-32	1.2	3.5	8.8	17.3	31.6	7	Susceptible
31	PM-33	1.4	3.8	6.2	14.4	27.3	7	Susceptible
32	PM-35	2.1	4.5	10.5	21.8	36.4	7	Susceptible
33	PM-36	1.7	5.3	13.3	20.0	30.0	7	Susceptible
34	PM-37	2.5	9.0	15.3	20.5	29.8	7	Susceptible
35	PM-38	0.5	2.3	6.8	12.5	25.3	7	Susceptible
36	PM-39	1.8	6.2	18.1	26.8	34.6	7	Susceptible
37	PM-43	3.1	7.9	18.6	26.3	33.9	7	Susceptible
38	PM-26	0.7	4.1	10.2	24.5	52.8	9	Highly susceptible
39	PM-28	2.3	6.9	18.3	32.9	53.2	9	Highly Susceptible
40	PM-34	2.8	6.8	14.9	22.8	51.6	9	Highly susceptible
41	PM-40	3.2	9.2	19.7	30.2	51.1	9	Highly Susceptible
42	PM-41	2.7	8.5	18.6	35.3	60.4	9	Highly susceptible
43	PM-42	3.7	9.0	25.1	30.1	66.3	9	Highly susceptible
44	Morden	4.0	13.6	30.2	51.6	68.5	9	Highly susceptible

Table 3: Reaction of 23 sunflower genotypes to powdery mildew under artificial conditions during *rabi* 2013

Sl.no.	Genotypes	Percent disease severity (%)					Host reaction
		30DAS	45 DAS	60 DAS	75 DAS	90 DAS	
1	PM-14	0.3	1.0	2.5	5.8	8.2	Resistant
2	PM-16	0.7	1.0	2.8	6.9	8.3	Resistant
3	PM-17	0.1	0.3	1.3	4.8	9.5	Resistant
4	PM-22	0.1	0.3	0.8	2.4	6.1	Resistant
5	PM-23	0.1	0.4	1.2	3.5	9.2	Resistant
6	PM-2	1.0	3.5	11.2	18.3	23.8	Moderately resistant
7	PM-3	0.8	2.6	4.8	14.8	22.7	Moderately resistant
8	PM-6	2.6	5.6	7.9	13.9	21.0	Moderately resistant
9	PM-7	0.2	1.0	1.8	8.6	24.6	Moderately resistant
10	PM-8	1.3	3.8	8.3	12.9	16.7	Moderately resistant
11	PM-9	1.6	4.0	8.0	10.2	20.8	Moderately resistant
12	PM-10	0.8	2.9	3.7	9.6	23.8	Moderately resistant
13	PM-11	1.7	3.3	7.0	12.7	24.3	Moderately resistant
14	PM-12	0	0.9	2.5	5.8	13.0	Moderately resistant
15	PM-13	0.6	1.6	3.0	10.1	20.4	Moderately resistant
16	PM-15	0.1	0.7	7.4	10.0	24.3	Moderately resistant
17	PM-18	1.3	3.9	5.3	13.6	22.8	Moderately Resistant
18	PM-19	0.2	1.4	3.8	5.2	18.5	Moderately resistant
19	PM-21	0.2	1.2	3.5	10.3	20.8	Moderately resistant
20	PM-24	0	0.3	1.8	4.0	12.1	Moderately resistant
21	PM-25	0	0.8	2.7	10.0	20.9	Moderately resistant
22	PM-20	1.9	4.2	6.8	14.4	27.3	susceptible
23	Morden	3.8	20.4	33.3	57.2	71.0	Highly susceptible

Table 4: Reaction of sunflower hybrids to powdery mildew disease under natural conditions during *kharif* 2014

Sl. No.	Cross	Parental reaction	Percent disease severity at (%)					Scale	Host reaction
			30 DAS	45 DAS	60 DAS	75 DAS	90 DAS		
1	PM-14x PM-36	R x S	0.3	1.2	2.8	4.3	8.5	3	R
2	PM-16 x PM-37	R x S	0.2	1.7	2.5	7.5	9.8	3	R
3	PM-16 x PM-38	R x S	0.5	1	2	4.7	7.1	3	R
4	PM-17 x PM-35	R x S	0.3	0.8	2.4	6	8.4	3	R
5	PM-17 x PM-36	R x S	0.8	1.4	4.2	7.5	9.4	3	R
6	PM-17 x PM-38	R x S	0.9	1.8	4.8	5.5	8.7	3	R
7	PM-22 x PM-36	R x S	0	0.3	1.5	2.9	4.7	3	R
8	PM-34 x PM-23	HS x R	0.0	0.5	1.0	2.3	3.6	3	R
9	PM-10 x PM-35	MR x S	0.1	1.2	10	17.8	21.4	5	MR
10	PM-18 x PM-34	MR xHS	0.4	1.5	3.4	9.6	12.2	5	MR
11	PM-20 x PM-38	S x S	1.2	3.7	9.6	16.9	20.4	5	MR
12	PM-21 x PM-37	MR x S	0.7	1.4	5.7	11.6	14.8	5	MR
13	PM-28 x PM-12	HS xMR	0.1	1.3	3.7	10.3	14□7	5	MR
14	PM-34 x PM-18	HS xMR	0.6	3.5	11.4	16.3	20.3	5	MR
15	PM-36 x PM-10	S x MR	2.0	3.7	10.2	17.2	23.3	5	MR
16	PM-38 x PM-20	S x S	0.4	1.2	7.4	16.4	18.0	5	MR
17	PM-40 x PM-19	HS xMR	1.4	3.5	5.0	13.0	15.6	5	MR
18	PM-20 x PM-35	S x S	0.3	1.9	8.4	20.8	27.5	7	S
19	PM-20 x PM-36	S x S	1.3	2.9	8.2	22.9	28.2	7	S
20	PM-28 x PM-4	HS x S	5.4	16.8	22.5	27.2	30	7	S
21	PM-28 x PM-19	HS xMR	1.0	3.4	12.1	21.2	28.9	7	S
22	PM-31 x PM-19	S x MR	0.5	1.3	11.7	21.2	26.2	7	S
23	PM-36 x PM-20	S x S	3.8	6.1	19	28.5	32.8	7	S
Susceptible Check									
1	Morden	-	6.7	14.7	20.1	31.8	51.5	9	HS
Commercial Hybrids									
1	RFSH-130	-	1.4	3.5	10.6	20.6	23.9	5	MR
2	RFSH-1887	-	1.0	2.6	9.8	17.2	21.3	5	MR
3	KBSH-53	-	2.9	8.9	10.5	17.1	22.4	5	MR
4	GK-202	-	1.2	6.5	15.4	19.0	24.5	5	MR
5	KBSH-44	-	3.7	7.4	16.0	27.0	42.4	7	S
6	DRSH-1	-	3.5	10.0	19.8	25.2	34.0	7	S

Table 5: Reaction of sunflower hybrids to powdery mildew disease under artificial conditions

Sl. No	Cross	Parental reaction	Per cent Disease Severity at (%) 30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	Scale	Host reaction
1	PM-14x PM-36	R x S	0.8	1.7	4.5	7.4	8.7	3	R
2	PM-16 x PM-37	R x S	0.5	1.3	2.9	4.6	7.3	3	R
3	PM-16 x PM-38	R x S	0.6	1	2.1	5.5	8.7	3	R
4	PM-17 x PM-35	R x S	0.1	0.6	1.5	4.8	8.6	3	R
5	PM-17 x PM-36	R x S	0.5	1.4	3	5.3	8.5	3	R
6	PM-17 x PM-38	R x S	0.3	1.3	2.4	5	7.1	3	R
7	PM-22 x PM-36	R x S	0.5	1.4	2.6	6.1	9.7	3	R
8	PM-34 x PM-23	HS x R	0.3	0.8	2	5.3	8.9	3	R
9	PM-18 x PM-34	MR x HS	1.3	3	5.6	13.9	22.4	5	MR
10	PM-28 x PM-12	HS x MR	0.1	2	5.4	13.7	21.5	5	MR
11	PM-34 x PM-18	HS x MR	0.3	1.4	4	15.6	23	5	MR
12	PM-10 x PM-35	MR x S	4.6	11.5	21.5	36.9	42.7	7	S
13	PM-20 x PM-35	S x S	0.7	1.9	4.5	15.7	30.6	7	S
14	PM-20 x PM-36	S x S	1	2.8	15.2	30.6	32.6	7	S
15	PM-20 x PM-38	S x S	5.4	13.8	23.5	35.1	43.2	7	S
16	PM-21 x PM-37	MR x S	1	3	4.1	27.2	35	7	S
17	PM-28 x PM-4	HS x S	8.3	20.5	28.9	36.5	49.2	7	S
18	PM-28 x PM-19	HS x MR	4.5	8.8	14.1	33.4	39.4	7	S
19	PM-31 x PM-19	S x MR	5.2	12.7	17.3	25.2	29.7	7	S
20	PM-36 x PM-10	S x MR	7.7	12.7	22.2	34.1	42.3	7	S
21	PM-36 x PM-20	S x S	1.5	7.1	14	24.5	39.8	7	S
22	PM-38 x PM-20	S x S	3.8	8	15.5	24	45.3	7	S
23	PM-40 x PM-19	HS x MR	3.6	9	23.1	37.6	45.6	7	S
	Susceptible Checks								
1	Morden	-	3	21	40	51	59.7	9	HS
	Commercial Hybrids								
1	RFSH-1887	-	3.8	7.8	15.2	22.3	24.1	5	MR
2	KBSH-53	-	2.1	5.6	13.1	20.8	23.5	5	MR
3	RFSH-130	-	4.5	7.1	18.8	25.5	28.7	7	S
4	DRSH-1	-	3.9	10.9	18.1	23.6	35.9	7	S
5	GK-202	-	5.7	10.8	20.3	30.1	40.5	7	S
6	KBSH-44	-	2.3	7.7	16.6	25.8	53.7	9	HS

represent a valuable reservoir of genes for several biotic stresses which have been successfully introgressed into cultivated sunflower (Seiler, 2008). Therefore, resistant breeding appears to be the most important approach in disease management. Availability of resistance source and proper screening procedure is pre-requisite for development of high yielding and powdery mildew resistant hybrids of sunflower.

Fourty three genotypes and susceptible check Morden were screened against *Golovinomyces cichoracearum* both under natural and conditions. Out of 43 genotypes screened under field conditions (Table 2), only nine genotypes were found to be resistant with less than 10 per cent PDS and 13 genotypes showed moderate resistant reaction with PDS ranging from11 to 25, 15 showed susceptible reaction with PDS ranging from 25-50 per cent and six showed highly susceptible reaction with PDS of more than 50 per cent. For further confirmation, selected 22 resistant and moderate resistant genotypes from field screening were screened under artificial epiphytotic condition by spraying conidial suspension at 30 and 45 DAS (Table 3).

Among them only five genotypes (PM-14, PM-16, PM-17, PM-22 and PM-23) showed resistant reaction (< 10 % PDS) whereas remaining 16 showed medium resistant (11-25 % PDS) reaction (PM-2, PM-3, PM-6, PM-7, PM-8, PM-9, PM-10, PM-11, PM-12, PM-13, PM-15, PM-18, PM-19, PM-21, PM-24 and PM-25) and one genotype, PM-20 recorded susceptibility reaction to powdery mildew. The genotypes PM-14, PM-16, PM-17, PM-22 and PM-23 recorded resistant reaction in both natural and artificial epiphytotic conditions. Which can be used in resistance breeding programmes. How ever, remaining four genotypes which were resistance in natural to be medium resistance indicating the importance of artificial screening. There was no much disease progress seen since these genotypes were resistant to the powdery mildew and hence can be used in resistant breeding. This indicates the importance of artificial screening (Karuna *et al*., 2010; Reddy *et al*., 2013 and venkata *et al*., 2014).

In the present investigation an attempt was made to investigate the inheritance of resistance to sunflower powdery mildew both under natural as well as artificial conditions in the 23 hybrids during *kharif* 2014. Out of the 23 crosses evaluated under natural conditions (Table 4), only eight crosses were found to be resistant *viz.,* PM-14(R)xPM-36(S), PM-16(R)x PM-37(S), PM-16(R)xPM-38(S), PM-17(R)xPM-35(S), PM-17(R)xPM-36(S), PM-17(R)xPM-38(S), PM-22(R)xPM-36(S) and PM-34(HS)xPM-23(R) with PDS less than 10 per cent and nine expressed medium resistant reaction with PDS of 11-25 per cent while, remaining six showed susceptible reaction with PDS of 26-50 per cent under field screening. Among six hybrid checks screened four recorded medium resistant to powdery mildew except KBSH-44 and DRSH-1. While, the open pollinated variety Morden registered highly susceptible disease

reaction (51.5 %) under field conditions.

The eight hybrids derived from crossing resistant and susceptible genotypes *viz.,* PM-14(R)xPM-36(S), PM-16(R)xPM-37(S), PM-16(R)xPM-38(S), PM-17(R)xPM-35(S), PM-17(R)xPM-36(S), PM-17(R)xPM-38(S), PM-22(R)xPM-36(S) and highly susceptible x resistant genotypes *viz.,* PM-34(HS)xPM-23(R) recorded resistant reaction in field screening were exhibited resistant reaction in artificial conditions also (Table 5). While three recorded medium resistance and 12 expressed susceptibility to powdery mildew. However, susceptible check Morden registered highly susceptible reaction (59.7 %) and all the six hybrid check recorded susceptible reaction except RFSH-1887 and KBSH-53. The results infers that expression of resistance in F_1 generation is an indication of the role of dominant gene in controlling powdery mildew in sunflower. Similar results were reported by Jan and Chandler (1988) in sunflower; Reddy and Haripriya (1990) in sesame; Reddy *et al*. (1994) in mungbean; Basandrai *et al*. (2000) in linseed; Gonocalves *et al*. (2002) in soybean; Kumaresan and Nadarajan (2002) in sesame.

These findings broadly agree with many of earlier reports by pathologists and breeders that no reliable source of resistance could be found (Rajpurohit, 1993 in sesame; Karunanithi and Dinakaran, 1996 in sesame).

Reliable sources of resistance to the pathogen were identified in four annual wild species *Helianthus argophyllus*, *H. argestris*, *H. debilis* and *H. praecox*), six perennials (*H. angustifolius*, *H. atrorubens*, *H. rigidus*, *H. salicifolius*, *H. pauciflorus* and *H. resinosus*), two interspecific derivativesa (HIR-1734-2, RES-834-3) and two exotic lines (PI642072, EC-537925), but it has associated with some limitations like cross incompatability, pre-fertilization, post-fertilization barriers and linkage drag Reddy *et al.*, 2013.

It is clear from the results that screening of sunflower genotypes both under field and artificial conditions will help to identify the precise resistance level of the genotypes (Sunil *et al*., 2013). Evaluation of hybrids derived from cross between resistant with susceptible and highly susceptible genotypes under both field and artificial conditions clearly shows the resistance to powdery mildew is dominant in sunflower. Significant findings are that these genotypes have not been previously studied in details for powdery mildew resistance and the genotypes showed resistance reaction can be used as confirmed source of resistance and utilized in breeding programme for the development of other elite powdery mildew resistant sunflower lines. Progeny of these crosses would be handled properly depending upon nature of resistant genes to introgress powdery mildew resistance in sunflower cultivar.

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