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Identification of redgram resistant genotypes and morphological bases of resistance to pod fly, *Melanagromyza obtusa* (Malloch)

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ABSTRACT: Screening of 49 redgram genotypes conducted to identify pod fly resistant genotypes and morphological basis of resistance to pod fly revealed consistently resistance reaction of ICP 8864 (mean PSI 3.0) and VRG–59-1(mean PSI 3.3) to redgram pod fly. Pod length of various redgram germplasm ranged between 3.55 and 4.84 cm. Pod width ranged from 0.64 to 1.28 cm. Pod wall thickness ranged from 0.21 to 0.43 mm. Trichome density ranged between 302 and 375 per 9 mm^2. Redgram pod width was the important morphological factor that influenced the redgram pod fly seed damage to a tune of 34.2 per cent. Pod length and width were positively correlated with the redgram pod fly seed damage while pod wall thickness and trichome density were negatively correlated. However, relationship between pod width and seed damage only was found to be significantly positive and rest of the morphological factors were not significant.

Keywords: Redgram pod fly, resistant genotypes, pod length, pod width, pod wall thickness and trichome density

INTRODUCTION

Redgram pod fly, *Melanagromyza obtusa* (Malloch) (Agromyzidae: Diptera), a potential threat in redgram, the most important pulse crop after chickpea in India is considered as a very serious insect pest inflicting 100 per cent pod damage resulting in 85 per cent seed damage in india (FAO/ RLAC, 1989). The young maggots damage by feeding on the soft seed just below the epidermis, burrow deeper down, consuming the starchy food as well as the embryo and deposit excreta become unfit for human consumption. According to Shanower *et al.*, 1998, redgram pod fly seed damage varied from 2 to more than 90 per cent with large variation across locations, seasons, and genotypes. In certain situations where, the target insect is exposed for only a brief period of its life cycle, host plant resistance has significant advantages over the other pest control strategies (Shanower *et al.*, 1998). These conditions ideally apply to redgram pod fly because, egg stage is the only exposing stage of pod fly and after hatching of egg, pod fly maggot enters in to the pod through the pod wall and feed on the seed and insecticides sprayed cannot reach the maggot to kill them. As

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different redgram cultivars have different levels of damage, identifying the cultivars with less pod fly damage appears to be a viable management option. In this context, the present investigations were carried out to screen and identify morphological resistant genotypes to pod fly.

MATERIALS AND METHODS

Screening of 49 redgram germplasm entries were conducted at National Pulses Research Centre, TNAU, Vamban, Pudukottai district, Tamil Nadu for a period of three years during kharif season 2016, 2017and 2018 for finding the sources of resistance to redgram pod fly, *Melanagromyza obtusa*. As the peak infestation of pod fly observed during the pod maturation stage, per cent pod fly seed damage was recorded once during that stage and another 15 days after the first observation while post harvest observations on pod fly seed damage by sampling 300 seeds were taken separately for each entry to calculate per cent damage. Based on the pod fly seed damage in the entries and check (VBN 3), pest susceptibility per cent (PSP) and pest susceptibility index (PSI) were calculated as indicated below for each entry. Redgram entries consistently performing in all the three years were selected as the resistant entries. Pest susceptibility per cent (PSP) was calculated by the following formula -

$$PSP = \frac{\text{per cent damage in check} - \text{per cent damage in entry}}{\text{Per cent damage in check}} \times 100$$

Following scale was followed for categorizing the resistance in various germplasm entries (Lateef and Reed, 1985).

PSP	PSI	Category of resistance
100	1	Highly Resistant
75 to 99.9	2	Resistant
50 to 74.9	3	Moderately Resistant
25 to 49.9	4	Moderately Resistant
10 to 24.9	5	Moderately Susceptible
(-10) to (9.9)	6	Moderately Susceptible
(-25) to (-9.9)	7	Susceptible
(-50) to (-24.9)	8	Highly Susceptible
Less than -50	9	Highly Susceptible

Redgram entries which recorded the mean pod fly seed damage less than the check, more than the check and slightly more/less than the check were selected to correlate some morphological basis of resistance *viz.*, pod length, pod width, trichome density and pod wall thickness to the pod fly incidence levels. For this, twenty uniformly developed pods from each entry were collected randomly at pod maturation stage and their length and width was assessed with the help of graph paper and expressed in centimetre per pod. Trichome density was measured in accordance with Jackai and Oghiakhe (1989). The pod was cut into bits of 0.25 cm^2 and number of trichomes present on the epidermis of pods was counted under a stereo zoom trinocular microscope (Leica S6D). Thickness of pod wall in ten pods was measured by using the Vernier calipers and expressed in millimetre per pod.

RESULTS AND DISCUSSION

A. First year screening of redgram germplasm (kharif 2016)

During the crop period at early maturity stage, among the germplasm, seed damage of pod fly ranged between 4 and 48 per cent while during the post maturity stage, 10 and 43 per cent as against the post harvest seed damage with between 9 and 63 per cent. Among the 49 entries, ICP 13918-A was the entry which showed moderately resistant reaction (PSI 3) to pod fly. ICP 8864 and VRG-59-1 entries were categorized as moderately resistant with the PSI of 4 (Table 1).

B. Second year screening of redgram germplasm (kharif 2017)

During kharif 2017, among the germplasm, pod fly seed damage was 1 to 38 per cent and 4 to 36 per cent (Table 1) at early maturity stage and post maturity stage respectively. At harvest, post harvest observations were taken and among the germplasm screened, pod fly seed damage ranged from 0.0 to 65.0 per cent. Sivakumar *et al.* (2015) assessed the redgram pod fly damage in forty entries and reported that the pod damage among the cultivars ranged from 24.67 to 88.67 per cent. Among the entries, ICP 14887 recorded least damage (24.67%)

Table 1. Incidence of pod fly in various redgram germplasm in field and at harvest (kharif)

Germplasm	Seed damage (%) – *kharif*											
	2016				2017				2018			
	Early Maturity	Post Maturity	Post Harvest	Resistance	Early Maturity	Post Maturity	Post Harvest	Resistance	Early Maturity	Post Maturity	Post Harvest	Resistance
ICP 3689	28.0	36.0	37.0	HS	9.0	13.0	8.0	MS	19.0	31.0	15.0	MS
ICP 7984	32.0	38.0	31.0	HS	13.0	11.0	8.0	MS	18.0	28.0	16.0	MS
ICP 12942	28.0	32.0	28.0	S	5.0	11.0	6.0	MR	14.0	20.0	12.0	MR
ICP 12569	29.0	37.0	39.0	HS	16.0	20.0	14.0	HS	21.0	29.0	15.0	MS
ICP 11174	30.0	26.0	31.0	HS	11.0	15.0	8.0	MS	23.0	32.0	20.0	S
ICP 9274	24.0	26.0	22.0	MS	20.0	22.0	13.0	HS	20.0	26.0	14.0	MS
ICP 6698	48.0	40.0	29.0	HS	1.0	5.0	4.0	MR	11.0	23.0	9.0	MR
ICP 13575	21.0	25.0	24.0	MS	23.0	19.0	15.0	HS	13.0	22.0	11.0	MR
ICP 941114	25.0	37.0	25.0	MS	16.0	22.0	16.0	HS	9.0	21.0	10.0	MR
ICP 11007	26.0	32.0	48.0	HS	15.0	17.0	10.0	MS	10.0	19.0	13.0	MR
ICP 11957	29.0	35.0	63.0	HS	10.0	8.0	7.0	MR	12.0	18.0	11.0	MR
ICP 13208	19.0	25.0	21.0	MS	17.0	25.0	14.0	HS	11.0	20.0	12.0	MR
ICP 11206	22.0	26.0	19.0	MS	2.0	10.0	6.0	MR	18.0	29.0	18.0	MS
BAHAR	41.0	35.0	46.0	HS	15.0	21.0	15.0	HS	23.0	32.0	14.0	MS
ICP 7085	36.0	34.0	41.0	HS	28.0	32.0	28.0	HS	19.0	28.0	22.0	S
P 3474	29.0	31.0	28.0	S	19.0	25.0	13.0	HS	21.0	35.0	15.0	MS
VRG 17	27.0	31.0	28.0	S	26.0	28.0	20.0	HS	22.0	29.0	25.0	HS
SMR 1693	35.0	41.0	30.0	HS	20.0	26.0	20.0	HS	17.0	26.0	23.0	HS
ICP 13938	26.0	32.0	24.0	MS	11.0	17.0	10.0	MS	10.0	19.0	12.0	MR
ICP 8864	7.0	11.0	14.0	MR	3.0	7.0	5.0	MR	8.0	15.0	4.0	R
RG 50	32.0	26.0	34.0	HS	15.0	21.0	12.0	S	22.0	27.0	15.0	MS
ICP 13918-A	4.0	10.0	9.0	MR	15.0	19.0	9.0	MS	16.0	23.0	12.0	MR
RG 83	25.0	31.0	18.0	MS	0.0	4.0	0.0	HR	12.0	16.0	10.0	MR
RG 129	22.0	28.0	26.0	S	16.0	22.0	12.0	S	19.0	31.0	21.0	S
ICP 11119	36.0	40.0	29.0	HS	11.0	13.0	9.0	MS	16.0	36.0	17.0	MS
ICP 10175	41.0	43.0	30.0	HS	10.0	16.0	11.0	MS	18.0	35.0	19.0	S
ICP 763-C	26.0	34.0	28.0	S	21.0	27.0	20.0	HS	26.0	29.0	32.0	HS
ICP 12116	25.0	29.0	27.0	S	16.0	14.0	16.0	HS	22.0	25.0	26.0	HS
IIRG 101	25.0	25.0	28.0	S	26.0	32.0	32.0	HS	21.0	28.0	33.0	HS
PL 59176	35.0	31.0	45.0	HS	22.0	24.0	23.0	HS	19.0	29.0	31.0	HS
ICP 12727	50.0	42.0	59.0	HS	3.0	9.0	7.0	MR	18.0	31.0	16.0	MS
ICP 6997	30.0	32.0	30.0	HS	15.0	19.0	11.0	MS	22.0	29.0	20.0	S
ICP 7624	28.0	32.0	41.0	HS	10.0	12.0	9.0	MS	25.0	31.0	17.0	MS
DA 322	26.0	20.0	29.0	HS	12.0	12.0	10.0	MS	23.0	38.0	16.0	MS
BRG 959-1	40.0	38.0	58.0	HS	19.0	17.0	15.0	HS	22.0	36.0	24.0	HS
VRG 59-1	7.0	13.0	12.0	MR	8.0	10.0	6.0	MR	11.0	16.0	3.0	R
CORG 9900134	31.0	33.0	31.0	HS	18.0	24.0	17.0	HS	28.0	29.0	26.0	HS
VRG 08-003	18.0	26.0	19.0	MS	16.0	20.0	14.0	HS	22.0	26.0	22.0	S
VRG 07-001	20.0	22.0	26.0	S	11.0	13.0	15.0	HS	18.0	25.0	21.0	S
VRG 06-013	27.0	23.0	27.0	S	12.0	18.0	18.0	HS	21.0	31.0	29.0	HS
VRG 06-004	27.0	31.0	29.0	HS	28.0	36.0	28.0	HS	18.0	38.0	35.0	HS
VRG 08-004	24.0	20.0	23.0	MS	19.0	29.0	20.0	HS	29.0	36.0	38.0	HS
VRG 54	26.0	24.0	23.0	MS	10.0	16.0	11.0	MS	20.0	27.0	21.0	S
VRG 60-001	31.0	25.0	25.0	MS	10.0	12.0	12.0	S	19.0	31.0	23.0	HS
VRG 06-002	18.0	24.0	25.0	MS	12.0	18.0	21.0	HS	25.0	29.0	36.0	HS
VRG 07-002	33.0	41.0	35.0	HS	17.0	19.0	14.0	HS	22.0	32.0	26.0	HS
VRG 05-008	25.0	31.0	18.0	MS	4.0	6.0	6.0	MR	26.0	34.0	15.0	MS
VRG 12-003	21.0	23.0	28.0	S	38.0	36.0	65.0	HS	23.0	28.0	47.0	HS
VRG 12-005	22.0	24.0	21.0	MS	0.0	6.0	4.0	MR	9.0	10.0	12.0	MR
VBN 3 (Check)	17.0	19.0	23.0		13.0	17.0	10.0		15.0	22.0	18.0	

H R - Highly Resistant; M R - Moderately Resistant; R – Resistant; M S - Moderately Susceptible; S – Susceptible; H S - Highly Susceptible

and was on par with ICP 14770 (27.33%) and BDN 2 (28.33%). Highest per cent pod damage was observed in ICP 9150 (88.67%) followed by ICP 12083 (84.33%), ICPL 15225 (81.33%), ICP 15580 (76.33%), TRG 59 (75.67%) and ICP 12082 (75.67%). The check cultivars, LRG 41 and TRG 22 recorded 57.33 and 60.67 per cent pod damage, respectively.

Based on the pest susceptibility index (PSI) entries RG 83 (HR with PSI 1), ICP 6698, ICP 8864 and VRG 12-005 (MR with PSI 3) and ICP 12942, ICP 11957, ICP 11206, ICP 12727, VRG 59-1, VRG 05-008 (MR with PSI 4) were found to be promising against pod fly.

C. Conformational screening study of redgram germplasm (kharif 2018)

During kharif 2018 among the germplasm, pod fly seed damage was 9 to 29 per cent at early maturity stage and 10.0 to 38.0 per cent (Table 1) at post maturity stage. At harvest, among the germplasm screened, pod fly seed damage ranged from 3.0 to 47.0 per cent. Maneesh Kumar Singh *et al. (*2017) screened twenty nine redgram genotypes against pod fly and recorded the population of pod fly on different genotypes ranged from 0.61 maggots/10 pods in IVT-520 to 1.57 maggots/10 pods in IVT-510. Pod damage significantly varied from 22.33 per cent in genotype IVT-520 to 46.67 per cent in genotype IVT-510. Highest grain damage was recorded in IVT-510 (20.96%) while the lowest grain damage was recorded in IVT-520 (10.67%). They concluded that among the twenty nine genotypes, IVT-520, IVT-509 and AVT-603 were found to be most tolerant against pod fly damage.

In the present study, based on the pest susceptibility index (PSI) entries ICP 8864 and VRG – 59 - 1 (Resistant with 3 PSI) and ICP 6698 (MR with 3 PSI) and ICP 12942, ICP 13575, ICP 941114, ICP 11007, ICP 11957, ICP 13208, ICP 13938, ICP 13918 – A, RG 83 and VRG – 12 – 005 (MR with PSI 4) are found to be promising against pod fly. During the three year screening study from 2016 – 19, two entries ICP 8864 and VRG – 59 – 1 showed consistently resistance reaction to redgram pod fly (Table 2).

Table 2. Categories of resistance and mean PSIs of the selected genotypes

Name of the genotypes	Category of resistance to pod fly			Pest Susceptibility Index (PSI)			Mean PSI
	2016	2017	2018	2016	2017	2018	
ICP 8864	M R	M R	R	4	3	2	3.0
VRG – 59 - 1	M R	M R	R	4	4	2	3.3
ICP 6698	H S	M R	M R	9	3	3	5.0
ICP 12942	S	M R	M R	7	4	4	5.0
ICP 13575	M S	H S	M R	5	8	4	5.7
ICP 941114	M S	H S	M R	5	9	4	6.0
ICP 11007	H S	M S	M R	9	6	4	6.3
ICP 11957	H S	M R	M R	9	4	4	5.7
ICP 13208	M S	M S	M R	5	8	4	5.7
ICP 13938	M S	M S	M R	5	6	4	5.0
ICP 13918 – A	M R	M S	M R	4	5	4	4.3
RG 83	M S	H R	M R	5	1	4	3.3
VRG–12 – 005	M S	M R	M R	5	3	4	4.0

H R - Highly Resistant; M R - Moderately Resistant; R – Resistant; M S - Moderately Susceptible; S – Susceptible; H S - Highly Susceptible

D. Identification of morphological bases of resistance to redgram pod fly

Pod length of various redgram germplasm ranged between 3.55 and 4.84 cm. Pod width ranged from 0.64 to 1.28 cm. Pod wall thickness ranged from 0.21 to 0.43 mm. Trichome density ranged between 302 and 375 per 9 mm^2 (Table 3). In the present study it was found that, pod length and width were positively correlated with the redgram pod fly seed damage while pod wall thickness and trichome density were negatively correlated. However,

Table 3. Redgram pod morphological characters in the genotypes and pod fly seed damage with their correlation

Name of the germplasm	Mean seed damage (%) #	Pod length (cm)	Pod width (cm)	Pod wall thickness (mm)	Trichome density/ 9 mm^2
ICP 8864	7.7	3.71	0.70	0.42	372.0
VRG – 59 - 1	7.0	3.55	0.64	0.43	375.0
ICP 6698	14.0	4.01	0.95	0.34	353.0
ICP 12942	15.3	4.34	1.00	0.25	321.0
ICP 13575	16.7	4.20	1.06	0.28	328.0
ICP 941114	17.0	4.14	1.05	0.31	342.0
ICP 11007	23.7	4.62	1.21	0.22	312.0
ICP 11957	27.0	4.24	1.08	0.29	330.0
ICP 13208	15.7	4.40	1.10	0.24	319.0
ICP 13938	15.3	4.41	1.12	0.23	315.0
ICP 13918 – A	10.0	4.40	1.14	0.25	318.0
RG 83	9.3	4.19	1.00	0.30	338.0
VRG–12 – 005	12.3	4.50	1.18	0.24	320.0
VBN 3	17.0	4.84	1.28	0.21	302.0
Correlation Coefficient r		0.519*	0.585*	-0.5226*	-0.5287*

#Mean of three years; Correlation coefficient values between pod fly seed damage and morphological characters of redgram pod; * - significant

Table 4. Backward regression model for the relationship between pod fly seed damage and morphological characters of redgram pod

Model	Pod fly seed damage and morphological characters of redgram pod		R^2
	Variables entered	Variables removed	
1	Pod length, pod width, pod wall thickness, trichome density	—	0.392
2	Pod length, pod width, trichome density	Pod wall thickness	0.377
3	Pod length, pod width	Trichome density	0.373
4	Pod width	Pod length	0.342

relationship between pod width and seed damage only was found to be significantly positive (Table 3) and rest of the morphological factors were not significant. Backward regression analysis was carried out to identify the relationship between pod fly seed damage and morphological characters of redgram pod. In model 1, where all the morphological parameters were correlated with pod fly seed damage, R^2 value was 0.392. In model 2, pod wall thickness was the excluded variable and the R^2 value was 0.377 and this showed that pod wall thickness had the effect of 1.5%. In model 3, trichome density was excluded with R^2 value of 0.373 and this revealed 0.4% influence of the variable, trichome density on pod fly seed damage. In model 4, pod length was the excluded variable and 0.342 was the R^2 value. So in the present study, it can be concluded that, redgram pod width was the important morphological factor that influenced the redgram pod fly seed damage to a tune of 34.2 per cent (Table 4).

The present findings are in line with the findings of Sivakumar *et al.* (2015) who studied the correlation between the pod characters and pod fly incidence and reported that redgram pod length (r=0.389*) and pod width (r=0.380*) were positively correlated with per cent pod damage, whereas pod wall thickness (r= -0.762**) and trichome density (r= -0.745**) had significant negative correlation with pod fly damage. Negative correlation of redgram pod wall thickness and trichome density with the susceptibility to pod fly damage was reported by Moudgal *et al.* (2008). Yadav and Rohilla (2010) observed more trichome density on green pods in redgram resistant varieties when compared to the susceptible varieties.

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