

Mechanism of Resistance to Aphid (*Lipaphis erysimi* Kalt) in Indian Mustard (*Brassica juncea* L. Czern and Coss)

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Abstract

A large collection of germplasm was screened for aphid resistance under high level of aphid infestation in field conditions for several years. Selected single plants were progeny tested for aphid resistance and seed yield and bred true. Five lines showing resistance to aphid and better yield along with two national resistant check varieties were crossed in a half diallel fashion. The segregants having higher level of aphid resistance and better seed yield were selected in F_2 — F_4 generations. A total of 55 F_5 lines were finally selected and used as experimental materials for the present study. The trials were conducted for two consecutive years in randomized block design with three replications. Data were recorded on plant height, number of primary branches, length of main raceme, number of siliqua on main raceme, total number of siliqua per plant, number of seeds per siliqua and seed yield per plant. Apart from these, aphid infestation index (AII) and aphid damage index (ADI) were also scored. The mechanism of tolerance was assessed on the basis of selecting best five lines giving higher seed yield in the first year, second year and when pooled. The scores and the seed yield of the best five lines confirmed the existence of tolerance mechanism among these lines. Further, the mechanism of antibiosis was also assessed through the scores. All and ADI. It proved that lines selected on the basis of these indices possess the mechanism of antibiosis for aphid resistance. The implications of these assessments are discussed.

Key words : Indian mustard, Aphid resistance, Tolerance, Antibiosis.

Among the various pests attacking mustard crop, mustard aphid (*Lipaphis erysimi* Kalt.) is a serious pest and is one the main limiting factors in the production of mustard. The excessive use of insecticides to control aphid leads to imbalance in the ecosystem and causes pollution and various health hazards. Therefore, host plant resistance which reduces the reproduction rate of insect population without appreciable reduction in economic yield seems to be better alternative to combat aphid infestation. Several studies revealed the presence of resistance in some varieties of different *Brassica* spp., but none of the varieties of different *Brassica* spp. was immune to aphid (1, 2). However, the mechanism of resistance has not been studied elaborately till date. Direct studies on the mechanisms of resistance are limited by the non-availability of proper genotypes, and elaborate laboratory facilities and above all direct collaboration of entomologists. While in the present study indirect evidences from field experiments were put forward to assess the mechanisms of resistance to aphid in Indian mustard.

Methods

A collection of 112 genotypes were screened for aphid resistance for several years under high aphid population pressure. A few plants from some genotypes were selected having various levels of resistance. These plants were multiplied and their progenies were continuously tested over years for resistance to aphid and seed yield and also for their true breeding nature. Five selected resistant lines along with two nationally recognized resistant varieties T-6342 and RC-1425 were crossed. The segregants were tested for their level of resistant and seed yield in the subsequent generations till F_4 . Fifty five lines (F_5) were selected as the experimental materials for the present study and for screening aphid resistance and seed yield under heavy natural infestation in the field conditions of the District Seed Farm, Kalyani, Bidhan Chandra Krishi Viswavidyalaya for two consecutive years 1999—2000 and 2000—2001. The materials were sown late, 24 November and 21 November for the first and second year respectively to assure maximum natural aphid infestation.

Table 1. Seed yield and other yield attributes of five best lines selected on the basis of high seed yield per plant. R₁=Line repeated from first year, R₂ = Line repeated from second year. 1. Seed yield per plant, 2. Total number of siliqua per plant, 3. Number of seeds per siliqua, 4. Aphid infestation index, 5. Aphid damage index.

Line no	1	2	3	4	5
First Year					
R ₁ B ₁ —26	1.40	88.3	12.7	3.00	3.67
R ₁ B ₁ —11	1.20	75.3	10.3	2.67	3.17
R ₁ B ₁ —12	1.13	66.1	11.0	3.00	3.33
R ₁ B ₂ —21	1.13	67.7	10.3	3.17	3.67
R ₁ B ₁ —24	1.07	82.6	10.9	3.00	3.17
Mean	1.18	76.0	11.0	2.97	3.40
Grand mean	0.69	63.8	11.11	3.01	3.49
Percentage of difference	71.00	19.12	-0.009	-1.32	-2.57
Second Year					
R ₁ B ₁ —7	1.42	51.5	11.9	2.67	2.50
R ₁ B ₂ —18	1.30	78.9	13.3	2.33	2.67
R ₁ B ₁ —13	1.24	78.3	12.3	3.17	2.50
R ₁ B ₁ —2	1.12	62.5	11.2	2.50	2.83
R ₁ B ₂ —8	1.10	92.5	12.8	2.50	2.17
Mean	1.24	72.7	12.3	2.63	2.53
Grand mean	0.73	61.2	11.9	2.71	2.96
Percentage of difference	69.8	18.7	3.36	-2.95	-14.52
Pooled					
R ₁ B ₂ —18 ^{R₂}	1.18	74.9	11.7	2.83	3.08
R ₁ B ₁ —26 ^{R₁}	1.01	67.6	12.0	3.33	3.75
R ₁ B ₂ —29	0.97	85.6	12.2	2.75	3.42
R ₁ B ₁ —12 ^{R₁}	0.95	59.9	12.1	2.83	3.08
R ₁ B ₂ —21 ^{R₁}	0.95	64.0	10.9	2.67	3.42
Mean	1.01	70.4	11.8	2.88	3.35
Grand mean	0.71	62.5	11.3	2.86	3.23
Percentage of difference	42.2	12.6	4.42	0.69	3.71

The experiments were laid out in randomized block design with three replications. Each entry was sown in single row plot of two meter long. The space maintained from plant to plant and row to row were 15 and 25 cm respectively. Usual cultural practices were followed. No control measures were taken against aphid attack.

Data were recorded on plant height, number of primary branches, length of main raceme, number of siliqua on main raceme, total number of siliqua per

plant, number of seeds per siliqua and seed yield per plant from five competitive plants of each entry. Observations were also recorded for aphid infestation index at the peak flowering stage according to Bakhetia and Sandhu (3). A five point visual assessment scale stated below was used to evaluate the genotypes for damage index score : 0—No damage by aphids, no infestation, 1—No specific symptom of injury on the leaves, few scars on the tip of inflorescence, good flowering and pod setting. 2—Average health. Scars on main raceme and secondary racemes, no scars on pod walls, 3—Pods on tip of the inflorescence deformed/not properly developed, 4—Less vigorous growth, stunted inflorescence, long patches of scars on the inflorescence, upper pods not developed, scars on the pod wall, and 5—stunted growth, no pod formation, death of plants.

Results and Discussion

Assessment of Tolerance

An attempt was made to assess the mechanism of tolerance. For this purpose, firstly five best high yielding lines among the 55 genotypes were selected from the first year, second year and when pooled (Table 1). The best five lines selected on the basis of seed yield showed 71, 69.8 and 42.2% higher mean yield than the population mean in the first year, second year and in the pooled analysis respectively. Mean aphid infestation index and aphid damage index were slightly lower than the population mean in two years and higher in the pooled analysis. The results indicated that best five high yielding lines must have tolerance type of mechanism. However, as their aphid infestation and aphid damage indices were comparable to the mean values of the population as a whole, there might be some mechanisms of antibiosis also operating along with tolerance. Only tolerance would have shown higher values of aphid infestation and aphid damage indices than the population mean. Tolerant genotypes are not supposed to inhibit build up of aphid population as evidenced in the aphid infestation and damage indices found in the present study.

The best five lines selected in the first year and second year were not same while in the pooled analysis (Table 1) out of 5 lines three lines from the first

Table 2. Seed yield, aphid infestation index and other yield attributes of five best lines selected on the basis of least aphid infestation index. R₁=line repeated from first year. 1. Aphid infestation index, 2. Total number of siliqua per plant, 3. Number of seeds per siliqua, 4. Aphid damage index, 5. Seed yield per plant.

Line No	1	2	3	4	5
First Year					
R ₁ B ₁ —6	2.17	44.5	10.9	2.83	0.60
R ₁ B ₁ —4	2.50	65.9	10.7	3.17	0.93
R ₁ B ₁ —27	2.50	91.1	12.3	3.50	1.00
R ₁ B ₂ —15	2.50	53.4	12.1	3.50	0.87
R ₁ B ₂ —29	2.50	86.2	11.9	3.67	0.87
Mean	2.43	68.2	11.6	3.33	0.85
Grand mean	3.01	63.8	11.1	3.49	0.69
Percentage of difference	-19.2	6.89	4.50	-4.58	23.18
Second Year					
R ₁ B ₂ —2	2.00	60.1	13.2	3.00	0.85
R ₁ B ₂ —21	2.17	60.3	11.5	3.17	0.77
R ₁ B ₂ —22	2.33	79.2	11.7	2.50	1.02
R ₁ B ₂ —12	2.33	54.5	12.3	2.83	0.62
R ₁ B ₂ —16	2.33	73.6	11.0	2.83	0.68
Mean	2.23	65.5	11.9	2.87	0.79
Grand mean	2.71	61.2	11.6	2.96	0.73
Percentage of difference	-17.7	7.02	2.58	-3.04	8.21
Pooled					
R ₁ B ₁ —6 ^R ₁	2.33	42.7	11.2	2.83	0.61
R ₁ B ₁ —4 ^R ₁	2.50	65.1	11.1	3.00	0.92
R ₁ B ₂ —9	2.58	57.8	11.3	2.92	0.77
R ₁ B ₂ —7	2.58	68.6	11.3	3.08	0.62
R ₁ B ₂ —26	2.58	66.9	11.9	2.83	0.81
Mean	2.51	60.2	11.4	2.93	0.75
Grand mean	2.86	62.5	11.3	3.23	0.71
Percentage of difference	-12.2	-3.68	0.884	-9.28	5.63

year and one line from the second year were represented. This result indicated firstly the importance of conducting screening experiments over years/environments and secondly for further screening of genotypes having varying degrees of resistance. Higher yield of the selected genotypes were achieved more through total number of siliqua per plant and partly through number of seeds per siliqua. Total number of siliqua per plant was contributed more through num-

ber of siliqua on primary branches rather than siliqua on the main raceme (Table 1).

Assessment of Antibiosis

Through Aphid Infestation Index. To assess the mechanism of resistance through antibiosis, two approaches were followed. Aphid infestation index which was recorded at the peak flowering stage is taken first. Aphid infestation index is reported to be an easy but reliable measure of mass screening of aphids in the field (3). It was assumed that after initial contact with the host plant aphids start feeding, growing and multiplying. Therefore, at the peak flowering stage relative resistance of the genotypes through antibiosis is also operating. The aphid infestation index at the peak flowering stage was taken to identify the best five lines scoring least aphid infestation index in the first year, second year and when pooled. The best five lines (Table 2) showed lower mean aphid infestation index than the population mean in both the years and when pooled. Aphid damage index of these lines also followed the same trend. These five lines together recorded 23.18% higher seed yield than the population mean (Table 2). In the second year, the best five lines scored lower mean aphid infestation index (-17.7%) than the population mean. Best five lines also recorded higher seed yield per plant in both the years and when pooled. The difference in the mean aphid infestation index and aphid damage index of the selected lines with the population mean indicated that these lines might possess some degree of antibiosis as a mechanism of resistance which operated to keep the scores lower. Increase in seed yield was not so spectacular as was observed in the tolerance mechanism. This might be partly due to antibiosis itself or due to lower yield potential of the genotypes themselves. Higher mean seed yield in the first year and in the second year was contributed largely by the total number of siliqua per plant followed by number of seed per siliqua.

Through Aphid damage index. To assess the mechanism of resistance through antibiosis a second approach was followed with the help of Aphid damage index. Aphid damage index was scored just at the time of dispersal of aphids from the plants. This score was done on the basis of visual damage done

Table 3. Seed yield, aphid damage index and other yield attributes of five best lines selected on the basis of least aphid damage index. R₁=Line repeated from first year, R₂=Line repeated from second year. 1. Aphid damage index, 2. Total number of siliqua per plant, 3. Number of seeds per siliqua, 4. Aphid infestation index, 5. Seed yield per plant.

Line No.	1	2	3	4	5
First Year					
R ₁ B ₁ —6	2.83	47.5	10.9	2.17	0.60
R ₁ B ₁ —5	3.00	69.3	12.3	3.00	0.60
R ₁ B ₂ —26	3.00	61.8	12.4	2.67	0.67
R ₁ B ₁ —4	3.17	69.9	10.7	2.50	0.93
R ₁ B ₁ —11	3.17	75.3	10.3	2.67	1.20
Mean	3.03	64.8	11.3	2.60	0.80
Grand mean	3.49	63.8	11.1	3.01	0.69
Percentage of difference	-13.1	1.56	1.80	-13.6	15.9
Second Year					
R ₁ B ₂ —8	2.33	69.3	12.5	2.83	0.58
R ₁ B ₂ —1	2.50	92.5	12.8	2.50	1.10
R ₁ B ₁ —7	2.50	53.7	11.9	2.67	1.42
R ₁ B ₂ —22	2.50	79.2	11.7	2.33	1.02
R ₁ B ₂ —24	2.50	72.1	10.3	3.00	0.63
Mean	2.46	73.4	11.8	2.67	0.95
Grand mean	2.96	61.2	11.6	2.71	0.73
Percentage of difference	-16.8	19.9	1.72	-1.47	30.13
Pooled					
R ₁ B ₁ —6 ^{R₁}	2.83	42.7	11.2	2.33	0.61
R ₁ B ₂ —8 ^{R₂}	2.83	79.6	11.3	2.75	0.82
R ₁ B ₂ —26 ^{R₁}	2.83	66.9	11.9	2.58	0.81
R ₁ B ₂ —9	2.92	57.8	11.3	2.58	0.77
R ₁ B ₁ —7 ^{R₁}	2.92	52.4	11.3	2.92	0.94
Mean	2.87	59.9	11.4	2.63	0.79
Grand mean	3.23	62.5	11.3	2.86	0.71
Percentage of difference	-11.1	-4.16	0.88	-8.04	11.2

by the aphids during their course of infestation, number of dead plants and health and vigor of the plants.

This index was used to identify the best five lines scoring least aphid damage in the first year, second year and when pooled (Table 3).

These best five lines scored lower aphid infestation index in both the years and when pooled. The lines selected on the basis of aphid damage index also recorded higher mean seed yield in both the years and when pooled. The difference in aphid damage index and aphid infestation index of the selected lines with the population mean indicated that these lines might possess some degree of antibiosis which operated to keep the scores lower. The difference between mean aphid infestation index and aphid damage index of the selected lines with the population mean might have been more pronounced if the population consisted of all susceptible lines in contrast to the present population which consisted of lines with various degrees of resistance. None of the yield attributes studies showed consistent positive effect on seed yield except plant height and number of seeds per siliqua. Although seed weight was not taken into account in the present study it may be assumed that both tolerance and antibiosis played a positive role to keep the seed weight in the higher side as seed weight may not be much affected by the aphid infestation (4).

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