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Screening Techniques for Different Insect Pests in Crop Plants

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Abstract

Insect resistance in crop plants is an important component of Integrated Pest Management (IPM) and it is considered as non-monetary input at farmers end. Resistant and tolerant cultivars form the basic component of Integrated Pest Management (IPM) over which other components are to be built up. Even a low level of tolerance in plants has a dramatic effect, which in fact reduces the need of insecticides. Use of resistant or less-susceptible cultivars is one of the most important methods of keeping insect populations below economic threshold levels. However, host-plant resistance is not a panacea for all pest problems. It is most useful when carefully utilized with other components of pest management. Screening techniques vary with crop and pest. Thorough knowledge regarding the pest life cycle and screening techniques enable breeder to breed for pest resistant varieties thus combating biotic stresses and reaping good yield which is the need of the hour

1. Introduction

All the crop species are attacked by insects, but the degree of damage to as well as the number of insect species attacking different crop species vary considerably. Therefore, an effective pest management is the basic requirement for reaping good crop. It was hoped that chemical control measures will effectively control or even eliminate the insect pests. But the experience with pesticides has shown that such hope was entirely misplaced. Extensive pesticide application leads to increase in cost of production of crops, reduces the population of natural enemies of insect pests, leads to the development of pesticide resistant races of insects, pollutes the environment.

Most of the Entomologists now speak of *Pest Management* in place of Pest Control. Pest Management involves several divergent measures to minimize the losses due to insect pests. Insect resistant varieties form an important component of pest management schedule. Thus resistance is a relative property and can be defined only in comparison to other more susceptible varieties (Maxwell et al., 1972).

Losses due to insect pests: In India, losses due to insect pests range from 10 to 20%. In cases of severe insect attacks, the yield losses may be upto 90%. Insect pests may be grouped into two classes on the basis of their mode of feeding.

Sucking pests- suck the cell sap eg : aphids, jassids, thrips, whitefly, mites and bugs.

Tissue feeders- feed on the various plant parts eg. stem or shoot borer, root borer, fruit borer, weevils, beetles etc.

- Direct damage: Reduce plant growth on stunting by causing damage to leaf, stem, branch, lower buds, flowers, fruits, seeds, vegetative buds, premature defoliation of leaves and finally wilting of plants occurs.
- Indirect damage: Many insects (eg.) aphids, mites, whiteflies, leaf/plant hoppers etc. transmit plant viruses i.e., serve as vectors of pathogens. Further, injuries caused by insects make the plants more vulnerable to attacks by fungal and bacterial pathogens.

In general, a program of breeding for insect resistance is conducted firstly through the survey for possible sources of insect resistance of varieties and strains locally available. Then some of the basic properties of plants responsible for resistance (non-preference, antibiosis, tolerance) are being determined. Hybridization is done next to combine genes for resistance with desirable agronomic characters followed by testing of resistance in advanced generation hybrids screening. Study of resistance of released varieties is done in plots and *on farms* to evaluate resistance as an insect control method

In the screening program, the general procedure followed are development of screening methods, sources of seeds for screening, selection of seeds to begin the screening program, multiplication of seeds for screening, seed storage - 20°C temp., 60 %RH, selecting a screening site, sources of insects for screening, sowing seed and maintaining plants, management of field plots, screening techniques.

Artificial infestation of plants in field and greenhouse are observed through field screening and screen house/ cage screening/green house screening

2. Cereals

2.1. Rice

2.1.1. Plant hoppers: Screening methods for plant hopper resistance in rice have already been compiled beautifully (Heinrichs et al., 1985). Greenhouse screening done by two methods:

2.1.1.1. Conventional seed box test: It is a rapid method for screening large volumes of material for qualitative resistance. However, it often cannot detect moderately resistant varieties and often these are rated as susceptible. Number of insects seedling^{-1} released are 10 BPH & 8 WBPH. Insects are distributed over the seedlings seven days after sowing (DAS) and evaluated as per the Standard Evaluation System for Rice (SES) (IRRI, 1988) when about 90% of the susceptible check seedlings are dead.

2.1.1.2. Modified seed box test : The modified seed box test detects varieties with moderate levels of resistance. In the modified test, the plants are older at the time of infestation (10 DAS) and fewer hoppers seedling^{-1} (3-5 seedling) are placed on the plants.

Scale		Damage
0	:	No damage
1	:	Very slight damage
3	:	First and second leaves of most plants partially with orange tips slight stunting
5	:	Pronounced yellowing and half of the plants wilting or pronounced wilting
7	:	More than half of the plants wilting or dead and the remaining plants stunted
9	:	All the plants dead

2.1.1.3. Field screening: Field screening is done by three methods

2.1.1.3.1. Resurgence Technique: Resurgence technique is used when the field population of BPH is too low for reliable field screening. Late instar BPH nymphs are distributed evenly at the rate of 5 insects/hill after the first application of resurgence-inducing insecticide (20 DAT) in the susceptible border rows throughout the field. Entries are graded for the damage score on a row basis, when plants in of the susceptible checks start wilting as per SES.

2.1.1.3.2. Polythene barrier technique : It is the modification of resurgence technique to prevent the movement of BPH nymphs outside the plot and to prevent predators from entering the plot with a polythene sheet placed around the field plots. Resurgence inducing insecticides are sprayed over the entire starting from 10 DAT. Test entries are enclosed with a 76 cm high polyethylene sheet (top open) at 30 DAT and infested with BPH. Entries are graded for damage score as per SES when plants in one of the susceptible checks begin wilting.

Scale		Damage
0	:	None
1	:	Slight yellowing of a few plants
3	:	Leaves partially yellow but with non hopper-burn
5	:	Leaves with pronounced yellowing and some stunting or wilting and 10-25% of plants with hopperburn, remaining plants with hopperburn and severely stunted
7	:	More than half of the plants wilting or with hopperburn remaining plants stunted
9	:	All plants dead

2.1.1.3.3. Micro-plot technique : It is designed to screen entries under simulated field conditions to avoid causing hopper burn in the field. Natural enemies, if any, are killed by a spray of decamethrin at 15 DT and hoppers are released at the rate of 2 pairs/hill or 70 pairs/cage at 20 DT. Entries are graded for damage score when 50% of the susceptible check plants in one cage are wilting or are hopper burned and grading is repeated at 4-day intervals until there is no further increase in damage.

2.1.2. Yellow stem borer: Standard Evaluation System has been developed for screening for resistance to YSB and the rating scale is below :

2.1.2.1. Screening at Vegetative phase: Twenty five days after sowing, test entries are planted in 20 cm clay pots @ one seedling/pot. Forty days after seedling, freshly hatched first instar larvae are released @ one larva/tiller. A susceptible check

Scale	% dead hearts (D)
0	No damage (HR)
1	1-10% (R)
3	11-20% (MR)
5	21-30% (MS)
7	31-60% (MS)
9	≥61% (HS)

Scale	% White heads (D)
0	No damage (HR)
1	1-5% (R)
3	6-10% (MR)
5	11-15% (MS)
7	(16-25% (S)
9	≥25% (HS)

$$\% \text{ dead hearts} = \frac{\text{No. of dead hearts counted}}{\text{Total no. of tillers observed}} \times 100$$

$$\text{D (level of infestation)} = \frac{\text{\% dead hearts in test entry}}{\text{\% dead hearts in susceptible}} \times 100$$

$$\% \text{ white heads} = \frac{\text{No. of white heads}}{\text{Total productive tillers}} \times 100$$

is maintained for each testing. The deadheart is recorded on 7, 14 and 21 days after release. This technique is used to screen bulk of the rice genotypes.

2.1.2.2. Screening at reproductive phase: Eighty days after seeding, YSB larvae are released @ one larva/tiller at the top most auricle. White ear head damage is recorded 10 days after release. The entries are evaluated based on the above rating scale.

2.1.3. Leaf folder: For field screening, five rows of the susceptible check was planted all around the field one month earlier to planting of test accessions. Twenty days after planting of susceptible check, phorate granules were applied at 1 kg a.i. ha^{-1} to induce leaf folder infestation. Each test accession was planted in 4 rows of five metre each with a spacing of 20 x 10 cm. A single row of susceptible check was planted in between test accessions.

Standard evaluation system has been developed for screening for resistance to leaf folders [IRRI,1998] and the details are as follows :

Grade	Leaf Area damaged (%)	Category
1	1	HR
3	1-10	R
5	11-25	MR
7	26-50	S
9	51	HS

Scale	Damaged plants
0	No damage
1	11-20%
3	11-20%
5	21-35%
7	36-50%
9	51-100%

Note: Plant susceptible and resistant check (if available) after every 10 test entries.

2.1.3.1. Field screening

2.1.3.2. Greenhouse screening: For greenhouse screening, consider both the % of leaves with damage and the extend of damage on each leaf. For each entry, first examine all of the leaves and rate each one from 0-3 as based on the extent of damage.

Based on the number of leaves with each damage grade, compute in below:

Calculate as below for each test entry and the susceptible check. Then adjust for extent of damage in the susceptible check by

Grade	Damage
0	No damage
1	Upto 1/3 of leaf area scarped
2	1/3 to 1/2 of leaf area scraped
3	More than 1/2 of leaf area scraped

$$\text{\% Rating(R)} = \frac{\text{(No. of leaves with damage grade of 1x 100) 1 +}}{\text{Total No. of leaves observed}} \frac{\text{(No. of leaves with damage grade of 2 x 100)2 +}}{\text{Total No. of leaves observed}} \frac{\text{(No. of leaves with damage grade of 3 x 100)3}}{\text{Total No. of leaves observed}}$$

$$\text{Adjusted \% damage (D rating)} = \frac{\text{R of test entry x 100}}{\text{R of susc. Check}} \times 100$$

The overall damage rating (D) is converted to a 0-9 scale

Scale	% damage rating (D)
0	No damage
2	1-10
3	11-30
5	31-50
7	51-75
9	More than 75

2.1.4. Gall midge

2.1.4.1. Greenhouse screening

- Scheduling sowing and infesting
- Listing and preparing all materials to be tested
- Preparing seed boxes for sowing
- Sowing seed of test entries and check
- Infesting seedlings with adults
- Maintaining the infested plants
- Evaluating percent infested plants

$$\% \text{ infested plants} = \frac{\text{No. of infested plants}}{\text{Total no. of plants}} \times 100$$

% of infested plants converted to 0-9 scale using SES

Scale	Plant with galls
0	more
1	< %
3	1-5%
5	6-15%
7	16-50%
9	51-100%

2.1.4.2. Field screening

- Selecting a hot spot and monitoring midge populations in the field to determine correct planting time.
- Scheduling land preparation sowing and transplanting
- Preparing a field lay out
- Transplanting
- Attracting gall midge for natural infestation
- Maintaining midge populations in the field

- Evaluating screening reactions

1.2. Sorghum

2.2.1. Shoot fly: The screening of sorghum lines can be done under field conditions with natural infestation. Seedling resistance was always evaluated through the determination of percent infested seedlings. After 25-30 days after planting, resistance was evaluated by counting number of dead hearts.

2.2.1.1. Cage screening : In order to eliminate much of the field variability and improve the control of infestation levels, a cage screening technique for sorghum shoot fly was developed. The sorghum seedlings were grown in 25 x 40 cm flats with 60 seedlings flat^{-1}. After 15 days, the flats were placed in small cages inside a screening house with 3 flats cage^{-1}. Pupae of sorghum shoot fly were placed in cages at the rate of 200 flat^{-1} and the flies emerged and oviposited on the seedlings. After 2 days, the flats were removed to observe the development of dead hearts, and more flats and pupae were put into cages. Infestation levels in susceptible checks were found as high as 100%.

Jotwani and Srivastava (1970) used eggs implantation on testing varieties for screening sorghum against shoot flies. The seedlings were infested with eggs on 5th day after germination. The symptom of dead heart formation generally appeared four days after infestation of the seedlings.Observations on dead hearts were taken 21 days with the seedlings were artificially infested.

3. Fibre Crops

3.1. Cotton : A special procedure for determining the resistance to pink bollworm in cotton cultivars based on carryover population in leftover green bolls has been given by Agarwal et al. (1973) and Sukhija et al. (1983).

The screening of cotton varieties against jassid is being done on the basis of injury grades. Four leaf injury grades have been recognized. Under natural conditions, the screening of cotton varieties against jassid is also being done by growing an infestor row of an okra between the two cotton rows(Batra and Gupta, 1970).

Free choice test for screening the germplasm against cotton whitefly under greenhouse conditions has been suggested by Butter and Vir (1989) and several genotypes were screened using this method. The sampling of whitefly adults and eggs from the lower surface of the three fully opened leaves of the upper canopy and 4th instar red eye nymphs of the middle canopy leaves has been advocated for correct population estimates by Butter and Vir (1990). Another criterion of leaf injury index based on plant damage which can be used for screening the germplasm has been suggested by Sukhija et al. (1986) and Butter and Kular (1986). Further studies are needed to refine these techniques of resistance for quick identification of whitefly resistant cultivars.

4. Commercial Crops

1.1. Sugarcane

4.1.1. Top borer: Evaluation of varieties for top borer infestation is generally done by randomly selected stalks of each of healthy and damaged canes which are examined for length, number of internodes, girth, weight and sugar concentration. Yadav (1985) categorized sugarcane varieties against top borer on the basis of percent incidence which are detailed below :

4.1.2. Shoot borer: Categorizing varieties for reaction to shoot borer infestation based on the attacked plants ha^{-1} is claimed to be the most appropriate method. However, based on the economic threshold level of 15% incidence, the varieties may be graded as being less susceptible (0-15%), moderately susceptible (15.1-30%) and highly susceptible (above 30%).

Incidence (%)	Category
00.0-10	Highly resistant
10.1-15	resistant
15.1-20	moderately resistant
20.1-25	moderately susceptible
25.1-50	susceptible
50.1 and above	highly susceptible

4.1.3. Scale insect: Evaluation of sugarcane varieties against scale insect has been done on the basis of its infestation, namely, heavy, moderate and light, depending upon the percent incidence or percent intensity of the pest under field conditions (Agarwal, 1960).

A quick technique for screening of sugarcane cultivars against infestation of scale insect has been reported by Singh and

Sl	Particular	Susceptibility
i)	When only a few insects are seen on any of the internode without a well established colony (very light) or when the incrustation of the pest covers only about ¼ of an internode (light)	Less susceptible
ii)	When the pest incrustation covers nearly ½ of an internode (moderate)	Moderately susceptible
iii)	When the incrustation covers ¾ of an internode (severe) or more than ¾ of an internode (very severe) or when the canes show drying due to the pest attack	Highly susceptible

Nigam (1985) in which mature cane stalks of test varieties of sugarcane were cut from a nursery plot and one end was sealed with molted wax. One hundred freshly emerged nymphs of *M. glomerata* were released on stalks and kept in a dark place for 48 h. The number of nymphs found settled 25 days after release was recorded and cultivars were graded.

5. Oil Seed Crops

5.1. Sesame

5.1.1. Shoot webber field screening methodology: Shoot webber screening will be done based on 5 selected plants entry^{-1} at random for leaf, flower bud and pod damage.

5.1.1.1. Leaf damage: Leaf damage for the shoot webber was recorded on 25, 40 and 60 DAS and percent leaf damage was worked out based on the number of leafs damaged by the shoot webber and the total number of leaves during different stages and the mean percent damage was arrived.

5.1.1.2. Flower bud damage: The percent buds damaged by the caterpillars by observing the total and affected flowers on 45 and 60 DAS were calculated and mean percentage was worked out.

5.1.1.3. Pod damage : Number of pods damaged by the shoot webber was assessed and percent pod damage was worked out. Damage assessed on different plant parts at various stages was converted to 1 to 9 score chart. Score chart was formulated based on intensity of damage. As the damage on reproductive parts like flower and more leaf damage were equated to a particular score.

5.1.1.4. *Scoring genotypes for shoot webber resistance*

% damage			
Leaf	Flower buds	Pod	Score
0-10	0-15	0-2	1
>10-20	>5-10	>2-4	3
>20-30	>10-15	>4-6	5
>20-30	>10-15	>4-6	5
>30-40	>15-20	>6-8	7
>40	>20	>8	9

5.1.1.5. Grade chart

Score	Grade	Mechanism
0-1	1	Highly resistant (HR)
>1-2	3	Resistant (R)
>2-3	5	Moderately resistant (MR)
>3-5	7	Susceptible (S)
>5-9	9	Highly susceptible (HS)

5.1.1.6. Screening under laboratory

Germplasm
↓
Sowing in nursery bags
↓
Thinning 2 bags^{-1} after 4 DAS
↓
Thinning 1 bag^{-1} after 8 DAS
↓
Adult release (10 pairs 50 lines^{-1})- 15 DAS
↓
Grading- 30 DAS

5.1.1.7. Grade chart for seedling screening

Extent of damage	Grade	Category
Partial loss of chlorophyll of one or two leaves of no damage at all	1	Highly resistant
Partial folding and loss of chlorophyll of one or more leaves of most plants	3	Resistant
Folding of four or more leaves and feeding or about half of the plants damaged or dead	5	Susceptible
Most of the leaves folded and damaged or all plants dead	7	Highly susceptible

5.2. Sunflower

5.2.1. Stage of observation

a.	Leaf hopper	:	Seedling and flower bud stage
b.	Defoliator	:	Starbud stage and flowering stage
c.	Helicoverpa	:	Bud and full bloom stage for larval count maturation stage for seed damage

5.2.2. Leaf hopper : 5 random plants/row were selected and the nymphal population on two leaves each from top, middle and bottom of each plant were recorded and mean population plant^{-1} were worked out.

5.2.3. Screening of leaf hopper injury (visual estimation scale)

0	Free from leaf hopper injury
1	Slight yellowing on edges of leaves upto 30%
2	Yellowing and curling upto 40% of leaves
3	Yellowing and curling upto 60% of leaves
4	Yellowing and curling upto 80% of leaves
5	Maximum yellowing, ‘cupping and curling of leaves upto 100%

5.2.4. Mean scale index

0	Highly resistant
0.1-1	Resistant
1.1-2.5	Moderately resistant/tolerant
2.6-3.5	Susceptible
3.6-5.0	Highly susceptible

5.2.5. Head borer: Randomly 5 plants were selected, % seed damage head and the larval number flower bud $^{-1}$and flower head^{-1} were recorded.

5.2.6. Damage by defoliators: Defoliation by ash weevil were recorded by 5 randomly selected plants, counting the total and affected leaves and express their damage in percent.

5.3. Rapeseed and mustard

5.3.1. Mustard aphid screening: Varietal resistance of cruciferous plants to insect pests in India was reviewed by Bakhetia (1976). Seedling survival, scoring the aphid injury, aphid population, aphid fecundity and development and the seed yield are the common screening methods/criteria used by different workers.

5.3.2. Seedling survival : A screening technique for determining the resistance against the mustard aphid in terms of seedling survival was given by Jarvis (1970) using optimum level of aphid population plant^{-1} under the greenhouse conditions. The population levels of 10, 20, and 30 apterae and 1 ml and 3 ml aphids (1 ml = about 600 nymphs + apterae) plant^{-1} were the optimal number for screening at the Cotyledonary, 2-, 4- and 6-leaf, flower bud initiation and flowering stages respectively.

5.3.3. Aphid injury : Aphid injury symptoms expressed as injury graded (0-4) were adopted by Pathak (1961). He used different injury grades based on injury symptoms caused due to the feeding by aphid colonies.

5.3.4. Aphid population : The *Brassica* germplasm was screened at the flowering stage on the basis of the number of aphids under laboratory conditions. The average grades for all the plant parts studied were worked as indicated below :

		Number of aphids on		
Grade	Designation	Stem	Leaf	Inflorescence
0	No aphid	0	0	0
I	Very low	<10	<10	<10
II	Medium	10-20	10-50	10-20 flowering normal
III	High	20-100	50-200	20-100, sickly inflorescence
IV	Very high	>100	>200	>100, inflores-cence drying or dried up

5.3.5. Aphid fecundity and development : The criteria of fecundity of aphids for classifying *Brassica* germplasm as resistant or susceptible at inflorescence stage was used by Singh et al. (1965). The fecundity was considered to be inversely related to resistance. The grouping in combination with the visual rating of the aphid injury to the plants was used for the final rating.

5.3.6. Yield evaluation: The yield component is governed by many factors under conditions of pest attack. Of the various screening techniques described above the seedling screening technique by Jarvis (1978) is preferable owing to many advantages i.e. (1) ease in handling the material (2) greater efficiency and quickness and (3) lesser requirement of aphid population, space and labour because of smaller plant size.

5.4. Groundnut

5.4.1. Leaf miner screening method: The resistance in groundnut leaf miner was evaluated on the basis of the leaf miner injury. In the 12th All India Workshop of AICORPO (1978), the following procedure was suggested by restricting observations on 10 leaflets plant^{-1} on 5 randomly selected plants suing 1-5 scale injury grade

I	Upto 2
II	3-5
III	6-10
IV	11-15
V	≥16

Finally the infestation index is calculated as:

$$\text{Infestation index} = \frac{Ixa+IIxb+IIIxc+IVxd+Vxe}{a+b+c+d+e}$$

Where I, II, III, IV and V are the injury graded and a, b, c, d and e are the number of plants falling in each grade.

5.4.2. Groundnut aphid

Resistance against the groundnut aphid was evaluated using (1) aphid population counts on 3-5 plants plot^{-1} and repeated twice during the peak activity of the aphid. (2) percentage plant infestation based on two counts on wingless aphids on 25 plants at 15 day interval. (3) aphid multiplication rate confining 1-5 mother aphids/plant and recording their progeny upto 3-5 days, using 5-10 plants in each line (4) Aphid infestation index, on the basis of degree of damage or injury.

The most accepted and modified evaluation system against aphid resistance is Aphid Infestation Index.

5.4.2.1. Germplasm screening

Following grades are adopted

Grade	Infestation
I	Pest free
II	A single branch infested
III	More than one branch infested
IV	All branches infested

Grade	Infestation
I	upto 10
II	11-25
III	26-50
IV	>50

The above grading is done for 5 randomly selected plants plot^{-1} and the infestation index is calculated as described above for the groundnut leaf miner.

5.4.3. Jassid

The procedure for evaluating the resistance against jassid is on the basis of nymphal counts on one compound leaf (3^{rd} to 4^{th} leaf from the terminal leaf) plant^{-1}. Five plant observations for each line were considered as optimum and grades adopted were I, II, III and IV for 0, 1-5, 6-10 and more than 10 nymphs plant^{-1}. Groundnut germplasm can also be screened by counting the jassid nymphs on the three young leaves on each of ten plants 60 to 80 days after sowing and comparing these counts with those of standard cultivars.

For the other pests of groundnut, however, no well-defined screening methods were available but Brar and Sandhu (1975) screened groundnut germplasm on the basis of percent plant infestation and population counts in the field for the leaf webber and grey weevil resistance.

5.5. Safflower

5.5.1. Screening methods against aphid:

5.5.1.1. Aphid count: At peak aphid infestation, the number of aphids was counted on 5 cm apical twigs from two randomly selected plants entry^{-1}. The aphid population was then expressed as percentage of the aphid count on susceptible check. These values were used for relative response of a line against the aphid.

5.5.1.1.1. Foliage drying grades: The drying of foliage due to aphid infestation was recorded by visual scoring of the entries before the maturity of the crop as given below :

Grade	Drying of foliage (%)	Category
1	0-20	Highly tolerant
2	21-40	Tolerant
3	41-60	Moderately tolerant
4	61-80	Susceptible
5	Above 80	Highly susceptible

From the above given grades, the Aphid Infestation Index (A.I.I) was calculated by using the formula given below :

$$\text{A.I.I.} = \frac{1xa+2xb+3xc+4xd+5xe}{a+b+c+d+e}$$

Where 1 to 5 are the different drying grades and a to e denote the number of plants falling in each grade. Finally the plant material is classified as per the groups indicated below :

5.5.1.1.2. Category Aphid infestation index

Highly resistant	<1
Resistant	1-2
Moderately tolerant	2-3
Susceptible	3-4
Highly susceptible	>4

Seed yield : Average yield plant^{-1} was recorded at harvest and used for assessing the agronomic potential of a line in relation to the aphid population and the aphid infestation index.

6. Pulses

6.1. Pigeon pea

Pigeon pea germplasm lines vary greatly in their maturity. It will be desirable to conduct separate trails with a narrow range of maturity for screening the lines against the pod borer and pod fly because the time of flowering and maturity of cultivars may influence the levels of damage caused by the insect pests. Such a procedure was followed by Lateef and Reed, 1981 who used a check cultivar in each trial, preferably a highly susceptible one. The percentage of pod damage can be scored on 1-9 scale. The pest susceptibility rating (PSR) for pod and seed damage was worked out as per the formula given by Lateef and Reed, 1980.

$$\text{Pest susceptibility (\%)} = \frac{\text{\% Pod Damage in check cultivar} - \text{\% Pod Damage in test cultivar}}{\text{\% Pod Damage in check cultivar}} \times 100$$

Where, P.D. = Mean of % pods or seed damaged

Pest Susceptibility (%)	Susceptibility rating	Category (1-9 scale)
100	1	Highly Resistant (HR)
75 to 99.9	2	Highly Resistant (HR)
50 to 74.9	3	Least Susceptible (LS)
25 to 49.9	4	Least Susceptible (LS)
10 to 24.9	5	Least Susceptible (LS)
–10 to 9.9	6	Moderately Susceptible (MS)
–25 to –9.9	7	Moderately Susceptible (MS)
–50 to –24.9	8	Highly Susceptible (HS)
–50 or less	9	Highly Susceptible (HS)

6.1. Mung bean:

The germplam of mungbean can be screened against whitefly (*Bemisia tabaci* Genn) and jassids (*Empoasca sps* in the field. The selected entries may be grown in replicated trial and the plots may be surrounded with infector rows. When the pest population reaches to its peak, the infector rows are cut down and after 10-15 days the pest population maybe recorded with split cages randomly from 3-5 spots plot^{-1}. The average population of insect pests for each entry is calculated.

7. Conclusion

The majority of screening that is carried out in pant breeding is not in the laboratory but in the field, where conditions are more variable and where screening and selection techniques need to be simple and economical of time and effort. Hence visual assessment of plant using scales or indices are the commonest form of resistance evaluation. The need for screening plants under natural conditions of infestation is a cause supported by few breeders but, on its own, the use of insecticides in this way plays a major contribution to the problems of crop susceptibility and the lack of horizontal resistance.

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