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OIL CROPS: PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4 – 17 JANUARY 1989

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OIL CROPS:
PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4-17 JANUARY 1989

1. The Brassica Subnetwork-II
2. The Other Oil Crops Subnetwork-I
3. The Oil Crops Network Steering Committee-I

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Part 3. Oilcrops Network Steering Committee-I

PROBLEMS OF INSECT PESTS IN BRASSICAS AND RESEARCH WORK AT PANTNAGAR

G.C. Sachan

Abstract

Rapeseed/mustard is attacked by about 38 insect pests, out of which mustard aphid, *Lipaphis erysimi* (Kaltenbach), mustard sawfly, *Athalia proxima* (klug), painted bug *Bagrada cruciferarum* (Kirk), leaf miner, *Chromatomyia horticola* and Bihar hairy caterpillar, *Spilosoma obliqua* (walker) are of major concern. Among these, mustard aphid is a national pest responsible for causing 54.2% yield loss on country basis. The avoidable losses in *Brassica campestris* var. Toria and Sarson, *B. juncea* and *B. napus* due to insect pests have been estimated to be 53.60, 77.96, 69.38 and 85.25%, respectively.

Food and oviposition preferences by sawfly and its development, pupation and basking behaviour have been discussed. Similarly, food preference, plant part preference and screening techniques like growth and development, honey dew and cafeteria tests have been discussed for aphid. Mechansim of resistance in RW-2--2, RW 15-6 and B-85 (glossy) have been discussed based on biochemical and physiological characters.

Management of sawfly and aphid by the use of insecticides has been elaborated and effect of insecticides on aphid population, oil and protein contents of plant and coccinellid predator have been presented.

Among oilseeds, rapeseed-mustard occupies second place both in area and production in the country covering 20.8% (3,879,000 ha) area and sharing 22.8% (2,641,000 tons) in oilseed production. It contributes 25.8% of the total vegetable oils in the country with production of 936,000 tonnes. India contributes 16% of the total production of rapeseed-mustard in the world. Inspite of this satisfactory contribution, the per hectare yield is only 6.94 quintals as against the world average of 12.62 quintals/ha, though we are better off than some other countries. The rapeseed-mustard production was 4.89 and 30.58 quintals/ha in Ethiopia and the Netherlands, respectively.

In India, one of the major constraints in the production of rapeseed-mustard is the ravage caused by insect pests. Among 38 attacking rapeseed species, mustard aphid (*Lipaphis erysimi* Kaltenbach), mustard painted but, (*Bagrada cruciferarum* Kirk), leaf miner (*Chromatomyia horticola* Goureau) and Bihar hairy caterpillar (*Spilosoma obliqua* Walker) are the major ones. The details of these insects with others of minor importance and the new insects recorded at Pantnagar are given in Tables 1 and 2.

Extent of Losses

The losses caused by insect pest complex on rapeseed-mustard vary from 53.60 to 85.25% being highest on *Brassica napus* and lowest on Toria, Table 3. Avoidable losses are more in Punjab and less in U.P. (3). In other states the avoidable losses are found to be 43.48% in Bihar (10), 25-30% in Rajasthan (36) 5% in Karnataka (28) and 5800 MT in Gujarat (11). At Navgaon, Rajasthan, the avoidable losses observed were 44.13, 14.68 and 51.25% with aphid alone, sawfly and painted bug and entire pest complex respectively on Varuna while on Pusa Kalyani (mustard varieties) the losses were 62.5, 17.62 and 63.24%, respectively (4). In Faizabad (U.P.) the losses caused by insects, except aphid, were

22.23% in Toria, 28.8% in yellow sarson, 7.25% in rai (mustard) and 15.6% in gobhi sarson (*B. napus*) (4). The avoidable losses at Pantnagar are presented in Table 4.

Table 1. Insect complex on rapeseed/mustard

Common name/scientific name	Stage of damage		Nature of damage	Intensity of the pest at Pantnagar
	Crop	Pest		
A. Major pests				
Mustard aphid *Lipaphis erysimi* Kalt.	All stages	Nymph and adults	Sucking sap	Moderate/High
Mustard sawfly *Athalia proxima* Klug	Seedling	Grub	Defoliation	Moderate
Painted bug (*Bagrada cruciferarum* Kirk.	Seedling and Pod	Nymph and adults	Sucking sap	Trace
Leaf miner *Chromatomyia horticola*	Leaf	Later maggots	Mining leaf	- do -
Bihar hairy caterpillar *Spilosoma obliqua* W.	Early/ later	Caterpillar	Defoliation	Low
B. Minor Pests				
Flea beetle *Phyllotreta cruciferae*	Coty- ledons	Adult	Shot holes	- do -
Peach aphid *myzus persicae* Sulzer	All stages	Nymph/ adult	Sucking sap	Very low
Cabbage aphid *Brevicoryne brassicae* Linn.	- do -	- do -	- do -	Nil
Cotton aphid *Aphis gossypii* G.	- do -	- do -	- do -	Nil
Cabbage butterfly *Pieris brassicae* Linn.	Leaves	Caterpillar	Defoliation	Trace
Cabbage leaf Webber *Crocidolamia binotalis* Z.	Leaves/ pods	- do -	Webbing	- do -
Cabbage Semilooper *Plusia orichalcea*	Leaves	- do -	Defoliation	Low
Diamond back moth *Plutella xylostella* Linn.	- do -	- do -	- do -	Trace
Whitefly *Bemisia tabaci* Genn.	- do -	Nymph/ adult	Sucking sap	Nil
Cutworm *Agrotis segetum* D. & S.	Seedling	Caterpillar	Cuts germinating plants	Trace

Table 2. Some new insect pests on rapeseed-mustard at Pantnagar

Common name/scientific name	Stage of damage		Nature of damage	Intensity
	Crop	Pest		
Stemborer *Melangogromyza cleome*	Stem	Maggot	Bores the stem	Trace
Banded flea beetle (to be identified)	Cotyledons	Adult	Making shot holes	Trace
Pantatomid bug (to be identified)	Seedling/ pod	Nymph and adults	Sucking sap	Low
Lygaeid but (to be identified)	Matured pods	Nymph and adults	Sucking seed content	Low
Curculionid beetle (to be identified)	30 days crop	Grub	Bores at cortical region	Trace

Table 3. Avoidable losses (%) caused by insects in Brassica crops (1986-87)

Places	Toria	Sarson	Mustard	Napus
Ludhiana (Punjab)	-	97.1	94.2	81.8
Pantnagar (U.P.)	80.03	37.20	38.73	-
Kanpur (U.P.)	27.18	96.95	73.14	-
Hissar (Haryana)	-	80.6	71.45	88.70
Mean	53.60	77.96	69.38	85.25

(AICORPO, 1987).

Table 4. Assessment of yield losses (%) due to insect pests at Pantnagar

Varieties	Percent loss in yield		
	1986-87	1987-88	Mean
Toria:			
PT-25	34.18	9.16	21.67
PT-30	30.96	16.67	23.81
PT-75	8.82	24.27	16.54
PT-303	19.12	13.72	16.42
PT-507 B	22.18	16.64	19.41
T-9	4.93	11.41	8.17
Mean	20.03	15.31	17.67
Mustard:			
Kranti	43.86	20.18	32.02
Krishna	44.77	7.89	26.33
PR-35	33.69	19.10	26.39
Varuna	32.62	14.49	23.55
Mean	38.73	15.41	27.07
Yellow sarson:			
PYS-6	34.94	13.24	24.09
YST-151	39.47	22.79	31.13
Mean	37.20	18.01	27.61

Mustard Sawfly

This is one of the important insects of rapeseed/mustard at seedling stage and causes 10-25% loss in yield under normal conditions but sometimes losses may be even 100% in severe attack. Sawfly appears in mid September and remains active till January with peak period of incidence during October-November and also higher during December particularly on late sown mustard crop.

The attack of this insect starts when seedlings are 2-3 weeks old. This stage of the crop is suitable for egg laying, but as the plant becomes older the preference for oviposition reduces. The four-week old crop is more damaged by this insect as compared to the eight-week old one.

Ovipositional preference

Ovipositional preference indicated that B. campestris Var. Toria, B. campestris Var. Dichotoma, B. campestris Var. Sarson, B. chinensis, B. rapa, B. juncea, B. rugosa and Seinebra pinnatifida are distinctly preferred over B. napus, B. oleracea Var. Botrytis, Raphanus sativus, Eruca sativa and Iberis aamara. No eggs were laid on Cherianthus cheiri and Tropaeolum majus. Both laboratory and field studies indicated that B. juncea, B. alba, B. nigra and Sinapis alba are more preferred by sawfly as compared to B. napus and B. carinata. Among the B. juncea, indigenous cultivars are more preferred, Table 5.

Table 5. Ovipositional preference of mustard sawfly

Host plant	Nature of leaf	Eggs laid 10 plants
Brassica juncea		
RC-781	Smooth	57.80
PR-15	Smooth	12.20
PR-18	Smooth	34.40
R-3245	Smooth	41.20
Varuna	Smooth	36.00
Blaze	Hairy	7.80
Matopolaska	Hairy	3.20
Lethbridge	Hairy	3.80
Stoke	Hairy	2.80
Domo	Hairy	13.00
Cultidoma	Smooth	21.60
Brassica napus	Smooth	4.60
Brassica rugosa FS-902	Intermediate	29.60
Brassica alba	Hairy	22.40
Brassica nigra	Hairy	7.60
Brassica tournifortii	Smooth	4.80
SE (Mean)		5.67
CD (5%)		15.84

This difference could be due to the hairyness of the leaf which acts as a barrier for oviposition in addition to some unknown biochemical and biophysical factors (20, 22a).

Feeding preference

Only the plants of family Cruciferae and Tropaeolaceae are accepted by grubs indicating the narrow host range of this insect was more on *B. campestris* var sarson, *B. rape, B. juncea* and *B. oleracea* var *capitata* and less on B. napus, B. carinata, Raphanus sativus, B. oleracea var botrytis, *B. oleracea* var gongyloides and least on *Iberis amara* and *Tropaeolum* sp. Among the exotic materials, *B. alba* is more preferred followed by porbiraya (*B. juncea*). *B. napus* as a whole, PC 1 and PC 2 (*B. carinata*) and *B. nigra* are least preferred (22).

Basking behaviour

Basking behaviour of grub indicates that larvae started coming out at 6.30 a.m. from cracks and crevices of soil and their maximum number reached during 10-10.30 a.m. At this stage larvae were seen on leaves and feeding. Population declined drastically between 12 to 15 hrs but again noticed at 16.30 hrs. Few grubs were observed on the leaf on cloudy days (17).

Growth and development

This insect can complete its life cycle on *B. campestris* vars. Toria, Dichotoma and Sarson, *B. chinensis, B. pekinsis, B. juncea, B. napus, B. rapa, B. rugosa, B. oleracea* var. Botrytis, *R. sativus* and *T. majus* but not on *Eruca sativa* (20). Full fed larvae pupate in soil. It prefers sandy soil for pupation having 16-20% soil moisture. Heavy soils are least preferred (24 and 35). Emergence and mating behaviour of this insect have been studied in detail (35).

Eruca sativa, I. amara, C. cheiri and *T. majus* have high degree of natural defense against this insect. Plant juices from fresh leaves act as ovipositional depressants and feeding deterrents (27). Mustard leaves treated with 1% glucosinolates and 0.1% isothiocyanates adversely affect the biology of this insect when offered for feeding. The higher concentrations of 2, 3 and 4% glucosinolate extracts and 0.1 and 1.0 isothiocyanate extract resulted in sharp reduction of larval feeding. This reduction was more in glucosinolate extract from *B. napus, E. sativa* and *T. majus* and isothiocyanates from T. majus than in extracts from Toria, *B. napus and B. juncea* seeds (1, 2).

Control:

Soil application of Phorate, Carbofuran, Disulfoton and Aldicarb at the rate of @ 1 kg a.i./ha is effective in contolling this insect. Among the various insecticides namely, 10% BHC @ 20 kg/ha, 0.02% Chlorpyriphos, 0.03 Dichlorvos, 0.035% Endosulfan, 0.04% Monocrotophos, 0.05% Phenthoate and 0.025% Quinalphos the use of 10% BHC dust is still effective and economical followed by Dicholorovos and Chlorphyriphos (Table 6).

Table 6. Chemical control of mustard sawfly on rai (1987-88) at Pantnagar

Insecticdes	Yield q/ha	Cost-benefit
BHC @ 20 kg/ha	12.75	1:48.89
Chlorpvriphos @ 0.02	12.75	1:17.50
Dichlorvos @ 0.03	13.00	1:26.74
Endosulfan @ 0.035	12.50	1:17.10
Monocrotophos @ 0.04	12.92	1:11.67
Phenthoate @ 0.05	12.17	1:13.28
Quinalphos @ 0.025	12.33	1:15.18
Control -	9.17	-

Tolerant Germplasm

More than 750 Toria germplams have been screened aginst sawfly and PT-30, PT-33, PT-75, TLC-1, PT 41, PT-48, PT-69 PT-79, PT-80, PT-81, PT-82, PT-83, PT-500, PT-501, PT-5078, RAHT-17, TGC-1, TGC-3, TGC-5, TK, 5503, TK-8202, TKCSP-56, DIDNS-53, PT-12 and PT-303 were found tolerant.

Among rai varieties, PR-15, PR-34, PR-1002, PR 1003, PR-29, RLM-29-25, PR-18, PR-1, PR-6, P-1/26, RL-11/1, 5412, 5501, RH-7-355, Rai 36, Raya-159 and 5503 were found least susceptible to sawfly.

Mustard Aphid

This is one of the most important constraints in rapeseed/mustard reduction in the country. The mean reduction in yield of Toria is 14.9% and sometimes as high as 50% at Pantnagar (20), in sarson and raya 68-96% and 27.66-66.00%, respectively in Punjab (6), 11.6-97% in Delhi (12), 70% in Bihar (9), 55.25% in U.P. (20), 73.3% in Orrisa (15) and 91.3% (8) and 35.4 - 73.3% in Punjab with overall mean damage of 54.20% on country basis (7).

Population dynamics

Winged aphids arrive in the afternoon in numbers and settle on the plant. Yellow colour of the flower is one of the attracting factors for these aphids. In general, on mustard crop aphid appears in the mid of December and its population increases gradually reaching the peak in January/February declining in subsequent months and disappears in March/April, but on longer duration crops such as *B. napus and B. carinata* the highest aphid population is observed druing March/April.

Food preference

Among *B. campestris* var. Toria, sarson and *B. juncea* the last one is less preferred by the aphid. Between Toria and sarson, the former one is more preferred and also completes its growth and development quickly. However, *B. napus* is more suitable for aphid at its flowering and pod formation stages in the absence of *B. campestris and B. juncea.* In addition to these *B. alba, B. carinata, B. nigra, Sinapis alba, R. sativus*, Cabbage, cauliflower, knolkhol, *B. rapa* are important hosts of this aphid.

Preference test on different varieties and species indicated that Porbiraya (rai), *S. alba*, PR-18 (rai) and Varuna (rai) are more preferred while all the varieites of *B. carinata, B. napus, B. alba* and *B. nigra* are least preferred at the inflorescence stage. In general, the exotic material of *B. juncea* are less preferred by aphid as compared to indigenous one (19), Table 7.

Table 7. Number of aphid on inflorescence of Brassica species/varieties

Species/ varieties	Number*	Species/ varieties	Number
Brassica alba	6	*Brassica napus*	3
Brassica carinata		Altex	3
PC 1	3	Olivia	2
PC 2	5	Pant n1	2
Brassica juncea		Pant n2	4
Blaze	11	Tilde	4
Lethbridge	14	Trawse	2
PR-15	9	WW 1313	2
PR-18	19	*Brassica nigra*	5
Porbiraya	23	*Sinapis alba*	22
Stoke	7		
Varuna	18		

* Cumulative, total of six days. Sachan and sharma (1986).

Plant parts preference

Before starting the screening program one has to ascertain the suitability of plant parts as various parts and stages differ in several ways. Based on the preference and growth and developmental studies, the pod of the Toria plant is most suitable followed by stalk and tender leaf. Hard leaves are most unsuitable (32). Similar results were also obtained in mustard (Varuna) where pods and tender leaves were more suitable (23).

Screening of germplasm

To find out the sources of resistance in *B. juncea* large amount of material both of indigenous as well as exotic origin was screened under field as well as laboratory condtions. Under field condtions, aphid damage rating (0-5 scale), percent plant infestation and aphid intensity were considered. Under laboratory condtions, growth and development studies, honey dew excretion techniques, cafeteria test for food preference by apterous and cage technique for a late aphids were followed.

a) Growth and development: Under this study different growth and developmental parameters were considered such as aphid survival, developmental period, fecundity, etc. which depicts the antibiosis of the material (21).

b) Honeydew excretion: Honey dew excreted by aphids is allowed to fall on bromocresol green treated filter paper and blue spots develop where honey dew falls. The area of this spot is related to the amount of honey dew excreted. As more honey dew is excreted more susceptible becomes the host (18) (Table 8).

Table 8. Amount of honey dew (mm^3) excreted by *L. erysimi* on different varieties of mustard (18)

Varaieties*	Plant part Leaf	Plant part Inflorescence	Mean
RW 2-2 (R)	23.25	25.25	24.25
RW 15-6 (R)	21.67	23.00	22.33
B 85 (R)	23.25	26.42	24.83
RLM 198 (MR)	26.75	29.50	28.12
RH 7361 (MR)	30.16	31.92	31.00
T 6342 (MR)	28.00	30.08	39.04
Varuna (S)	41.00	45.16	43.08
Porbiraya (S)	38.17	43.25	40.71
S. alba (S)	55.17	64.08	59.62

CD at 5% = 2.00 (Test plant)
= 0.94 (stage)
= 2.84 (Test plant x stage)

*R = Resistant, MR = Moderately resistant, S = Susceptible

c) Cafeteria test for apterous aphid: Test hosts are kept in the periphery at equi distance and aphids, starvested for 6 hrs, are released in the centre. The number of aphids settling on test hosts after a definite interval is counted (21).

d) <u>Cage technique for alate aphids</u>: Cut ends of inflorescence or leaf is kept in plastic vial containing water or plant nutrient solution. These vials are placed in the circumference at equidistance with a radius of 70 cm. In the centre a twig of *B. campestris* harbouring apterous and winged aphids is placed as a source of alate aphid. The entire setup is caged with an 80 mesh wire cage. Number of alate settled on the test plant is counted after six days (19).

<u>Resistant mustard varieties for aphid</u>

Variteis RW-2-2, RW 15-6, RW 15-29-6, RW-33-2, RH 7846, B 85 (glossy, RLM - 198, T 6342, are tolerant to mustard aphid.

<u>Mechanism of resistance</u>

The flowering inflorescence is the main seat of aphid infestation. The possible cause of more susceptibility of toria and sarson could be their tender, dense, compact and thickly packed buds offering highly suitable space for aphid, whereas in *B. juncea* inflorescence is usually long, slender and hardy and provides comparatively less suitable space for aphid settlement (13).

Brassica napus is susceptible at inflorescence because of its yellow colour and compactness, however, the presence of wax on leaf at early stage of the crop renders it unsuitable for aphid settlement. The twigs of *B. carinata, B. nigra* and *B. juncea* are stiffer and hence are less preferred. Glossiness of the leaf is also responsible for lower preference in *B. napus* and *B. carinata* (3).

Experiments were conducted to study the possible mechanism of resistance in *B. juncea* varieties (16). Nine cultivars namely, Varuna, Porbiraya and S. alba, RLM-198, RH 7361 and T 6342 and RW-2-2, RW 15-6 and B-85 (glossy) belonging to susceptible, moderately susceptible and resistant groups, respectively, were selected on the basis of their field performance, population buildup, growth and developmental parameters and preference/non-preference tests.

1. Physical factor, trichome density has no effect as *S. alba* has more hair but more susceptible.

2. Among physiological parameters, moisture and pH of host tissue have no effect on aphid. Chlorophyll content has negative correlation whereas carotenoids have positive relationship with aphid population.

3. Biochemical parameters such as protein, sugar and oil content in seed pod are more in susceptible groups.

4. Phenol content in stalk and seed pod impart resistance to the plant.

5. Among plant nutrients, N, P and Na were higher in the susceptible group. On the other hand, K, Ca, Mg, Zn and S were higher in resistant material.

<u>Chemical control of aphid</u>

i) <u>Efficacy of insecticides:</u> Decamethrin was most toxic followed by Cypermethrin Phosphamidon, Mathyl-o-demeton, Dimethoate, Monocrotophos, Quinalphos, Carbaryl, Endosulfan and Sevisulf (31). In another study, again, Decamethrin was best followed by Cypermethrin, Methyl-o-demeton, Fenvalerate, Permethrin, Dimethoate Phosphamidon & quinalphos(33).

ii) Field test: Out of 10 insecticides tested during 1986-87 and 1987-88, Dichlorvos, Chlorphyriphos and Phosphamidon were better, Table 9.

Among the granular systemic insecticides, phorate 10 G at the rate of @ 0.5 kg a.i./ha is most economical for the control of mustard aphid in rai crop (Table 10).

Table 9. Cost-Benefit ratios of chemical control of mustard aphid

Insecticides	Cost/Benefit 1986-87	1987-88
Chlorpyriphos @ 0.025	1:8.48	-
Dichlorvos @ 0.033	1:6.07	1: 8.71
Dimathoate @ 0.030	1:2.07	-
Endosulfan @ 0.035	1:2.46	1:10.26
Formothion @ 0.025	1:3.73	-
Methyl-o-demeton @ 0.025	1:2.35	1: 3.00
Monocrotophos @ 040	1:5.19	1: 4.52
Phenthoate @ 0.050	-	1: 6.05
Phosphamidon @ 0.033	1:6.64	1: 5.54
Quinalphos @ 0.025	1:3.63	1: 3.96

Table 10. Aphid control by granular systemic insecticides

Insecticide	Dose (kg a.i./ha)	Yield (q/ha)	Cost-Benefit
Carbofuran	0.5	12.92	1:3.76
	1.0	13.00	1:1.05
	1.5	12.66	1:1.09
Phorate	0.5	12.66	1:9.20
	1.0	12.33	1:3.77
	1.5	13.00	1:3.64
Control	-	10.83	-

iii) Compatibility with fungicide: Dithane M-45 has synergistic effect on Phosphamidon and Dimathoate. However, fungicide and Monocrotophos are incompatible. Decamethrin, Cyparmathrin, Methyl-o-demeton and Quinalphos can be mixed with fungicide without appreciable loss in toxicity (30).

iv) Effect of sublethal doses of insecticides on aphids: Because of improper selection of insecticide and its use, insecticides can produce resurgence like conditions at very lower doses. Decamethrin, Cypermethrin, Fenvalerate and Phosphamidon at LC 10 and LC 20 levels enhance fecundity and reduce nymphal duration (29).

v) Safety of insecticides to coccinellid: Methyl-o-demeton is most safe followed by dimethoate, decamethrin and cypermethrin. Quinalphos, phosphamidon are not safe (34).

vi) Effect of insecticides on oil content: Various insecticides have been reported to change the nutritive value of the plant. The application of dimethoate increased the oil content by 14.62% and with other insecticides it ranged from 0.07 to 11.76% (5). At LC 50 level of Methyl-o-dematon, Cypermethrin and Decamethrin, this increase is 1.27, 1.07 and 1.07%, in aphid free conditions (29).

vii) Effect of insecticides on protein contnent: Insecticides showed an adverse effect on the protein content which increases with the increase in concentration. Protein content of mustard leaf and inflorescence ranged from 2.7 to 3.51 and 2.82 to 3.44%, respectively in various treatments. This is low as compared to control, 4.12 and 4.02%, respectively (25).

Pollination

Rapeseed-mustard crops are pollinated by *Apis carana indica, A. dorsata, A. florea* and *Melipona* sp. Their peak period of activity is from 11.00 A.M. to 1.00 P.M. on rai and 10.30 A.M. to 2.30 P.M. on Toria during peak flowering period (20).

Granular systemic insecticides, phorat and carbofuran, when used for the control of mustard aphid do not disrupt foraging activity of bees. Similarly phosphamidon, methyl-o-demeton, dimethoate and endosulfan at 0.03 concentration did not deter the bees visiting mustard crop (14).

Future Research Needs

1. Screening of germplasm for insect pest resistance.
2. It has been observed that some varieties show tolerance to aphid at one centre but are susceptible at another. This could be due to their biotype and such studies are needed.
3. Aphid arrival is not regular. In some years it is severe but in others moderate or totally absent. For large screening of germplasm a continuous source of aphid is needed. Hence work on rearing of aphid on artificial diet must be initiated which will also help in understanding the role of various organic and inorganic constituents that are responsible for resistance/ susceptiblility.
4. Evaluation of biocontrol agents and their field application should be explored.
5. Ecological studies of various insect pests are lacking which will help in finding out the weakest link in their life cycle that can be explored for their management.

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