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Review Article

MUSTARD APHID, *LIPAPHIS ERYSIMI* KALTENBACH (APHIDIDAE: HOMOPTERA); A REVIEW OF HOST SUSCEPTIBILITY AND MANAGEMENT PRACTICES

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A B S T R A C T

Mustard aphids, *Lipaphis erysimi* are small (about 2mm), generally globular with piercing and sucking mouthparts. They possess a pair of small tubular structures at the posterior region of their body, called cornicles. It pierces its proboscis into the tender plant tissue and sucks the plant sap. It excretes honeydew that covers practically the whole surface of leaves and the tender shoots. A black mould develops on the honeydew which interferes with the photosynthetic activities of the plant. Current effort was made to get a comprehensive note on the control strategies adapted to date for mustard aphid and its host variation.

INTRODUCTION

Lipaphiserysimi is the most severe pest of the mustard crop in India. Besides brassicas to which mustard belongs, this pest attacks some other economic plants, particularly those of the family Cruciferae. Like many other important aphid pests, this species has an extensivedistribution in the world. The Aphid population generally makes its appearance sometimes during winter, and it continues to breed parthenogenetically till the end of spring when winged individuals are produced,andlarge-scale dispersal takes place. The population, however, dwindles mostly due to climatic reasons and practically disappears for the whole of the summer and also most of the autumn.

Review

KumarandDikshitapplied Imidacloprid as a seed treatment (Gaucho 70 WS, 5 and 10 g ai kg−1 seed) and foliar spray (Confidor 200 SL, 20 and 40 g ai ha−1) at 50% pod formation stage on mustard (Brassica campestris Linn.) to control mustard aphid, Lipaphis erysimi Kalt. It was detectable upto 82 and 96 days in plants after sowing from lower and higher doses of seed treatment. However, it dissipated faster and became nondeductible after 7 and 15 days of foliar treatments from lower and higher rates of application, respectively.

The dissipation models yielded the rate constants of 0.0209 and 0.0230 and 0.0736 and 0.0779 day-1 from seed and foliar treatment. The corresponding half-lives of 14.40 and 13.07 and 4.09 and 3.86 days were recorded. This suggested that the dissipation was independent of initial doses and followed first-order rate kinetics. The projected TMRC of imidacloprid from seed (0.136 and 0.225 mg person−1 day−1) and foliar (0.069 and 0.1497 mg person−1 day−1) treatments were found lower than the MPI (3.135 mg person−1day−1). At harvest, mustard grains did not contain imidacloprid residues. The absence of imidacloprid in 0–10 and 10–20 cm soil layers indicated no leaching of insecticide. Therefore, imidacloprid treatments could be taken as safe for crop protection, consumption of leaves and environmental contamination point of view.

Farooq and Tasawar conducted a study to evaluate various measures, viz., application of insecticide methomyl @ 560 gm/ha, plant spraying with tap water, release of *Coccinella septempunctata* (L) @ 50 grubs per plot, release of another predator *Chrysoperla carnea* (Stephen) @ 1000 eggs per plot and release of both predators together for the control of canola pests, *Brevicoryne brassicae* and *Lipaphis erysimi* during 2002- 2003. Methomyl was found to be the most effective treatment resulting in maximum control of aphids till the seventh day after treatment followed by the plant washing with tap water and release of both predators. Blank spray with tap water gave adequate control of the pest till 48 hours after application. The efficiency of the predators, when released singly or released together, was increased as the releasing

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period was prolonged. Plant height, number of branches per plant, number of pods per plant, number of grains per pod and grain yield were significantly affected in all the treatments.

Narayanan observed that this aphid appears in November and causes severe damage to the various cruciferous crops up to April. Their number goes on decreasing as the temperature rises and the summer approaches, with the development of a generation of winged adults. The winged aphids are often observed flying about in February and March. Singh and Sandhu (1958) reported that the mustard aphid makes its first appearance in November and remains active up to April in Punjab. After that, the population decreased considerably with the production of a generation of winged adults and their colonies develop on the plants growing in cool and moist places. The multiplication of pest is favoured by moist and cloudy weather.

Atwal *et al.* noticed that the fluctuation in population growth was brought about mainly by high temperature and maturing food. The aphid population decreased immediately after every rainfall but increased within a week during spring. Lakhanpal and Raj (2002) observed the three aphid species populations by using Moerick yellow pan water trap, among which *L. erysimi* was recorded maximum percentage of alate aphid catches, i.e. 66.15 and 83.33 percent during the 1993 and 1994 in February, respectively. Correlation coefficient showed significant positive correlation (0.821) with maximum temperature and significant negative correlation (0.805) with minimum temperature.

Jaglan *et al.* observed the maximum population of *L. erysimi* infesting mustard cv. Prakash from the end of February to end of March. Temperature and humidity did not influence aphid population, but rainfall caused a significant and sudden population reduction. Sinha *et al.,* (1989) observed the population build up in January – February and reached a peak around the middle of February. The ambient maximum (21.7 – 23.5^{o}C) and minimum (7.2 – 9.4^{o}C) temperature in January – February appeared to be highly conducive to the population build up. Minimum humidity (55.7 – 69.4%) in January – February favoured population build up, while high humidity had little effect. The activity of the pest ceased at 50.9 percent humidity and below. Frequent rains during the phase of population increase adversely affected the aphid population.

Lefroy reported *L. erysimi* infesting mustard crop in different states of India and found that the pest first appears during November –6 December and makes colonies and damage the crop by draining the sap from the plant stem. There is the development of sooty moulds on honeydew secreted by this insect, which finally affects the yield of the crop adversely. Sinha *et al.,* (1990) reported that aphid appeared in the third week of December, increased in January/February and reached at peak number in February. The environmental temperature was important in aphid multiplication. Frequent rain kept the population density low.

Srivastava and Srivastava observed the maximum incidence of the mustard aphid when temperature ranged from 17 to 18^{o}C and relative humidity 61 to 83 percent. Roy (1975) studied the population dynamics of mustard aphid and observed that the aphid population was independent of the effects of temperature and humidity. The rain had, however, profound effect on its population and was one of the most consistent factors in a population reduction of *L. erysimi*. Prasad and Phadke (1980) observed that the meteorological parameters like temperature and saturation deficiency except for rainfall, in general, remain seven conducive for aphid population build up. About 107.3 days were completed before peak aphid population was observed.

Bakhetia and Sidhu reported that the fecundity, life-span, and reproduction of the aphid were adversely affected by rainfall, temperature above 30^{o}C and sub-zero winter temperature. *L. erysimi* developed and reproduced most rapidly at a temperature between 20 to 30^{o}C.

Mathur and Singh noticed that the abundance of *L. erysimi* had a definite pattern of distribution on the plant as its number was much higher on upper and lower leaves than the middle ones. Its population was observed in January, and it was independent of the temperature, and the rainfall had shown detrimental effect.

Mathur and Singh reported that the maximum temperature above 15^{o}C with relative humidity below 75 percent, increase in wind velocity more than 3 km per hour and rate of evaporation 5 mm per day, had their combined effect in a sudden fall of aphid population as prevailed during the third week of March.

Singh and Singh reported that the average temperature, maximum of 25.31^{o}C and minimum of 5.15^{o}C with R.H. 88 percent morning, 28 percent evening proved most conducive to the development of mustard aphid irrespective of varieties. The average temperature (maximum) beyond 30^{o}C, the action of a ladybird beetle (*Coccinella septempunctata*) and maturity of the crops proved detrimental for the development of mustard aphid. Sachan and Sharma (1986) studied the antibiosis response of various mustard varieties on growth and development of *L. erysimi* at 27+1 ^{o}C with 60 to 80 percent R.H. in BOD incubator and found that fecundity rate was highest on PR-18 (6.03 nymph/female/day) and lowest on RLM-198 and R.H. 7846 (4.48 nymph/female/day).

Ram and Gupta reported that 21.4 to 22.8^{o}C (maximum), 5.9 to 7.6^{o}C (minimum) temperature and 80.2 to 83.8 percent (F/N) and 31.2 to 40.9 percent (A/N) relative humidity were congenial for the development of aphid population. Mild winter shower (around 2.0 mm) and cloudy weather conditions caused in boosting up of aphid population, whereas, heavy winter shower (around 10.0 mm) dislodged the aphid population and followed the sudden decline in temperature curtailed the further build-up of population.

Bishnoi *et al.,* reported that after clearance of western disturbance and a sharp rise in air temperature by 6 to 10^{o}C, the population builds up in aphids may further intensity on Indian mustard, *B. juncea*. The temperature of 10 to 13.5^{o}C and relative humidity of 72-85 percent proved optimum. Rana *et al.,* (1993) noticed that the aphid, *L. erysimi* made its appearance towards the end of December or 1st week of January on rapeseed and mustard. An average temperature of 14.12 ^{o}C coupled with 85 percent R.H. proved most nine conducive to the development of this pest. Temperature (minimum), R.H. (evening) and rainfall exhibited deleterious impact on the population of mustard aphid as they had a significantly negative correlation with its population.

Singh and Rai studied the influence of relative humidity and temperature of 1 – 6 days before the date of observation on the development of *L. erysimi* and found that the maximum R.H.

three days before observation was the most important factor in increasing the aphid population. Rohilla *et al.,* (1996) observed that *L. erysimi* appeared on *B. napus*in the 3rd week of January and in the 1st week of January on all other cultivars (*B. campestris* – brown sarson and yellow sarson, *B. juncea* and *B. nigra*). Infestation reached its peak on *B. napus*in the last week of February, and in the 2nd week on the other cultivars. Pest incidence increased with an average temperature of 13.7 ^{o}C and R.H. of 65 percent. It decreased with a temperature above 35^{o}C, < 60 percent R.H., > 10 mm/day of rain and host crop maturity.

Samdur *et al.,* observed that mean aphid infestation index was significantly and negatively correlated with maximum temperature, evaporation, sunshine and wind velocity, and significantly and positively correlated with maximum R.H. for *B. juncea* sown in the first and third weeks of November, and with minimum R.H. for *B. juncea* planted in the first week only. The conditions of an average – maximum temperature around 23 ^{o}C, minimum temperature around 10 ^{o}C, maximum R.H. from 85-88 percent, minimum R.H. from 30-35 percent, sunshine for 4 – 7 h/day, evaporation from 2 – 3 mm/day and wind velocity from 3.0 – 4.5 km/h/day were optimum for aphid population increase in the field.

Singh and Malik reported that the population build-up of *L. erysimi* on Indian mustard (*B. juncea* cv. Varuna) was initiated at the beginning of January and reached its peak in the middle of February and eliminated from the field at the beginning of March. The increase in temperature was significantly conducive to aphid multiplication, but R.H. had shown a slightly negative response on its intensity without any remarkable response of mild rainfall, while wind velocity had negative effect on this pest. The extent of losses was as great as 59.3 percent in yield.

Jitendra *et al.,* observed that aphid appeared on all the test varieties (Varuna, Rohini and Vardan) in 3rd standard week (January), when temperature was below 20 ^{o}C with more than 90 per cent R.H. and reached at its peak in 6th/ 7th standard weeks (February) during both the years (1994 & 1995) when maximum temperature was ranging between 22-23.25 ^{o}C at > 84 per cent R.H. An increase in maximum temperature above 25 ^{o}C along with R.H. < 60 per cent was found responsible for elimination of aphid during 8th/9th standard weeks in March. The aphid multiplication was found to be influenced by morning R.H. up to the extent of 51.29 – 84.33 percent on Rohini and 64.45 – 85.98 percent on Vardan independently, whereas maximum temperature was found responsible for determining 6.20 – 19.78 percent of the population during the first year which was not much identical during the second year. The role of wind velocity was also unique in determining aphid elimination from the infested crop.

Srivastava *et al.,* reported that the average maximum temperature had a direct relationship with the aphid population on *Brassica* cv. Varuna. Jitendra *et al.,* (2000) noticed that the aphid multiplication was positively governed by temperature, whereas, R.H. and wind velocity had negative effect on mustard, *Brassica juncea* Czern. And Coss cv. Varuna. Temperature (max. 25.14 & min. 11.42 ^{o}C) and R.H. (morning 84.14 & evening 57.57%) along with wind velocity below 3.0 km/hr were very conducive to this pest.

Panda *et al.,* noticed that the aphid species infested the crop from 52nd to 14th standard week (SW) with its peak (302.10 aphid/plant) during 7th SW at 70 days old crop. The minimum temperature between 7.1 to 15.1^{o}C, maximum temperature between 24.9 – 29^{o}C and mean R.H. between 61 – 65.5 percent were found to be congenial for the proper development of aphid population.

Gupta *et al.,* noticed that population of mustard aphid during the second year of study was higher than the first year due to variation in meteorological factors. The temperature ranged between 13.28 – 27.17 ^{o}C in the year 1999 while it was 6.14 – 22.08 ^{o}C during the observation period of the second year. Humidity average of 72.78 percent in the second year invited more aphids than the first year in which a maximum number of aphid was recorded at the R.H. of 67.35 percent. Scanty rainfall in February did not affect the aphid population. However, rainfall in March resulted in sharp decline of aphid population

Pathak reported that as against 80 to 100 percent of yellow and brown *sarson* varieties, only 9 percent of the *rai* varieties tested showed stunted growth as a result of aphid attack, yellow *sarson* varieties, YS-159, 175, 181, 188 and 5519 showed considerable resistance while YS-111, 175 and 5519 although carried heavy aphid colonies on them, yet did not show stunting effect, indicating that they were more tolerant to aphid attack than other varieties. The brown *sarson* variety BS-38, 78, 90 and 95 (U.P.) and BS-2, 43 and 93 (Bengal) were resistant type while BS-38 (U.P.), BS-254 (Punjab), showed a tolerant effect by supporting heavy population of aphid on them, but is only slightly stunted in growth. The varieties *raya*code 17, 45 and 273 (Punjab) and L-16/3 showed greater resistance than other varieties.

Prasad and Phadke reported that the aphid population was higher on yellow sarson, brown sarson and toria varieties of *B. campestris*, lower on rai (*B. juncea*) and lowest on Banarsi rai (*B. nigra*) varieties. Singh *et al.,* (1982) observed a minimum population of 8 aphids (*L. erysimi*)/leaf on Pusa Kalyani (*B. campestris*) followed by Rye-75-1 (10 aphids/leaf). Brown sarson K-1 was the most susceptible variety, with 20 aphids/leaf. Prasad (1983) observed minimum mean aphid infestation index in the mustard cultivar IB-680 and the maximum in the yellow sarson variety, IB-787. The index was less than the overall mean in 4 cultivars of yellow sarson, 8 of brown sarson and 36 of mustard against 29, 30 and 40 cultivars tested respectively.

Prasad reported the aphid infestation indices minimum 0.2 – 0.3 in EC 114317, 114116, 114337 against 2.6 to 3.2 in Pusa Kalyani (check line). All 71 germplasm have shown less than 0.9 aphid infestation indices which is the mean value of 159 indigenous and 17 exotic germplasm of *B. juncea*. Vir and Henry (1987) reported that variety T-59 and Durgamani were the most resistant to the attack of *L. erysimi* on mustard. Rai *et al.,* (1989) reported that most of the ten mustard cultivars were found free from attack by *L. erysimi* but glossy white flower harbored the fewest aphids.

Rohilla *et al.,* observed field resistance in 10 strains of *B. juncea* (RLC-1036, RLM-198, RLC 1037, PR-43, RW white Glossy, RW-29-6 Glossy, B-85, RW 15-6 Glossy and T-6342) and five strains of *B. napus* (GS-47, GS-140, GS-825, GSL-1, and GSL-1501) against *L. erysimi*. Two types, those having a white flower and those having glossy stems, showed a low degree of initial settling and a mechanical barrier to colonization, respectively. In general, the wax content of inflorescence branches was negatively correlated with aphid infestation. The thickness of the stem between the epidermis and phloem was positively correlated with resistance, with resistant varieties having a thickness of 125-130 5 m and susceptible ones 110-117 5 m.

Rohilla *et al.,* screened eighteen varieties in the field for the size of aphid population and found that percentage of shoot infestation was positively and significantly correlated with some aphids/central shoot. The late flowering varieties RL-18 and RLM-198 were resistant and RLM-14, Vardan, RH-819, and RH-7859 were tolerant.

Begum and Huq observed that the population of *L. erysimi* increased from 40 to 60 days after sowing and then declined. The infestation was heaviest at the 6th leaf and flowering stages of crop growth in M 121-4 and Tori-7. In descending order of susceptibility, the varieties were Tori-7, M-121-4, M-38-3, Kallyania, M-26E 6-3, SS-75, M 25E 1-2, Sampad, YS-67, and M-211.

Kher and Rataul studied the settling behavior of *L. erysimi* on seven strains of *B. campestris*, sevenstrains of *B. juncea* (Indian mustard) and five strains of *B. napus* (rape), in free choice experiments with all plant species present at the cotyledon stage. *B. campestris* preferred while *B. napus* were significantly less preferred than others. At the two leaf stage, sarson was again the least preferred and *B. campestris* BSH-1 was the most susceptible of the plants tested followed by *B. campestris* span and YSPB-24, *rape* GSL-1512 was the most resistant followed by GLS-1501 and GSL-1.

Talpur *et al.,* reported from Pakistan that *B. campestris* cv. P-63 and P-7 and *B. juncea* (Indian mustard) cv. S-9 was the most resistant cultivars to aphid *L. erysimi.* Among 24 varieties of Indian mustard tested by Bhadauria *et al.,* (1992), lower aphid population (72.2-89.6/5 cm twig) and lower multiplication indices (9.0 and below) were observed on RKV-47, RKV-24, and RH-781, which were classed as resistant to the aphid. The varieties RH 80-03 and RLM 571 had higher aphid populations (118.8-121.2/5 cm twig) and a multiplication index above 12 and were classed as highly susceptible.

Kher and Ratul reported that the strains of *B. napus* viz., GSL-1512, GSL-1501 and GSL-1 harbored significantly lower aphid population than the Regent and Gulliver at all the three stages of plant growth (inflorescence, flowering and pod-formation) tested and thus proved more resistant, whereas, all the seven strains of *B. campestris* supported very high population and were considered highly susceptible to aphid. All seven strains of *B. juncea* showed moderate resistant status toward aphid population.

Upadhyay *et al.,* found that varieties EC 212661 and RLM-514 recorded the lowest mean number of aphids/plant (439 and 491, respectively), JGM-873 and Pusa Bold had the lowest percentage shoot infestation (26% each) and MT-12 and Pusa Barani had the lowest loss in seed yield (22% & 33%, respectively). Genotype RK-8602 is recommended as suitable for a range of environments, having average resistance and the highest seed yield (1388 kg/ha).

Singh *et al.,* found that *Brassicae* cultivars havegreenish-yellow flowers and with scattered flower buds, viz., BC 2, HC 2, T 6342, RH 7846, RH 30, Prakash and *B. nigra* were resistant to the mustard aphid, *L. erysimi* infestation. The fecundity of mustard aphid was low on resistant cultivars T 6342, RH 7846 and *B. nigra*. The amount of nitrogen, reducing sugar and phenol did not see to have any influence on aphid resistance.

Mandal *et al.,* screened 25 varieties of rapeseed (*B. campestris*) and mustard for resistance to the aphid. Yield losses in both years varied from 28.2 to 83.3 percent. The varieties Seeta, Pusa bold, Kranti and SJM-191 were the least susceptible. Aphid population varied from 88 to 141 aphids/20 cm shoot during both years. Bhadauria *et al.,* (1995) found that mustard cultivars RW 255676 B, RK 8501, RW 5453-B 2 and RJ-4 were less susceptible to the aphid, the susceptibility index computed bymean aphid population and multiplication index were ranged from 234.0 to 357.0. On the other hand, cvs PR 8303, RH 851, PR 8309, RK 8502 and PR 8301 with a susceptibility index varying from 1014.7 to 1703.5, proved to be highly susceptible.

Rai *et al.,* found that cvsPYS-843, PR-8801, and PYS-841 were most resistant to *Lipaphis erysimi* and gave the highest yields as against 18 different entries of *toria, sarson,* and *rai.* Rana *et al.,* (1995) screened eight cultivars belonging to 6 *Brasica* sp and *Eruca sativa* in the greenhouse for their susceptibility to *L. erysimi* and found that *B. carinata* (cv. HC 2), *B. nigra* (cv. local), *Eruca sativa* (cv. T 27) and *B. juncea* (cv. Haryan Saag) had the lowest aphid population with 10.33, 18.67, 43.33 and 60 aphid/plant, respectively, compared to 1033.33 for the susceptible control, *B. campestris* (cv. BSH-1), at the full pod formation stage.

Ashwani *et al.,* observed the susceptibility of 15 mustard genotypes to *L. erysimi* in the order of Vaibhav > DIR-437 > RK-8605-I > NDR – 871 > CSR –83-97 > NDYS-2 > CSR-83155 > CSR-88-224 > Varuna > Kranti > NDR-873 > RK-8605-2 > NDR-872 > RLC-1037 > RW-2-2-1 > RW-2-2-1 was significantly more resistant to *L. erysimi* (24.29 aphid/plant) than any other genotype. Aphid population/plant was negatively correlated with plant height, number of pods/plant and number of branches/plant.

Bhadauria *et al.,* screened the 16 genotypes of *B. juncea* under conditions of artificial infestation and found that according to aphid population and multiplication index, cv. White Glossy was least, and JGM 56 was most, susceptible to aphid infestation. Varuna gave 907 kg/ha yield even at higher aphid number and multiplication index indicated the presence of a tolerance factor. Age of the crop was responsible for host selection but not for a multiplication of aphids. The correlation study indicated that with every day's delay in flowering there was an increase of 1.03 aphids per 5 cm twig length. Lal *et al.,* (1997) found that by aphid infestation index (AII), two *Brassica* germplasm B-85 glossy and RW-white glossy were highly resistant, whereas NDR-8501, PR-8805, RH-7847 and RLM-198 were categorized as moderately resistant. The varieties most susceptible to *L. erysimi were Kranti,* PR-43, and Varuna.

Rana and Khokhar screened the 56 cultivars of *Brassica* among which, RLM-198, RW-2-2 (non-waxy), PR-43, RH-7846 and RH-7847 were found tolerant, supporting on average of 100-150 aphids/plant.

Ashwani and Sharma reported that entries of mustard germplasm RK-8802 (30.24 aphids/plant) and RK-8602 (44.30 aphids/plant) were the least and most susceptible against *L.*

erysimi, respectively. The rank order of susceptibility was RK-8602 > RK-8801 > CSR-83-268 > DIRA-333 > DIRA-335 > CSR-83-247 > NDR-8602 > CSR-83-225 > RK-8501 > DIRA-337 > CSR-83-58 > RW-29-6 > DIR-247 > NDR-8601 > RK-8802.

Malviya and Lal screened 78 *Brassica* germplasm among which 15 germplasm viz., BIO-464, BIO-902, DIRA-337, DLSC-1, DLSC-2, KM-999, Kranti, PCC-2, Purple Mutant, PSR-30, RH-7846, RLM-198, RSK-84, RW-2-2, SKM-9320, and TKG-5 were found as promising against mustard aphid, *L. erysimi* under field condition.

Vekaria and Patel found that among forty promising *Brassica* and allied genotypes tested; none was immune; however, five genotypes viz., GLS-1 (*B. napus*), PC-5 (*B. carinata*), T-27 (*Eruca sativa*), Local genotype (*B. touresefortii*) and T-6342 were resistant against mustard aphid, *L. erysimi*. Rangrez *et al.,* (2002) recorded the maximum aphid population per plant (97.3) from yellow *sarson* cv. YSK-157 followed by BSH-1, BS-1, KS-103, BS-2, KS-102, DBS-5, KOS-1, KS-101 at post bloom stage. Minimum mean aphid per plant (30.6) was recorded on KS-104.

Takar *et al.,* found that based on aphid (*L. erysimi*) population, the varieties of *B. juncea* T-59 (Varuna), BIO-902, PCR-7 (Rajat) and DLM-29 were highly resistant (below 70.45 aphids/plant), varieties/entries Kranti, Pusa Bold, Rohini, VSL-5, BIO-772, DLM-58, Brani, RH-8113, Pusa Basant, DLM-80, and DLM-68 were moderately resistant (between 70.45 to 116.51 aphid/plant) and varieties/entries DLM-75, M-21, AG-5, DLRA-343 and P. Lord were least resistant, having more than 116.51 aphid/plant.

Bhat *et al.,*recorded maximum aphid infestations of 20.96 and 100.66 aphids/plant at bloom and post-bloom stages, respectively on yellow sarson (*B. campestris* var. sarson) cv. YSK-151, while the infestation was lowest (8.77 and 46.18 aphids/plant, respectively), on KS-104, BSH-1 was the least resistant cultivar. KS-104 and KS-101 were relatively resistant to aphid infestation, while the remaining cultivars (KS-102, KS-103, KBS-1, DBS-5, and KDS-1) were categorized as moderately susceptible.

Banerjee and Pramanik from West Bengal reported that dimethoate, methyl-parathion, endrin, and nicotine Sulphate were effective against *L. erysimi.* Saini and Chhabra (1966) worked out the efficacy of dimethoate (0.037%), menazon (0.05%) and phosphamidan, parathion and methyl-demoton (each 0.025%) sprayed 2-4 times @ 686 – 1372 litres/ha. They found that out of all the insecticides, menazon was best followed in order of merit by phosphamidan, parathion, methyl demeton, and dimethoate.

Srivastava and Srivastava showed that the average number of *L. erysimi* on mustard was 370/5 plants in untreated plots compared to 18 for 0.025 percent parathion treated plots, 50 for 0.1 percent gamma BHC or 0.033% diazion, 52 for 0.037 percent dimethoate and 67 for 0.1 percent malathion treated plots. Nicotine sulphate was found to be less effective in Uttar Pradesh.

40.Ganguli and Roy found at Tripura that when mustard plant sprayed with endosulfan 35 EC @ 1250 ml/ha at seven day intervals registered good control of aphids and gave significantly higher yields and profit than those sprayed at intervals of 14 or 21 days. Sharma and Joshi (1972) from Madhya Pradesh recorded mortalities 72 hr after spray treatments with 0.02 percent phosphamidan and dimethoate, 0.1 percent methyl demeton, 0.075 percent fenthion and 0.1 percent endosulfan, formothion, carboryl,andthiometon. The averaged percentages respectively were 93.4, 85.6, 81.0, 74.0, 59.0, 63.5, 61.7 and 71.3 percent compared to 12.4 percent for the controls. In a comparative study with Diazinon (0.037%), dimethoate (0.037%), gamma BHC (0.025%), parathion (0.025%), nicotine sulphate (0.1%) and malathion (0.1%) applied thrice @ 675 litres/ha/spraying for controlling *L. erysimi* on mustard at Kanpur (U.P.), Srivastava *et al.,* (1972) found that dimethoate was the most effective insecticide followed by parathion. Kakar and Dogra (1978) found in Himachal Pradesh, methyl-demeton (0.025%), phosphamidon (0.03%) and endosulfan (0.1%) were effective in descending order after 3, 10, 15 and 30 days following treatment. However, by the 10th day, their effect was non-significant when a repeat spray was given. Besides, two spray schedule was superior to one as it covered the peak infestation period.

Brar and Sandhu evaluated the effectiveness of 18 insecticides (different ones in different years) at 0.025 or 0.05 percent at Ludhiana (Punjab) against *L. erysimi* on brown sarson and reported that chlophysifos, dicrotophos, monocrotophos, phosalone, dimethoate, and oxydemeton-methyl were most efficient, and compounds which gave moderately good control of aphids included carbophenothion, carbofuran, endosulfan, malathion, and vamidothion.

Mohan *et al.,* found that the 19 insecticides applied at intervals of 7 or 14 days in the field at Bangalore against *Lipaphis erysimi* and *Crocidolomia binotalis*, major pest of cabbage, Methamidophos at 0.25 or 0.5 kg/ha gave excellent control of both pests; of the remaining insecticides, quinalphos, endosulfan, ethiofencarb and pirimicarb were the most effective against *L. erysimi* alone and fenvelerate, permethrin and methamidophos against *C. binotalis* alone.

Bakhetia (1986) reported that an effective control could be achieved by foliar spray with 625 to 1000 ml of oxydemeton-methyl 25 EC/dimethoate 30 EC/endosulfan 35 EC/quinalphos 25 EC/formothion 25 EC or 950 to 1500 ml of chlorpyriphos 20 EC or 150 to 250 ml of phosphamidon 100 EC dissolved in 200 – 300 litres of water/ha, depending upon the stage of crop growth. Besides soil application of phorate 10 G (10 kg/ha) or aldicarb 10 G (10 kg/ha) disulfoton 5 G (20 kg/ha) or carbofuran 3 G (33 kg/ha) broadcasting followed by light irrigation could effectively control the aphids.

Baral *et al.,* evaluated the efficacy of 0.025 percent methyl demeton, 0.025 percent quinalphos, 0.025 percent formothion, 0.025 percent monocrotophos, 0.03 percent dimethoate, 2 percent ascorbic acid and 1 percent acetic acid against *L. erysimi* on mustard and found that methyl demeton was most effective, resulting in the lowest incidence of the aphid and the highest seed yield.Singh *et al.,* (1986) suggested application of insecticides like dimethoate 0.03 per cent phosphamidon 0.025 per cent, quinalphos 0.025 per cent oxydemeton methyl 0.025 per cent endosulfan and monocrotophos 0.04 per cent as they provided effective control of mustard aphid.

Vir and Henry suggested four sprays of 0.03 percent dimethoate 30 EC at fortnightly intervals to get significantly higher yield and more economic returns. Zaman (1990 a) reported that sprays of dimethoate EC (80 ml a.i./100 litres water), formothion EC (49.5 ml a.i./100 litres water) and pirimicarb (75 g 26 a.i./100 litres water) significantly reduced infestations of aphid *L. erysimi* on rape seedlings and remained effective for more than 3 weeks without affected by frequent rains.

Zaman tested four insecticides against *L. erysimi* and found that carbosulfan at 57.14 ml a.i./100 liters water and dimethoate (60 ml) were significantly effective in reducing infestation and remained effective for more than two weeks in preventing secondary infestation. Dichlorovos (75 ml) had good initial effects but was only moderately persistent, whereas, dinobuton was less effective in both the short and long term.

Upadhyay and Agrawal studied the efficacy of monocrotophos, phosphamidon, oxydemeton-methyl, dimethoate, malathion, chlorpyriphos, cypermethrin, fenvelerate and endosulfan against *L. erysimi* on Indian mustard, cv. 'Varuna' in field experiments and found that oxydemeton- Mat 0.025 percent and phosphamidon at 0.03 percent were most effective resulting in higher seed yield of 2.40 and 2.28 tonnes/ha, respectively. Bhalla *et al.,* (1994) found that endosulfan, Malathion, monocrotophos, and oxydemeton tested against *L. erysimi* on rapeseed-mustard were effective. Monocrotophos and oxydemeton – M (at 50 and 100 g a.i./ha) gave complete control up to 14 days of spraying. Malathion was the least effective insecticide tested.

Sinha *et al.,* observed that phosphamidon proved most effective against the aphid in one as well as two spray schedule. It remained effective for 15 days in one spray schedule and protected the aphid for 30 days in two spray schedule with repeat application after ten days. The insecticide used showed a descending order of efficacy as phosphamidon > dimethoate > lindane > thiometon > carbaryl > Malathion > chlorpyriphos > endosulfan > quinalphos. Singh *et al.,* (1999) studied the efficacy of six insecticides against mustard aphid *L. erysimi* and their safety to aphid predator, *Coccinella septempunctata* and forging honey bee, *Apis cerana*were evaluated. Phosphamidon 0.03 percent proved to be the most effective insecticides against mustard aphid and moderately safe to honey bees with highest seed yield (17.63 q/ha). Phosalone was found to be effective against aphid and safe to predator and pollinator. Endosulfan proved to be the safest insecticide to pollinator and predator.

Brohi observed that two sprays at fortnightly at recommended doses against *L. erysimi* on mustard crop, Dimecron 100 EC, and Thiodan 35 EC were comparatively more effective and persistent than the Nuvacron 40 SCW, Advantage 20 EC, and Sumicidin 20 EC. Rajendra *et al.,* (2001) observed the efficacy of imidacloprid as a seed treatment (Gaucho 70 WS, 5 and 10 g a.i./kg seed) and foliar spray (confidor 200 SL, 20 and 40 g a.i./ha; at 50% pod formation stage) against *L. erysimi* on rapeseed-mustard. The lower treatment rates of both proved sufficient to optimize the yield. Mustard grains and soil at harvest did not contain imidacloprid residues.

Sinha *et al.,* observed the relative toxicity of insecticides against mustard aphid in laboratory test and found that phosphamidon was most toxic insecticide followed by dimethoate, lindane, thiometon and chlorpyriphos, phosphamidon remained most effective up to 14 days followed by dimethoate, lindane, thiometon, carbaryl, malathion, chlorpyriphos, endosulfan and quinalphos. Gami *et al.,* (2002) found that among 11 different insecticides treatments methyl-0-demeton 0.025 percent, carbosulfan 0.04 percent, methyl parathion 2 percent dust @ 25 kg/ha and monocrotophos 0.04 percent were highly effective against mustard aphid, *L. erysimi.* Pthe rofenophos 0.05 percent,and azadirachtin 0.00075 percent were found less effective against this pest.

Lal *et al.,* found that thiamethoxam was most effective among five insecticides tested against *L. erysimi* on cabbage. The population reduction over control due to thiamethoxam was 72.88 percent after one day of spray which increased to 96.82, 97.44, 99.86 and 99.72 percent after 7th, 14th, 21st and 28th day of spray, respectively. The population reduction of *L. erysimi* over control due to betacyfluthrin, lambdacylothrin, endosulfan, and cartap hydrochloride after seven days of spray was 75.32, 90.06, 88.80 and 92.29 percent in the first spray while it was 72.14, 74.70, 82.56 and 87.64 percent in case of the second spray, respectively.

Gour and Pareek evaluated nine insecticides each with two concentrations against *L. erysimi* (Kalt.) and fund that treatment of dimethoate (0.03%) was most effective followed by dimethoate (0.015%), imidacloprid (0.05%), acephate (0.05%) and cypermethrin (0.002%). Neem extract (0.2%) was found least effective in reducing aphid population followed by neem extract (0.4%) cartap hydrochloride (0.04%) and ethofenprox (0.002%), whereas, endosulfan (0.02 and 0.035%), acephate (0.025%), malathion (0.025 and 0.05%), cypermethrin (0.001%), ethofenprox (0.004%) and cartap hydrochloride (0.08%) existed in moderate group of efficacy.

Meena and Lal observed the bio-efficacy of different synthetic insecticides against mustard aphid, *L. erysimi* Kalt., on cabbage in a descending order of imidacloprid (0.01%) > endosulfan (0.07%) > ethofenprox (0.1%) > lambda cyhalothrin (0.01%) > cartap hydrochloride (0.05%) > beta cyfluthrin (0.00125%) > imidacloprid, proved most effective against *L. erysimi.* Rohilla *et al.,* (2004) evaluated the bio-efficacy of 10 insecticides against mustard aphid, *L. erysimi* among which imidacloprid 17.8 SL @ 0.0178 per cent, thiamethoxam (Actara) 25 WG @ 50 g a.i./ha, oxydemeton methyl 25 EC @ 0.025 per cent and monocrotophos 36 EC @ 0.036 per cent proved most effective.

Kabir and Mia tested six indigenous pesticides as sprays against *L. erysimi* on mustard in Bangladesh and found that all the treatment viz., extract of neem, garlic, onion, tobacco straw ash and a mixture of soap with kerosene reduced the infestation and increased the yield. Pandey *et al.,* (1987) evaluated the three concentrations (0.5, 1.0 and 1.5%) of neem seed kernel extract against *L. erysimi* under laboratory conditions and found that 80 percent mortality was given by 1.5 percent concentration. 1.0 percent concentration was also effective.

Gupta evaluated the neem leaves and the endosperm of *Azadirachtaindica* against *L. erysimi* and found that neem product caused 100 percent mortality of *L. erysimi* on ornamental plants. Bhathal *et al.,* (1993) studied the effects of AZT-VR-K (an azadirachtin enriched acetone extract of neem seed kernel extract) and commercial neem products and reported that development, reproduction, and mortality of mustard aphid (*L. erysimi*) reduced. Mishra (1993) evaluated the dimethoate, quinalphos, chlorpyriphos, deltamethrin and fenvelerate at 0.3, 0.25, 0.2, 0.007 and 0.1 kg a.i./ha respectively and 1 percent Repelin neem oil for the control of *L. erysimi* on *B. compestris*cv. Toria and reported that quinalphos was most effective insecticide followed by dimethoate and repelin.

Bhathal and Singh observed that the commercial formulation of neem viz., Neemark and Neemgaurd, resulted in 73 to 87 percent mortality of *L. erysimi*. Delayed mortality during the 4th instar was recorded with AZT-VR-K (Neem extract) and Neemgaurd. The highest adult's abnormalities were induced by AZR-VR-K extract of neem.

Prasad observed that neem (*Azadirachta indica*) spray formulations were effective at controlling infestations of *L. erysimi* on *B. compestris* for only three days after application and were inferior to the level of control given by oxydemeton-methyl.

Lal evaluated four neem formulations under field condition against mustard aphid, *L. erysimi* and found that Nimbicidine and Neemark caused 20 to 26 percent mortality of winged adult aphid after two days application while Neemgold and Jawan gave about 15 percent mortality. Patel *et al.,* (1996) evaluated the seven insecticides against *L. erysimi* and found that endosulfan (0.035%), chlorpyriphos (0.02%) and neem seed kernel suspension (NSKS 0.3%) were most effective in controlling the pest.

Sontakke and Dash determined the efficacy of synthetic insecticides and neem formulations for the control of *L. erysimi* infesting mustard and found that quinalphos was the most effective followed by chlorpyrifos and endosulfan and resulted in the highest seed yield. Nimbicidine and azadirachtin gave a comparatively better level of control of aphid and a higher seed yield.

Dhingra *et al.,* found that 0.01 and 0.07 percent concentrations of Achook, Neemark and Methenolic neem seed extract applied by direct spray on the leaves with insects reduced the number of live offspring of aphid, *L. erysimi* by 90, 70 and 60 percent, respectively in comparison to control. Gupta *et al.,* (2001) evaluated the seven neem-based formulations (Neemarin, Neemazal, Bioneem, Nimbicidine, Achook, Econeem and Neemgold) against *L. erysimi* infesting mustard and found that reduction in the pest population was highest with the spraying of Neemazal followed by Neemarin and lowest with the spraying of Neemgold. Singh (2004) evaluated the plant extracts viz., marua (*Ocimum basilicum*), neem (*Azadirachta indica*), Datura (*Datura stramonium*), aak (*Calotropi procera*), along with metasystox (0.025%) and dimethoate (0.05%) and found that yield was highest with metasystox followed by dimethoate, marua, and neem.

Bhat *et al.,* recorded maximum aphid infestations of 20.96 and 100.66 aphids/plant at bloom and post-bloom stages, respectively on yellow sarson (*B. campestris* var. sarson) cv. YSK-151, while the infestation was lowest (8.77 and 46.18 aphids/plant, respectively), on KS-104, BSH-1 was the least resistant cultivar. KS-104 and KS-101 were relatively resistant to aphid infestation, while the remaining cultivars (KS-102, KS-103, KBS-1, DBS-5, and KDS-1) were categorized as moderately susceptible. Takar *et al.,* (2003) found that based on aphid (*L. erysimi*) population, the varieties of *B. juncea* T-59 (Varuna), BIO-902, PCR-7 (Rajat) and DLM-29 were highly resistant (below 70.45 aphids/plant), varieties/entries Kranti, Pusa Bold, Rohini, VSL-5, BIO-772, DLM-58, Brani, RH-8113, Pusa Basant, DLM-80 and DLM-68 were moderately resistant (between 70.45 to 116.51 aphid/plant) and varieties/entries DLM-75, M-21, AG-5, DLRA-343 and P. Lord were least resistant, having more than 116.51 aphid/plant.

Gami *et al.,*found that among 11 different insecticides treatments methyl-0-demeton 0.025 percent, carbosulfan 0.04 percent, methyl parathion 2 percent dust @ 25 kg/ha and monocrotophos 0.04 percent were highly effective 28 against mustard aphid, *L. erysimi.* Profenophos 0.05 percent and azadirachtin 0.00075 percent were found less effective against this pest. Considering the seed yield, two sprays of methyl-o-demeton 0.025 percent gave maximum seed yield (1575 kg/ha).

Lal *et al.,* found that thiamethoxam was most effective among five insecticides tested against *L. erysimi* on cabbage. The population reduction over control due to thiamethoxam was 72.88 percent after one day of spray which increased to 96.82, 97.44, 99.86 and 99.72 percent after 7th, 14th, 21st and 28th day of spray, respectively. The population reduction of *L. erysimi* over control due to betacyfluthrin, lambdacylothrin, endosulfan, and cartap hydrochloride after seven days of spray was 75.32, 90.06, 88.80 and 92.29 percent in the first spray while it was 72.14, 74.70, 82.56 and 87.64 percent in case of the second spray, respectively. Gour and Pareek (2003) evaluated nine insecticides each with two concentrations against *L. erysimi* (Kalt.) and fund that treatment of dimethoate (0.03%) was most effective followed by dimethoate (0.015%), imidacloprid (0.05%), acephate (0.05%) and cypermethrin (0.002%). Neem extract (0.2%) was found least effective in reducing aphid population followed by neem extract (0.4%) cartap hydrochloride (0.04%) and ethofenprox (0.002%), whereas, endosulfan (0.02 and 0.035%), acephate (0.025%), malathion (0.025 and 0.05%), cypermethrin (0.001%), ethofenprox (0.004%) and cartap hydrochloride (0.08%) existed in moderate group of efficacy.

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Singh and Lal attempted different methods such as mechanical, biological and botanical were adopted singly as well as in combination to manage mustard aphid. The mustard aphid was regularly monitored during crop season to give treatments for management of mustard aphid on a need basis. The application of treatments was done by ETL, *i.e.*, 25 aphids ten cm^{-1} central twig $plant^{-1}$. All the treatments were effective in controlling mustard aphid. The chemical control with oxydemeton methyl 25 EC @ 0.05% was found as the most effective resulting in significantly higher yield as compared to other treatments. The treatments comprising mechanical + botanical+ biological control were found to be the best alternative to chemical control for management of mustard aphid.

In addition chemical management of insects, residual effects of insecticides, toxicity of some insecticides, insecticidal and for antifeedant activity, biopesticides, botanical pesticides mixture for insect pest management, insecticidal activity of essential oils, bioefficacy of some indigenous plant extracts and , antifeedant properties in support of Eco-friendly control of insect pest have also being reviewed as follows.

Chawla *et al.,* observes the quinalphos to be quite effective for the control of insect pests of cauliflower and cabbage including the resistant strain of *Plutellq xyostella* L. Talekar *et al.,* (1977) reported that 40 percent of quinalphos could be removed from Chinese cabbage.

66.Jain and Gupta reported initial deposits of 10 to 11 ppm when lindane was applied in 0.01% solution on Brinjal which fell below the then fixed tolerance limit of 10 pm on the same day.Kumar *et al.,* gave the TLC-enzyme inhibition technique to determine the nature of organophosphate residues in soil. Manske and Johnson reported the presence of traces of Dieldrin, ODE, DOT, Endosulfan and hepta chlor epoxide in potato in the U.S.A. Metivier *et al.,* considered that the amount of oxaphosalone in plants was always very low and no case exceeded 2 percent of the phosalone Content and considered that the determination of the parent compound would accurately indicate the hazards of its residues to the eventual consumers of the treated commodities. Singh *et al.,* and Chawla *et al.,* reported about 70 percent degradation of quinalphos in 4 days on cabbage and cauliflower respectively. Murthy *etal.,* found efficiency and residue dissipation pattern of fenvelerate in/on Brinjal (*Solanum melongena* L.) fruits. The efficacy of fenvelerate against insect pests of aubergine was assessed in Karnataka, India, in 1983-84. The insecticide (at 0.005, 0.01, 0.015 or 0.02%) was sprayed four times at an interval of 20 days commencing 20 days after transplantation. The most effective dose in controlling Jassids (Cicadellids) and giving the highest yield was 0.02%. At this dose, the residues were below the tolerance limit of 1 ppm. Within 1.7 days in washed and cooked fruits and the waiting period for raw fruits was 12.99 days.

Banerjee and Pramanikfrom West Bengal reported that dimethoate, methyl-parathion, endrin, and nicotine Sulphate were effective against *L. erysimi.* Saini and Chhabra worked out the efficacy of dimethoate (0.037%), menazon (0.05%) and phosphamidan, parathion and methyl-demoton (each 0.025%) sprayed 2-4 times @ 686 – 1372 litres/ha. They found that out of all the insecticides, menazon was best followed in order of merit by phosphamidan, parathion, methyl demeton, and dimethoate.

Sangama *et al.,* was found relative toxicity of some insecticides against Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. The relative toxicities of Endosulfan, Lenitrothion, Malathion, quinalphos, and gamma - HCH (lindane) to the pyralid beucinodesorbonalis was determined by topical application to the throx of 1-day old 4th instars larvae. The mortalities were assessed 24 h after treatment. By the LC_{50}, quanalphos (6.841 g/gwas the most toxic insecticide followed by lenitrothion [8.801 g/g), endosulfan (7.577 g/g), malathion (8.281 g/g*),* and lindane (8,588 Ug/g).

Singh *et al.,* studied the determination of endosulfan and carbaryl residues in/ on Brinjal fruits. Carbaryl at 0.1 % and endosulfan at 0.07% were applied to aubergine in Rajasthan, India, about 53 days after planting, and the residues in fruits were determined at the various interval after spraying. The initial deposits of endosulfan (5.47-5.66 ppm) were reduced by about 50% in 3 days and had disappeared by 21 days after spraying, and fell below the tolerance limit of 2 ppm in 7 days. Bhattacharya *et al.,* (1992) was found residue studies on endosulfan in okra pods and monocrotophos in Brinjal fruits. In field trials at West Bengal, India. Brinjal (aubergine) was treated twice (with 20 days between sprays) with 350 and 700 g. 3.i.lha endosulfan. Residues in the fruits were below safe levels for consumption (as defined by WHO/FA~) by 15 days after the 2nd application, except where monocrotophos had been applied at 700 g a.i/ha, when extrapolation predicted that the state level would be reached 15.95 days after the 2nd application.

Dethe *et al*.; found the influence of formulation on endosulfan residues on brinjal fruit. In a field experiment in India in 1988, three endosulfan formulations (35 EG, 50 EG, and 25 ULV) were sprayed on to brinjal (aubergine), and the residues in the fruits were measured 0,1,3,5,8 and 15 days later. Initial canon in the fruits was higher when the ULV formulation was used. The residues in the fruits reached 2 ppm. By 6 and 3.4.3.6-days after spraying with the ULV and EG formulations, respectively.

Jadhav *et al*.; found effects of different processing methods in the elimination of residues from brinjal fruits. A field experiment was carried out in 1985 on aubergine fruits which had been sprayed with insecticides (20.40 or 60 ppm. pp 321 (lambda-cyhalothrin), 100, 150 or 200 ppm. permethrin, 75,100 or 150 ppm. cypermethrin, 2000 ppm. acephate or 700 ppm. endosulfan) when ready for harvest. A 100 g sample from each treatment was analyzed for insecticide residues. Fruits were analyzed 0,7, 10 and 20 days after spraying and were processed by washing with tap water, washing with warm water (60G) or cooking in tap water for 15 min. Tap water washing has no significant effect on reduction of residues. The warm water washing reduced the waiting period for attainment of acceptable residue levels to 2 days for synthetic pyrethroids, one day for acephate and four days for endosulfan. Cooking reduced the waiting period of 1 day. [Aubergine] and leaf blight (caused by *Alternaria solani*). However, the insecticide fenvelerate, applied either alone or in combination with either fungicide, was not effective.

Singh *et al*., experimented determination of residues of cypermethrin in brinjal fruits, leaves, and soil. Residues of cypermethrin were determined in the fruits and leaves of aubergine and the soil when the insecticide had been applied in sprays in the field in Punjab, India, at 50 and 100 g a.i./ha. After eight applications at the lower dosage, initial deposits averaged 1.16 1.69 mg/kg; residues declined by 68% in 10 days. Doubling the application rate resulted in corresponding increases in residues. The half-life of the insecticide in soil was 5.2 days.

Singh *et al.,* found GLC analysis of deltamethrin in brinjal fruits, leaves, and soil. Residues of deltamethrin in brinjal fruits, leaves, and soil. Residues of deltamethrin on the fruits and leaves of aubergine and in soil were determined after the insecticide had been applied in sprays in the field at 50 and 100 g. a.i/ha. Residues on the fruits, after application at the lower dosage, were always less than 0.11 mg/kg. At the higher dosage, residues were higher. The half-life of the insecticide was 1.1-1.6 days. Leaves treated at the lower dosage received deltamethrin residues 2-6 times as high, and residues declined by about 63-68% in 10 days, Residues in the soil were 0.09-0.22 mg/kg; and the half-life was 6.2 days. There did not see to be any risk of accumulation of deltamethrin in the soil.

Barooah *et al.,*have reported residues of quinalphos in/ on brinjal (*Solanum melongena*) fruits. The dissipation of residues of quinalphos was studied in/on brinjal [aubergine] fruits under field conditions in Assam, India. The insecticide (Eralux 20 AF) was applied 35 days after transplanting by foliar spraying at 0.5 (T1) and 1.0 kg a.i/ha (T2), sprays were given at 15-day intervals. At either rate, the cumulative residues of the insecticide in/on marketable size fruit sampled one h after the last spray ranged from 1.26 to 1.79 *mg/kg.* These dissipated with half-life values of 2.1 to 2.2 days and had fallen below detectable levels 15 days after the last spray. Fruit samples at 2-7 days in T1 and 1-7 days in T2 showed the presence of quinalphos Oxon in addition to the parent compound in amounts ranging from 0.02 to 0.09 mg/kg. Safe waiting periods were found to be 4.9 and 6.1 days for the two treatments respectively. Washing coupled with rubbing under tap water removed 76% of the residues from the treated fruits.

Choudhary *etal.,* experimented influence of growth regulators and insecticides on growth on the yield of brinjal (*Solanum melongena* Linn.). Growth and yield parameters of aubergine cv. Pusa Kranti plants were increased by dressing the seeds with growth regulator powder (30 ppm. IAA, gibberellic acid or IPA isopentenyladenosinei) before sowing or by applying insecticides after transplanting. The most effective of the growth regulators was ITA, which resulted in a fruit yield of 331.318 9/ha(compared with 287.415 9/hain controls in which the seeds were dressed with an inert-powder) and the highest net profit. In the case of the insecticide treatments, soil application of phorate combined with hiodan [endosulfan] sprays was more effective (yielding 3.26 111 9 fruits(ha) than dimethoate sprays in combination with a later thiodan spray (3.09.413 9/ha*).* The insecticide treatments significantly reduced the percentages of fruits and plants affected by fruit and shoot borer (*Leucinodes orbonalis).*

76.Sharma *et al.,* recorded persistence pattern of triazophos and lindane residue on okra and brinjal. Persistence and dissipation of triazophos and lindane residue were studied on the fieldhas grown okras and brinjal [aubergine in 1995 in Karnataka. The crops were sprayed with 350 or 700 g a.i/ha of triazophos or lindane. With okras and aubergine, triazophos residue level in the fruits reached the prescribed MRI (maximum residue limit) after 7-9 and 7-10 days after spraying respectively whereas, for lindane, the prescribed MRL values in okras and aubergine were reached after 5-7 and 4-6 days.

Kabir *et al.,* had observed the efficacy of different insecticides in controlling brinjal shoot and fruit borer, Leucinodes orbonalis Guen. Several insecticides were evaluated over three seasons in 8angladesh rabi 1990-91 at Joydebpur, and rabbi 1991-92 and Kharif 1992 at Jessore) to determine their efficacy to control *Leucinodr orbonalis* on aubergine. None had a significant effect in reducing the pest population, and there was no difference between treatments and yield on either infested or un infested plants during the rabbi season of 1991-92 and the Kharif season of 1992. Although the insecticides commencing from 1st incidence were applied at the peak of adult emergence at an interval of not less than 21 days. The intensity of the infestation in insecticide-treated plots was as that recorded from control plots. The results suggested that *L. orbonalis* may be developing resistance.

Maleque *et al*., experimented judicious use insecticides for the management of the brinjal shoot and fruit borer. A study on the use of insecticides for the management of brinjal shoot and fruit borer *Leucinodes orbonalis*) was undertaken at Bangabandhu Sheikh Majibur Rahman Agricultural University, Salna, Gazipur, ban.9ladesh, during the period from 29 October 1997 to 17 June 1998. Brinjal [aubergine] variety Singhnath used in the field experiments Some treatments consisting mechanical" (hand collection of infected shoots/fruits) and. chemical (cymbush 10 EC [cypermethrin] and Diazinon 60 EC) were tested. The benefit-cost ratio (BCR) was highest in plots treated with mechanical control+cypermethrin. A similar BCR was achieved in the plots with the weekly spraying of cypermethrin. However, the weekly spa raying involved applying eight times more insecticides.

Mishra *et al*., observe that insecticides for management of brinjal fruit and shoot borer Leucinodes orbonalis. Field experiments with sixinsecticides were carried out in 1990 91 in Orissa, India, to assess insecticide resistance of *Leucinodes orbonalis*in aubergines. Lowest pest incidence was found in plots treated with fenvelerate. Patel *et al*., (2003) evaluated quinalphos residues in/on brinjal and cabbage. Field experiments were carried out in Gujarat, India; for two seasons to study the magnitude of quinalphos residues in/on brinjal [aubergine] fruits and cabbage curds. One spray of 0.05% quinalphos was applied at the fruiting stage in brinjal, while on cabbage 0.05 and 0.1% sprays were applied at curd formation. The sate waiting period for brinjal was 2.1 days with a half-life of 0.9 days. The corresponding values for a waiting period and half-life on cabbage were 2.5 and 4.2 days and 1.3 and 1.3 days for the lower and higher doses resp. Gate samples of brinjal [aubergine] from Jaipur, Rajasthan. India and nearby villages contained residues of monocrotophos. Dimethoate, phospham, idon, Malathion, quinalphos. Fenvelerate, carbofuran. endosulfan and BHC [HCH]. In 37 samples, the residue of various pesticides was within the maximum residue limit (MRL). Only 13 samples contained insecticide residues above the MRI. Patel *et al*., was found chlorpyriphos residues in/oncabbage and brinjal. The persistence of Chlorpyriphos on cabbages and brinjal [aubergine] fruits was studied in field experiments conducted at Gujarat. Agricultural University, Anand. India. Residues persisted up to 15 d in cabbage and 10 d in aubergine. The half-life values were 1.0 and 0.3 d for cabbage. When applied at 0.04 and 0.08% respectively,while for aubergines it was 0.4 d for both applications.

Pal found that dissipation of carbaryl residues in brinjal. The persistence of carbaryl in brinjal (aubergine) was studied in Orissa, India. The initial deposits of the insecticide on the leaves were 25.2 and 45.2 ppm after application at 0.75 kg. a.i. and 1.5 kg. a.i /ha. respectively. After five days, the residues had declined to 4.5 and 9.4 ppm and were below the detectable level after 16 days. The initial deposits on fruits were 11.4 and 18.5 ppm for the lower and higher dose. Srimanarayana and Rao (1984) studied the insecticidal and for the antifeedant activity of various plant derivatives and revealed that *Annona procynidin* (1000 ppm) offered moderate (50-75% protection of leaf disc) antifeeding activity against 4th instars larvae of *S.ltura.* They argued that the plant reputed, for insecticidal activity may now possess true insecticidal but principles positively posses antifeedant property.

Quadri had studied the behavioral and physiological approaches to control insect pests and reported that the bioactive component of annonaina from custard apple. Azadirachtin from neem seeds, diallyledisulphide from garlic and clove, caused diuresis to instars nymphs to *Periplaneta americana.* Growth inhibition in *Eemuisana* and rice weevil *(Sitophilus oryzae* L) was caused by neem, garlic, and custard apple. Neem for custard apple and garlic for oleoresin served as synergists against pulse beetle *(C. chinensis),* Jesse grain borer (*R.dominica)* and housefly *(Musca domestica).* Tripathi *et al*. (J990) worked out on a methanolic extract of *Tylophora esthamati*leaves by bioassay leaf disc method for feeding deterrence, using obligua as the test insect. Tylophorine isolated from the extractwas evaluated under the laboratory and greenhouse conditions for its feeding deterrence persistence and systemic properties by using the natural host plant *(Ricinus communis) of* the test insect and crude neem *(Azadirachta indica)seed* extract as a standard. Tylophorine produced complete inhibition of feeding under laboratory conditions and was persistent in the trial, for two days as determined by the damage rating score. However, both tylophorine and the crude neem extract were known to be nonsystemic when tested in Hoagland culture media.

Ahmed and Bhattacharya determined the growth regulating effects of powdered leaves of *neem. Dipalazium esculentum. Parthenium hysterophorus.· Bougainvillea spectibilis. Osmium sanctum* and *Murraya koenigi*mixing into the diets and the impact of different solvent extracts of leaves from the same plants were noticed against *Spilosoma oblique.* Akhauri *et al*., conducted a field trial to test the efficacy of neem off (2%) against the spotted pod borer of pigeon pea. They concluded that neem oil was effective to minimize the damage (27.2 to 18%) and increasing mature pods (64.4 to 85.8 per plant) and grain yield (13.5 to 17.4 per plant) over control 50% extracts. Chavan cited that the neem seeds, leaves, and bark contain several active compounds. Their use has been elaborated and suggested by many solvents of extraction of Azadirachtin technologies. These technologies may prove to less expensive and also solve a major requirement to have solvent and chemical free products. Ketkar and ketkar collected the sample of neem fruits, seeds, kernels, oils and cakes from different parts of India to estimate *Azadirachtin* Venkateswara and Rasaidh studied the botanical insecticides like Neemguard, Repelin and Kernel extract of neem -seed at 5% in field alone and combination with against the pest complex hibiscus Nicotine Sulphate either alone or in combination with carbaryl was equally effective in suppressing the population of Jassids and Aphids.

Bhathal and Singh reported that the feeding deterrent activity of Neemark (80% extract of *Azadirachta indica* water miscible formulation containing *Azadirachtin)* was evaluated against 3rd instars larvae of *Spilosoma oblique (Spilosoma oblique)* by the leaf disc dipping method. The damage within 48 hours of feeding was significantly reduced over the untreated control. The antifeedant activity at the lowest concentration was 0.313% and 86% at the highest concentration.

Tripathi and Singh observed that the methanol extracts of 37 plants in 21 families were tested for antifeedant activity against *Spilosoma oblique*. Antifeedant activity was confirmed in eight plant species by using the leaf disc method as a bioassay Crude neem extract was taken as the standard. Bhatnagar has studied the efficacy of certain indigenous plant extracts against the eggs of maize stem borer *Chilo partellus* Swinhoe and concluded that petroleum ether fractions of Neem were the most toxic and completely inhibited the hatching. The LC_{50} value of both of the extract was 0.03545. Ghatak and Bhusan (1995) tested the ovicidal properties of the crude extracts of indigenous plants - *Azadirachta indica, Acorus calamus. Erythrina indica. Piper nigrum, Thevetia neriifolia, Annona squamosa* and *Pachyrhizus erosus* were evaluated in the laboratory on eggs of *Spilosoma obliqua (Spilarcliaboliqua).* The results revealed that none of the eggs could hatch in treatment with 1.0% methanol and petroleum ether extract of E. *nigrum.* Petroleum ether extracts of *Azadirachtaindica* and *E. indica* at 1.5% and methanol extracts of J. *indica* and *Annona squamosa* at 2.0% and *Azadirachta indica* at 1.5% produced the same result. Shukla *et al.,* found that the Ursolic acid isolated from leaves and stems of *myoporoides* (collected from India) was bioassay for janata feeding deterrence against *Spilosoma obliqe*and *Spodoptera litura*using the leaf disc method. Ursolic acid was a potent antifeedant and produced 90.12 and 91.96 inhibition at 5000 ppm against *S.oblique ; S.ltura* respectively. *Azadirachtin* was used as a standard.

Agarwal and Bhatnagar found that the six commercial neem formulation were tested under laboratory conditions against IIIrd instars larvae of *Achaea janata* Neemgold (2 at 20 mil lit.) exhibited strong antifeeding activity against the tested larvae followed by another neem formulation, fortuneaza*(0.5%* at fivemil/lit). Jagadeesh and Srimananarayana found that extracts of neem fruit, seed, kernels, cake, and oil from fruits, seeds, and kernels (Solvents extract in the laboratory of expeller pressed) have been evaluated for *Azadirachtin* content by HPLC. Salannin and him bin are identified by TLC.

Agnihotri *et al.*, used seeds of Annona emphasized the need for proper harvesting of the biomass of Annona plants part which may serve as a sustainable source for the biomass of Annona plants part which may serve as sustainable source for the supply of raw material for botanical pesticides. It has been shown that powdered stem wood of *R.peciosa* efficiently controls of Lepidopterus pests at 3 to 16-gram alkaloid equivalent per acre which makes it one of the most potent natural product. Insect control properties of Rocaglamide derivatives are worth mentioning as its EC_{50} value (0.08-0.52 ppm) comported well with that of Azadirachtin *(*EC_{50} 04 ppm). Sharma *et al.,*(1999) have reported in case of the antifeedant test against *Spodoptera litura* 5th instars larvae 100% protection was provided only by *Acorus calamus* (AC-l and AC-2 extract at stand 2.5% doses). Pandey and Pandey *et al.,* (2004) described the effect of some plant against Radish Aphid, *Raphanus sativus* (Hemiptera: Aphiliae) and found a very good result for their control.

The mixtures of Neem and Eucalyptus leaf extracts with extracts of other plant species was investigated for efficacy in the management of two major post flowering insect pests (Maruca pod borers and *Clavigralla tomentosicollis* Tal.) of cowpea in the Research Farm of the Institute for Agricultural Research, Hamada Belo University, Zaire, Nigeria. The results revealed that in 2000 and 2001 seasons the mean number of *Maruca vitrata* (F.) was reduced (< 1.0 / flower and /or pod) on plots sprayed with leaf extracts of Neem + Lemongrass, Neem + African curry, Neem + Tomato, Neem + Bitter leaf and Eucalyptus + African Bush tea. Pod sucking bugs (dominated by *C. tomentosicollis*) numbers were suppressed (< 1.5 / plant) on plots treated with leaf extracts of Neem + African curry, Neem + Lemongrass, Neem + Tomato, Neem + Bitter leaf, and Eucalyptus + African Bush tea. Theseextracts mixtures caused great reductions in pod damage per plant and ensured higher grain yield compared with the unsprayed plots during the two years of investigation. The complementary roles played by individual plant species used for the extracts mixtures in reducing pests numbers and increasing grain yields on sprayed plots suggest the future direction of new formulations of Biopesticides in the management of field pests of crops on farms owned by limited resource farmers in low input agriculture characterizing the developing countries.

Abdurrahman experimented to determine the insecticidal activity of essential oils from oregano, *Origanum onites*L. (Lamiales: Lamiaceae), savory, *Satureja thymbra*L. (Lamiales: Lamiaceae), and myrtle, *Myrtus communis* L. (Rosales: Myrtaceae) against three stored-product insects. Essential oils from three species of plants were obtained by Clevenger-type water distillation. The major compounds in these essential oils were identified using gas chromatography-mass spectrometry, and their insecticidal activity was tested against adults of the Mediterranean flour moth *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae), the Indian meal *moth Plodia interpunctella* Hubner (Lepidoptera: Pyralidae) and the bean weevil *Acanthoscelides obtectus.* While the major compound found in oregano and savory was carvacrol, the main constituent of the myrtle was linalool. Among the tested insects, *A. Obtectus* was the most tolerant species of the essential oils. However, the insecticidal activity of the myrtle oil was more pronounced than other oils tested against *A. Obtectus* adults. The essential oils of oregano and savory were highly effective against *P. Interpunctella* and *E. kuehniella*, with 100% mortality obtained after 24 h at 9 and 25 µl/l airs for *P. Interpunctella* and *E. kuehniella*, respectively. LC_{50} and LC_{99} values of each essential oil were estimated for each insect species.

88.Mondal and Ghatak conducted a field trial on ‘Baripada’ variety of cucumber in a replicated Randomized Block Design at Viswavidyalaya Instructional Farm during 2004–05 to find out the impact of plant derived pesticides viz; Neem Azal, Rhizome extracts of *Acorus calamus* with petroleum ether as solvent and seed extracts of *Annona squamosa* with methanol as solvent in controlling *Epilachna* beetle, *Henosepilachna vigintioctopunctata*, Fabr; Both Neem Azal and seed extracts of *Annona squamosa* were used at 4ml, 5ml and 6ml (per Lt. of water) while this was 1ml, 2ml and 3ml (per Lt. of water) in case of petroleum ether extract of rhizome of *Acorus calamus*. Endosulfan 35 EC was used at 1ml, 1.5ml and 2ml (per Lt. of water) to compare the efficacy of plant products. Results of the experiment revealed that Endosulfan 35 EC at 2mL-1 of water performed very well in reducing population build-up of *Henosepilachna vigintioctopunctata*, Fabr. to the extent of 75.00%, while among the botanical pesticides, this was highest (76.37%) in seed extracts of *Annona squamosa* at $3mL^{-1}$ of water followed by 64.00% in Neem Azal at 5mL-1 of water and 57.00% in petroleum ether extracts of the rhizome of *Acorus calamus* at $2mL^{-1}$ of water.

Saroj *et al.*, reported the insecticidal inhibiting growth and anti-feedant properties of hexane, acetone and ethanol extracts of three indigenous herbs of northeastern Thailand (*Anthem graveolens* Linn. *Oroxylum indicum* Linn; and *Polygonum odoratum* Lour.) were investigated on the 2nd instars larvae of tobacco cutworm, *Spodoptera litura* F. The leaf dipping method using various concentrations of extracts; 0.0 (10% Tween-20 as control), 2% (0.29 mg/cm^2), 4% (0.58 mg/cm^2), 6% (0.87 mg/cm^2), 8% (1.16 mg/cm^2) and 10% (1.45 mg/cm^2) were applied. The results showed that the hexane extract of *A. graveolens* and *P. odoratum* were highly effective in controlling tobacco cutworm. Extracts at concentrations of 10% (1.45 mg/cm^2) completely controlled the cutworm within 72 hours and showed the LD50 of 0.29 and 0.33 mg/cm^2 (w/v), respectively. These two extracts were effective at inhibiting the growth of the cutworm larval stage but could not inhibit the growth of pupae developing into an adult. All extracts from the three test plant species had low anti-feedant efficiencies.

Biswas studied the effectiveness of different doses of neem extracts and a synthetic organic insecticide against mustard aphid in the experimental farm of the Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during two consecutive years 2010-2011 and 2011-2012 for the control of mustard aphid. Eight treatments were evaluated against mustard aphid under field condition. The maximum aphid population was (180 percent) observed at pod formation stage of the mustard crop. Among the treatments, Malataf (Malathion 57 EC) @ 2ml/l significantly reduced the highest aphid population (93.75%) over pretreatment which produced the highest seed yield(1440kg/ha) of mustard. The neem leaf extract reduced73-81% aphid population over pretreated plants in both the years. Among the different doses of neem extracts, the highest aphid population reduced over treatment (81%) was recorded from 50 g neem seed per liter of water treated plots with high MBCR (3.88) followed by 75g neem seed/ l treated plots having a reduction of 80% and MBCR 3.78.

Singh *et al*, evaluated seven insecticides viz, acephate 75 @ 350 g, acetamiprid 20 SP @10 g, dimethoate 30 EC @ 300 g, fipronil 5 SC @ 50 g, imidacloprid 17.8 SL @ 20 g, oxy-dematon methyl 25 EC @250 g and thiamethoxam 25 WG @ 25 g a.i/ha in the field against mustard aphid. The plot treated with imidacloprid provided their superiority over other insecticides, which resulted in the maximum mortality of mustard aphid with the highest yield (1963.5 kg/ha). However, remaining insecticides were also found significantly superior to the control. The highest cost-benefit ratio was obtained from imidacloprid (1:3.5) with a record of the maximum monetary benefit of Rs. 29,973.3.

Yadav and Singh evaluated the various treatments for their bio-efficacy against mustard aphid on Indian mustard during 2011-2012 and 2012-2013 at CCS Haryana Agricultural University, Hisar, the spray of Dimethoate 30 EC @ 1ml/l followed by *Verticillium lecani* @ 108 CS/ml was proved to be the best treatment with pooled mean aphid population of 4.5, 3.25 and 1.65 aphid/plant as against 22.0, 24.0 and 26.0 aphids/plant in the control after 3, 7 and 10 days of treatment, respectively. The pooled mean yield was also maximum (1485.0 kg/ha) in this treatment as compared to control (1305.0 kg/ha). The treatment was found on par with spray of dimethoate @ 1 ml/l followed by Coccinella septempunctata @ 5,000 bottles/ha with pooled mean aphid population of 5.0, 4.0 and 2.0 aphids/plant after 3, 7 and 10 days of treatment, respectively and pooled mean seed yield of (1470.0 kg/ha).

But the cost-benefit ratio was maximum (7.25) in treatment dimethoate followed by *C.septempunctata* and NSKE @ 5% followed by *C.septempunctata@* 5,000 beetles /ha (6.68). Thus, entomopathogenic fungi like V. lecanii or NSKE along with the release of *C.septempunctata* can be used as an alternative measure to manage mustard aphid instead of solely relying on insecticides.

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