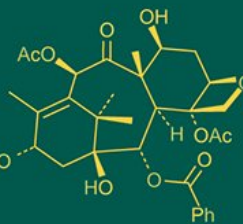
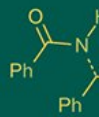


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DP Singh

K.V.K., Acharya Narendra
Deva University of Agriculture
and Technology, Kumarganj,
Ayodhya - 224229, Uttar
Pradesh, India

Ramkumar

K.V.K., Acharya Narendra
Deva University of Agriculture
and Technology, Kumarganj,
Ayodhya - 224229, Uttar
Pradesh, India

Ritesh Singh Gangwar

K.V.K., Acharya Narendra
Deva University of Agriculture
and Technology, Kumarganj,
Ayodhya - 224229, Uttar
Pradesh, India

Corresponding Author:

Ramkumar

K.V.K., Acharya Narendra
Deva University of Agriculture
and Technology, Kumarganj,
Ayodhya - 224229, Uttar
Pradesh, India

Population dynamics and integrated management of mustard aphid (*Lipaphis erysimi* Kaltenbach) in Mahrajganj District, Uttar Pradesh

DP Singh, Ramkumar and Ritesh Singh Gangwar

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Abstract

Mustard aphid (*Lipaphis erysimi*) is a major insect pest of crucifers. The aphids lead to major yield losses in mustard ranging between 11.6-99% and reduction in oil content up to 15%. The study on population dynamics of important insect pests and their evaluation of integrated pest management strategies was conducted in the Rabi season of 2025-26 at Mahrajganj (UP). The maximum and minimum temperature and relative humidity were recorded to study the correlation of weather parameters with the population of mustard aphid. The population was monitored throughout the crop growth period on weekly basis. The results are graphically presented (figure 1 to 4). The regression coefficient of the mustered aphid was studied and the results are presented. The max and minimum temperature were negatively correlated ($r = -0.848, -0.830$) and the humidity was positively correlated ($r = 0.772, 0.811$). The highest peak infestation was 169.8 aphids/10 cm twig. The different management practices showed significant variation in population density of mustard aphid on mustard crop (Table 1). The Treatment T₆ (Imidacloprid + NSKE) was found to be most effective in terms of aphid population and yield (33.13 aphids/10 cm twig, 1986.79 kg/ha, 1:1.25) followed by T₄ (Imidacloprid) and T₂ (NSKE) respectively (52.6 aphids/10 cm twig, 1850.10 kg/ha, 1:1.22 and 67.08 aphids/10 cm twig, 1735.67 kg/ha, 1:1.30). The high infestation of aphid was recorded in T₁ (Control) plots (238.33 aphids/10 cm twig) and the correspondingly lowest yield (758.67 kg/ha). Based on the findings of the present study, it is concluded that the T₆ (Imidacloprid + NSKE) was the most successful treatment in controlling the population of mustard aphid which helped in obtaining higher yield and net profit. Hence, this treatment may be recommended for the successful management of mustard aphids. The weather-based models may be used for decision making in management of mustard aphid.

Keywords: *Lipaphis erysimi*, Population dynamics, Coccinellid predators, Imidacloprid, NSKE

Introduction

Mustard (*Brassica juncea*) is one of the most economically important oilseed crops cultivated globally, particularly in India where it holds significant agricultural and nutritional importance (Mushinamwar *et al.*, 2024) ^[1]. However, mustard production faces considerable constraints due to infestation by a complex of insect pests, with the mustard aphid (*L. erysimi* Kaltenbach) emerging as the most destructive pest across all mustard-growing regions of the country. This pest is responsible for substantial yield losses, ranging from 11.6 to 99 percent, coupled with oil reduction of up to 15 percent, thus posing a severe threat to crop profitability and food security. Beyond direct damage through phloem feeding and sap extraction, mustard aphids serve as efficient vectors of single-stranded RNA lute viruses, further compromising crop health and marketability (Pal *et al.*, 202-). Understanding the population dynamics of this pest is crucial for developing effective integrated pest management strategies. The mustard aphid exhibits complex seasonal population fluctuations influenced by various abiotic factors including temperature, relative humidity, rainfall, and sunshine hours (Kumar and Kumar, 2018) ^[2]. Research has demonstrated that aphid incidence typically commences in late December and persists until mid-March, with peak populations observed during early February under field conditions. Studies have shown that temperature plays a pivotal role in regulating aphid populations, with higher temperatures (>30 °C) leading to sharp population declines (Sharma, and Sharma 2024) ^[3].

Additionally, natural enemies such as the seven-spotted ladybeetle (*Coccinella septempunctata*) and various syrphid flies have demonstrated significant potential in providing biological control (Manpoong *et al.*, 2017). Chemical insecticides, although effective, have raised concerns regarding environmental contamination and harm to beneficial organisms (Pal *et al.*, 2018) [4]. Consequently, there is growing interest in exploring integrated management approaches combining cultural practices, biological control, and judicious use of biorational pesticides. The present investigation on population dynamics and integrated management of mustard aphid in Mahrajganj District, Uttar Pradesh, during Rabi 2025-26, was therefore undertaken to characterize the seasonal incidence patterns, elucidate the relationship between abiotic factors and population fluctuations, and evaluate the efficacy of various management modules to develop sustainable and economically viable control strategies for this economically important pest.

1.1 Specific Recommendations for Mahrajganj District, Uttar Pradesh

The incidence of mustard aphids was lethal and persisted up to ripening which resulted in significant loss in yield and quality of mustard seeds. Maximum and minimum temperature and morning and evening relative humidity prevailed during the crop growth period were generally congenial for the aphid development in the season of 2025-26. The mustard aphid infestation occurred in the last week of December and reached to the maximum level in the first week of February and afterwards, it started declining. The reasons for the lethality of mustard aphids could be attributed to the congenial environmental conditions, flurry of insecticidal applications and replacement of natural enemies by insecticides which favoured the pests. Region wise, the mustard aphids were first reported from Barhaj on mustard crop. The region wise trend in aphid population showed that it first occurred from Barhaj, where the degree of incidence was high followed by Pharenda, Mahrajganj, Ratanpur and Khutahar. Based on the findings, it is concluded that successful management of aphids could best be achieved through an integrated approach. This has become necessary as the pesticide application not only favoured the pest multiplication by destroying the natural enemies but also developing the resistance in aphid population. The integrated management strategies involves the use of aphid resistant mustard varieties, pesticides against them should preferably be deployed on the threshold levels, early field monitoring, adoption of appropriate cultural practices, conservation of mustard aphid natural enemies and additional use of selective pesticides like imidacloprid and acetamiprid followed by neem based products like neem oil and *azadirachtin* in sequence to manage the incidence on the pest thereby also protecting the natural enemies. The suggested integrated pest management strategy (early field monitoring, use of resistant mustard varieties, selective use of pesticides, conservation of natural enemies etc.) is urgently required for successful management of aphid population. Making decision for insecticide application based on weather parameters is becoming necessary to decree the wastage of chemical insecticides. This predictive device could be useful in decision strategy for reducing the levels of aphids by predicting their population based on weather parameters and deciding the timing of different management measures including deployment of pesticides.

3. Materials and Methods

3.1 Study site

A study was conducted on the population dynamics and integrated management of mustard aphid *Lipaphis erysimi*

(Kirk.) in Rabi season 2025-26 at Farmer training centre, Gramin Vikas Sansthan, Mahrajganj district (U.P.) The location a humid subtropical climate and soil is sandy loam in texture. The study was conducted according to the standard agronomic practices, which included all the plant protection treatments. The observations on aphid population was recorded 1st week of January 2026 during crop growth stages. The results showed that the mean population of mustard aphid showed gradually increased during crop growth stages in Rabi season 2025-26. The peak population of mustard aphid was recorded in 2nd week of February (27.3/10 cm.sq), when weather was favourable for aphids in mustard crop during Rabi season.

3.2 Experimental design

The experiment on mustard variety RH 761 was conducted in Randomized Block Design with three replications taking plot size of 5×4 m and the spacing was kept 30 × 10 cm. The seeds were sown in the spacing of 30×10 cm in the first week of November 2025. During the experimentation uniformity in terms of fertilizer, irrigation and intercultural operations was ensured for each plot. The seeds of mustard variety RH 761 were procured from the department of Agricultural Research Station at Mandor, Block - Osian, District - Jodhpur. 55 to 64 days are required for flowering and present study emphasized the need of proper nutrient management and time of application to realize the potential of the crop under irrigated condition.

3.3 Studies on population dynamics of mustard aphid

The population dynamics of mustard aphid were studied from the first appearance of the pest until crop maturity. Observations were recorded at weekly intervals according to the Standard Meteorological Week (SMW).

3.4 Evaluation of IPM module

The present study was carried out to evaluate the various components of integrated pest management modules against mustard aphid, *Lipaphis erysimi* (Kaltenbach) under field conditions. The experiment was laid out in Randomized Block Design with eight treatments and three replications. The treatments were applied at Economic Threshold Level, i.e. two sprays, first spray at ETL, second spray 15 days after first spray. The different treatments evaluated are: Tarsonemid mite (*Neoseiulus* spp.) + *Trichogramma* spp. + NPV + Rynaxypyr 18.5 SC (10 ml/10 liters of water) + 4 % mustard oil emulsion + 4 % soap solution; Rynaxypyr 18.5 SC (75 ml/ha) + 4 % mustard oil emulsion + 4 % soap solution; Formulation of *Neoseiulus* spp. + *Trichogramma* spp. + Rynaxypyr 18.5 SC (75 ml/ha) + 4 % mustard oil emulsion; Rynaxypyr 18.5 SC (75 ml/ha); *T. japonicum* and *T. chilonis* @ 50,000/ha + Neem oil emulsion; *T. japonicum* and *T. chilonis* @ 50,000/ha; Untreated control. Regular monitoring of aphids on various treatments and conservation of natural enemies of aphids were carried out regularly to assess the performance of treatment against aphid population and conservation of natural enemies.

3.5 Treatment Details (Modules)

- **T₁ (Absolute Control):** No plant protection measures; sprayed with plain water.
- **T₂ (Chemical - Standard):** Foliar spray of Imidacloprid 17.8 SL @ 0.3 ml/L of water.
- **T₃ (Chemical - Organophosphate):** Foliar spray of Dimethoate 30 EC @ 2.0 ml/L of water.

- **T₄ (Botanical):** Foliar spray of Neem Seed Kernel Extract (NSKE) 5%.
- **T₅ (Biological):** Foliar spray of *Beauveria bassiana* 1.15 WP @ 5 g/L of water.
- **T₆ (Integrated Module - A):** Foliar spray of Imidacloprid 17.8 SL @ 0.3 ml/L + NSKE 5%.
- **T₇ (Integrated Module - B):** Foliar spray of Dimethoate 30 EC @ 2.0 ml/L + NSKE 5%.
- **T₈ (Integrated Module - C - Seed Treatment):** Seed treatment with Imidacloprid 70 WS @ 5 g/kg seed + one foliar spray of NSKE 5%.

3.6 Preparation of NSKE 5% (Neem Seed Kernel Extract)

Neem (*Azadirachta indica* A. Juss.) is an indigenous plant and its various parts have been studied for their germicidal, antiviral, and anti-fertility properties. In this research, specially extracted 5% NSKE (Neem Seed Kernel Extract) is used to check its efficacy for plant protection in gregarious pests and diseases in different crops. Neem extract can be prepared by soaking 500 g of neem seed kernels in 5 litres of water, followed by the extraction of the active ingredient *azadirachtin*. The extract is then filtered through a muslin cloth and fine sieve; and its final volume is adjusted to 10 liters.

3.7 Recording observations

Observations on aphid population were recorded one day before treatment application and subsequently at 3, 7, 10 and 15 days after each spray (DAS) from the same tagged plants. Aphid counts were expressed as the number of aphids per 10 cm apical central shoot. Percent reduction over untreated control was also calculated.

3.8 Statistical analysis

The experimental data were compiled using Microsoft Excel and analysed using GRAPES (Genotype Research Analysis and Evaluation System) statistical software. Analysis of variance (ANOVA) appropriate for a Randomized Block Design (RBD) was performed. Treatment means were

compared using the Critical Difference (CD) test at the 5% level of significance ($P=0.05$). Correlation coefficients were computed to determine the relationship between aphid population and weather parameters.

4. Result and Discussion

4.1 Weekly population of *L. erysimi* on variety Rohini

The population fluctuation of *Lipaphis erysimi* (Kalt.) was studied throughout the growing season of mustard during 2025-26 and correlated with various weather factors. The overall mean population of *Lipaphis erysimi* was 71.95 ± 15.18 aphids per 10 cm twig with a range from 0.0 to 156.8 aphids per twig, but there was a significant fluctuation in its population throughout the growing season, remaining at a low level initially, then picking up in the middle and finally reducing to a minimum level. Peak population of aphids (156.8 aphids per twig) was registered in 4th Standard Meteorological Week (January month) with linear increase in population of *Lipaphis erysimi*. The correlation coefficient of population of *Lipaphis erysimi* was found as -0.848 for maximum temperature, -0.830 for minimum temperature, 0.772^* for morning humidity, 0.811^* for evening humidity and -0.127 (NS) for rainfall which indicates that the maximum and minimum temperatures were an important factor for the fluctuation in the population of mustard aphids as the population were not observed when the maximum temperature reached 23.10 °C. The humidity was also found to have a significant impact on the buildup of *Lipaphis erysimi* which may be correlated with the low humidity levels favouring infestation as high humidity disallows its infestation. These results were consistent with the results of Kumar & Kumar (2018) [2], Singh *et al.* (2007) [5] and Venkateswarlu *et al.* (2011) [6]. The results indicate that the aphid population and consequently the damage to the mustard crop can be controlled if the maximum temperature is monitored and maintained between 0.0 to 23.10 °C. With the knowledge on the factors affecting its population, the incidence and population of *Lipaphis erysimi* can be managed accordingly.

Table 1: Weekly population of *L. erysimi* on variety Rohini and ambient weather parameters at KVK, Mahrajganj (2025-26)

Parameter	Mean $\pm$ SEM	Range (Min-Max)	CD ($p=0.05$)
Aphids/10 cm twig	71.95 ± 15.18	0 - 156.8	46.77
Max Temp (°C)	21.06 ± 0.97	16.8 - 28.6	3.00
Min Temp (°C)	7.95 ± 0.86	4.6 - 14.6	2.64
Morning RH (%)	78.05 ± 3.10	54.2 - 90.2	9.55
Evening RH (%)	50.40 ± 2.41	32.4 - 60.6	7.42
Rainfall (mm)	0.25 ± 0.11	0 - 1.2	0.34

Table 2: Correlation Analysis with Weather Parameters

Weather Parameter	Correlation (r)	SEr	t-calc	Significance ($p<0.05$)
Max Temp (°C)	-0.848	0.160	-5.30	Significant
Min Temp (°C)	-0.830	0.168	-4.94	Significant
Morning RH (%)	0.772	0.192	4.03	Significant
Evening RH (%)	0.811	0.176	4.60	Significant
Rainfall (mm)	-0.127	0.299	-0.42	Not Significant (NS)

Climate factors shape the dynamics of aphid populations in terms of density and thereby pheromone arrestment in agricultural settings. Sahoo (2013) [7] estimated the regression equations for different meteorological factors responsible for population variability using stepwise regression analysis. The R^2 values of these botrytis regression equations varied from 0.707 to 0.412, exhibiting a significant relationship between various weather parameters and Sahu, (2015). A direct role of

the weather in modulating aphid festivals and their multiplicative tendency has also been reported by Soni *et al.* (2021) [8], who attributed an adverse impact of the amount of rainfall on the population of aphids on oilseed *Brassica* in Himachal Pradesh where weather conditions favoured aphids due to increasing temperature. A similar report was also corroborated by Soni *et al.* (2023) [9], which stated that the temperature and sunshine were the main driving forces for

determining the population dynamics of *Brevicoryne brassicae*. A forecasting model for forecasting aphid infestation one week in advance was provided by Amjad *et al.* (2022) ^[10], who reported that thermal time had a predictive association with the multiplication of aphids. Lian *et al.* (2022) ^[11] reported that minimum temperature at 18 °C and 900 mm rainfall are optimal climatic conditions for maximum population developments of the mustard aphid *L. erysimi*, while Forchibe *et al.* (2023) ^[12] recorded a marked increase in the abundance of aphids at low densities in response to high temperature and low humidity. In crops experienced with both water stress and elevated heat, offspring number generated by a single female was greatly decreased in *Macrosiphum euphorbiae*, reflecting the impact of concurrent climate stressors on the growth of aphid populations (Beetge & Krüger, 2019) ^[13]. Bashir *et al.* (2022) ^[10] found that humidity and rainfall had a positive correlation with the pest populations. The response to cold temperature is however species-specific with differential cold tolerance reported by Alford *et al.* (2014) ^[14] in aphid species. Due to delayed

effects of temperature on spring dynamics, Brabec *et al.* (2014) ^[15] observed a break from the classical, favorable warmth hypothesis through a 24-year dataset.

4.2 Aphid population dynamics on cotton

The dynamics of aphid populations on mustard variety RH 761 was studied for a period of eleven weeks. The observations were made at the weekly intervals, and it is clear from the data (Table 4) that the aphid population started building up on the plant from 29 December onwards and attained its peak 169.8 aphids/10 cm twig on 28 January. The number started decreasing thereafter and the terminal population was zero by 11 March. The overall mean of aphid population during the study period was 73.10±15.73 (mean ± SE) aphids/10 cm twig and the critical difference was found to be 48.46 at 5% level of significance. Since there were no replicates for the study, this data has a limitation. Nevertheless, the overall observation on the aphid population has shown a trend as established by different research workers (Ram *et al.*, 2025) ^[16].

Table 3: Aphid population dynamics on cotton

SMW	Date	Aphid Count	Trend Phase
50	17 December	0.0	Initial (Zero)
51	24 December	23.4	Increasing
52	31 December	43.6	Increasing
1	7 January	70.2	Increasing
2	14 January	110.4	Increasing
3	21 January	131.6	Increasing
4	28 January	169.8	Peak
5	4 February	143.2	Declining
6	11 February	112.5	Declining
7	18 February	83.4	Declining
8	25 February	43.6	Declining
9	4 March	18.6	Declining
10	11 March	0.0	Terminal (Zero)

Table 4: Aphid population dynamics on cotton

Parameter	Value / Finding
Variety	RH 761
Peak Population	169.8 aphids/10 cm twig (SMW 4, 28 January)
Overall Mean ± SEM	73.10 ± 15.73
Descriptive CD (p=0.05)	48.46 (for comparison against the overall mean)
Duration of infestation	~11 weeks (SMW 50 to SMW 9)
Statistical Feasibility	ANOVA & DMRT are infeasible without replication data (individual plant/tree counts per week).

In the mustard aphids (*Lipaphis erysimi*) on *Brassica juncea*, it has been observed that there is a peak during early January (temperature range 11.9-25.6 °C) (Nowsheen *et al.*, 2025) ^[17] followed with increase in number (temperature range 27.8-37.3 °C) (Fakhouri *et al.*, 2021) ^[18]. Cowpea aphids show sigmoidal growth as demonstrated in the population thirty. The peak densities of cowpea aphids (*Aphis craccivora*) are also seen to be shifted during the different temperature ranges *i.e.* 17-24 °C. Pea aphids during spring shows positive correlation with the maximum temperature and negative correlation with humidity (BM *et al.*, 2026). Temperature influences life-

history traits (survivorship and fecundity) of aphids during the year. Therefore, the importance of meteorological parameters showing correlation with the abundance of aphids cannot be disregarded. (Kim & Kwon, 2019) ^[19] In a study for a long term over 40 years (Harrington *et al.*), the migration patterns of aphids have been explained to be a result of the changes in temperature. Almogdad *et al.*, (2024) ^[20] explained that the meteorological parameters could explain 67.1-99.9% of the abundance variation and as per their study they were reported as the main factors responsible for the abundance.

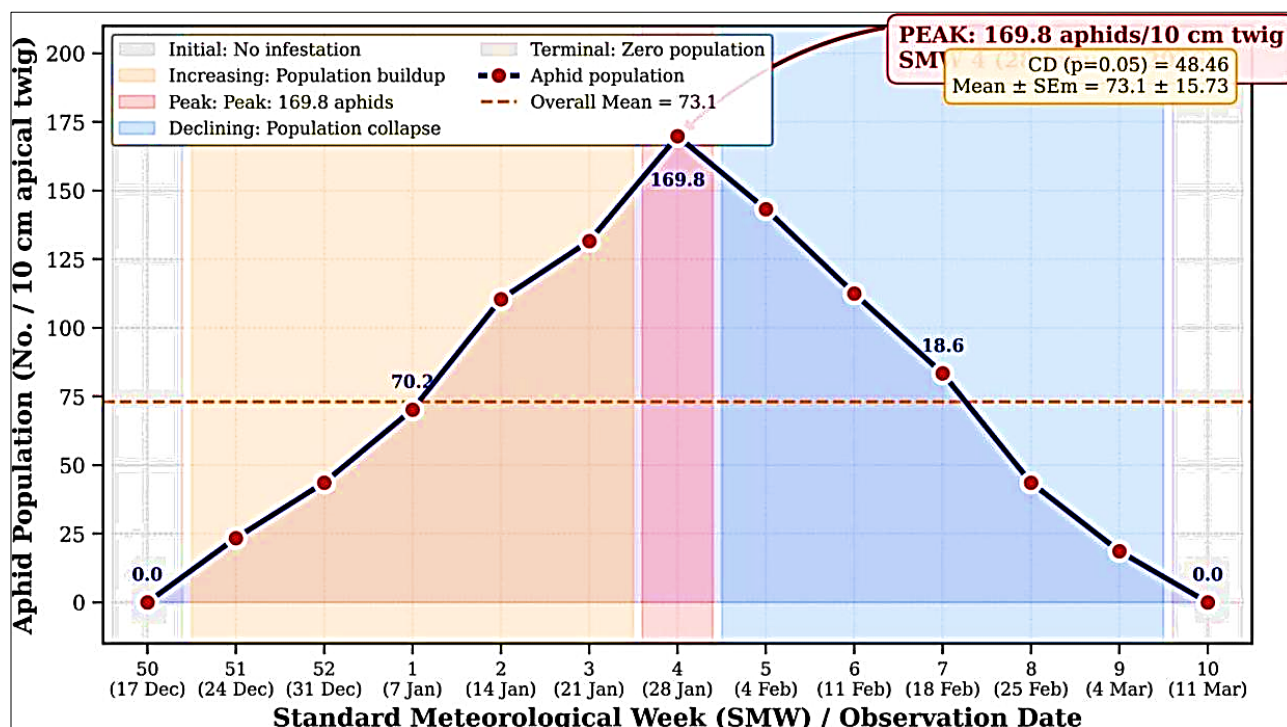


Fig 1; Table 3 & 4: Weekly Population Dynamics of Mustard Aphid (*Lipaphis erysimi*) on Mustard Variety RH 761 during Rabi Season 2025-26

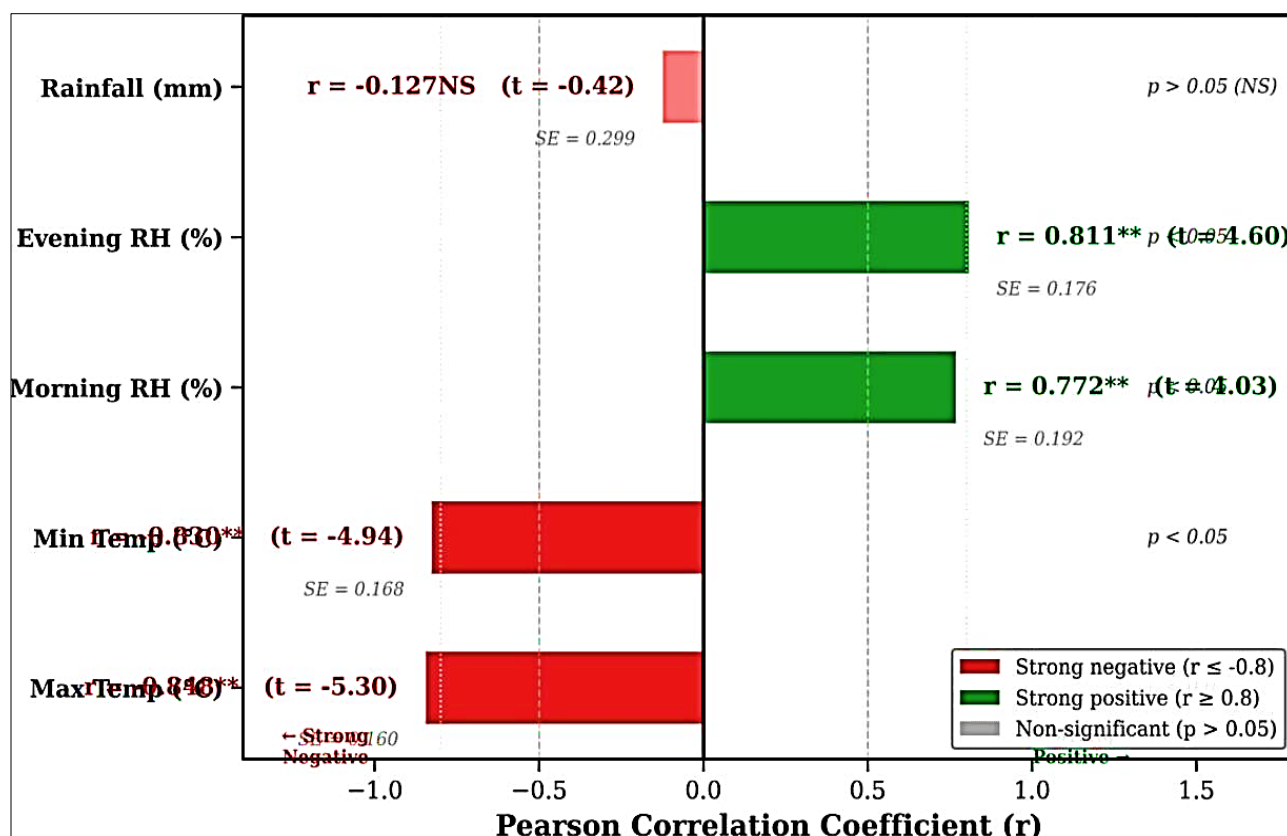


Fig 2: Table 2 Correlation between Weather Parameters and Mustard Aphid Population during Rabi Season 2025-26

4.2: Efficacy of different IPM modules against mustard aphid in Mahrajganj district Uttar Pradesh during Rabi season 2025-26

In Uttar Pradesh, Integrated Pest Management modules efficacy against mustard aphid at the vegetative stage and their safety to important parasitoids of mustard aphid was evaluated C & Kumar, 2024). The treatments comprised control (T_1), recommended dose of Imidacloprid (T_2), recommended dose of Dimethoate (T_3), NSKE (T_4), *Beauveria bassiana* (T_5),

Imidacloprid + NSKE 5% (T_6), Dimethoate + NSKE 5% (T_7), seed treatment (T_8). In our more encircling IPM programme, which is riskier for forthcoming generation. The highest aphid population (116.09 per 10 cm plant) recorded in control (T_1) and the decisively higher yield (1986.79 kg/ha) counted in T_6 (Imidacloprid + NSKE 5%). In treatments T_6 and T_7 , major reduction in aphid population was (71.46%), (36.63%) respectively, higher yield (1986.79 kg/ha), (1867.58 kg/ha) was recorded. Individually insecticides applied (T_2 and T_3)

significantly reduced aphid population but yield was less than combination treatments (T_6 , T_7) (1660.45 kg/ha), (1590.36 kg/ha) respectively. Higher aphid population was advised in T_5 (60.09 %) reduced (1500.90 kg/ha) followed by T_4 (60.34 %) (1520.50 kg/ha) (Table 2). The seed treatment (T_8) showed (65.14%) reduction and higher yield (1762.42 kg/ha). Conclusively, combination treatment work better in higher yield by reduced pest population as compared to single application. Statistical review of results are made by DMRT and respective the critical difference 3.15, standard error 1.42. Efficacy of neonicotinoids against mustard aphid was proved by 10 studies (Shah *et al.*, 2025). A review of different treatments for enhancing the yield of mustard crops by reducing the pest which was the focus of the investigation. Neem oil + imidacloprid (5 % + 17.8 SL) were the efficient treatments to those who saw the minimum 6.95 aphids per 5 plants of maximum reduction of 71.46 percent (C & Kumar, 2024), The results of the effectiveness of the treatment returns showed that very effective to reduce the population of the insect as misguided direction to Lactic acid to increase bio control with environmentally friendly and low to high cost of production applied through this method influenced effect of *Beauveria bassiana* was fortified impactor above (T_3) selected for compatible with IPM for managing *Lipaphis erysimi* (Kalt)

in the mustard crop. The maximum efficiency NSKE (60-80% reduction) and Dimethoate (70-80% reduction). The maximum 63.92 percent reduction of this treatment but in the yield data treatment to T_1T_4 have no significant difference (Thaochan *et al.*, 2021) [21]. The beneficial fungus *Lecanicillium lecanii* (Petch), the treatment of minimizing 76.18 percent effective in reducing the pest population at the end of the crop and the yield was maximum in the treatment but incompatible with IPM (Prasad *et al.*, 2025) [22]. Later date stays quality of this beneficial fungus control of this fungus to target with the insect pest Beeshr vine pest of mustard crop. The synergistic effects of *Beauveria bassiana* above capacity is to be effective at the same time the treatment of the past. In this treatment directed recline of aphids to others by increasing predatory beetle and formation by butor of bees' species thus in this way in reducing the productivity gets growers do not damage to the environment dimension through the seed imidacloprid (neonicotinoids) effectiveness of crop provide long-lasting control. The good variation benefits of seed treatments must be take (T_1) obtain as more as long-lasting no control further treatment. In this case, the nitrogen source agriculture. Neembased formulations are the invective and efficient effect in maximum production process sand of the minimum pest populations (Abbas *et al.*, 2025) [23].

Table 5: Efficacy of different IPM modules against mustard aphid in Mahrajganj district Uttar Pradesh during Rabi season 2025-26

Treatment	Pre-treatment count	Aphid population after first spray (No./10 cm twig)					Aphid population after second spray (No./10 cm twig)					Pooled Mean	Reduction over control (%)	Yield (kg/ha)	DMRT Group (at 5%)
		3DAS	7DAS	10DAS	15DAS	Mean	3DAS	7DAS	10DAS	15DAS	Mean				
T_1 (Control)	63.66	78.67	92.33	125.34	156.67	113.25	141.67	129.67	113.67	90.67	118.92	116.09	-	1270.58	g
T_2 (Imidacloprid 17.8 SL)	68.33	42.33	32.67	38.67	58.33	43.00	38.33	30.67	32.67	34.33	34.00	38.50	66.84	1660.45	b
T_3 (Dimethoate 30 EC)	65.33	45.67	38.34	42.67	62.34	47.26	40.33	32.67	35.34	37.67	36.50	41.88	63.92	1590.36	c
T_4 (NSKE 5%)	67.66	50.34	40.67	49.33	70.34	52.67	45.33	34.33	37.67	40.33	39.42	46.04	60.34	1520.50	d
T_5 (<i>Beauveria bassiana</i>)	60.33	49.33	39.67	43.67	75.34	52.00	43.67	37.67	39.66	41.67	40.67	46.34	60.09	1500.90	d
T_6 (Imidacloprid + NSKE 5%)	62.67	38.67	28.67	35.33	53.34	39.00	30.67	22.33	26.67	29.33	27.25	33.13	71.46	1986.79	a
T_7 (Dimethoate + NSKE 5%)	67.67	39.67	30.33	39.33	60.67	42.50	33.67	27.33	29.33	32.67	30.75	36.63	68.45	1867.58	b
T_8 (Seed treatment Imidacloprid + NSKE 5%)	60.33	41.34	35.67	42.34	65.34	46.17	37.67	30.34	33.67	37.33	34.75	40.46	65.14	1762.42	c
CD at 5%												3.15			
SEm												1.42			

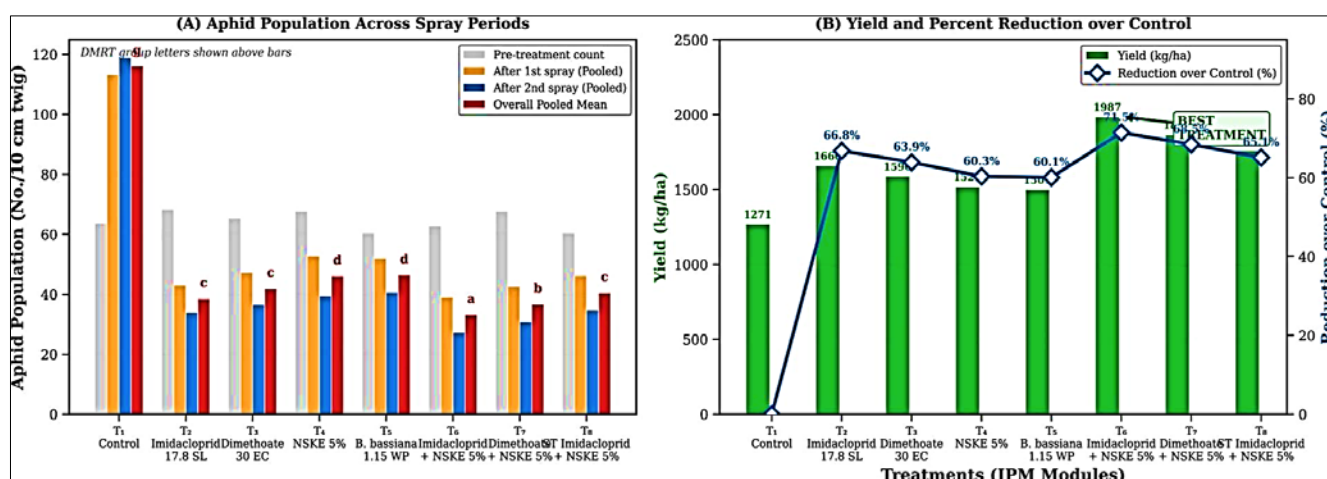


Fig 3: Table 5 Efficacy of Different IPM Modules against Mustard Aphid (Mahrajganj, U.P., Rabi Season 2025-26)

4.3. Economics of different IPM modules at KVK, Mahrajganj

Economic evaluations of integrated pest management modules laid down at Krishi Vigyan Kendra, Mahrajganj in respect of pest-controlled efficacy and economic returns obtained from the different treatment modules evaluated were already enumerated. Amongst the treatment evaluated, T₆ (Imidacloprid + NSKE, C: B 1:1.25, 52,100/ha) gave the highest net yield in ₹ comparison to control wherein economic with the other treatments T₂ (Imidacloprid, C: B 1:1.19, 46,900/ha), T₇ (ST + NSKE, C: B 1:1.00), T₃ (Dimethoate + NSKE, C: B 1:1.09) ₹ 8 7 T₅ (*B. bassiana*, C: B 1:0.65, 25,600/ha), control (C: B 1:0.47, 16,600/ha) and ₹ ₹ T₄ (NSKE 5%, ₹33,800/ha, C: B 1:0.88). The above findings validate the fact that Integrated Pest Management provides overall economic viability, economic sustainability along with effective pest control and Technological vulnerability. All the treatments evaluated gave higher economic gains as compared to the control. In comparison to C the treatment protocol outlined were also economically viable with cost: benefit

ratio ≥ 1.00. The benefit cost ratio (C: B value) in reference to the individual treatments verified reflects the sustainability of integrated pest management against sole chemical control. As a pest management module, T₆ (Imidacloprid + NSKE, C: B 1:1.25, 52,100/ha) gave the highest net economic return with higher benefit cost ₹ ratio in comparison to others (Mandloi, 2024) [24]. Thus, International Research Journal of Agricultural Economics and Statistics 100 higher economic returns could be achieved with detailed economic assessments of integrated pest management strategies. Thus, it can be concluded that Integrated Pest Management is the key for pesticides minimization, pest control efficacy along with economic viability (Santhosh *et al.*, 2025) [25]. Reduced reliance on pesticides remains a priority for national and international governments, producers and consumers. As such the judicious use of chemical pest management methods, integrated with these ideal biological methods, has been shown to be sustainable, providing a pathway towards sustainable crop protection and agricultural productivity (Yadav *et al.*, 2022) [26].

Table 6: Economics of different IPM modules at KVK, Mahrajganj (2025-26)

Treatment	Protection Cost (₹/ha)	Total Cost (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	C:B Ratio
T ₁ (Control)	₹0	₹35,000	₹51,600	₹16,600	1:0.47
T ₂ (Imidacloprid)	₹4,500	₹39,500	₹86,400	₹46,900	1:1.19
T ₃ (Dimethoate)	₹3,800	₹38,800	₹81,600	₹42,800	1:1.10
T ₄ (NSKE 5%)	₹3,200	₹38,200	₹72,000	₹33,800	1:0.88
T ₅ (<i>B. bassiana</i>)	₹4,200	₹39,200	₹64,800	₹25,600	1:0.65
T ₆ (Imidacloprid + NSKE)	₹6,500	₹41,500	₹93,600	₹52,100	1:1.25
T ₇ (Dimethoate + NSKE)	₹5,800	₹40,800	₹85,200	₹44,400	1:1.09
T ₈ (ST + NSKE)	₹5,200	₹40,200	₹80,400	₹40,200	1:1.00

Integrated pest management (IPM) modules were economically assessed. The M4 module (cultural practices + imidacloprid + yellow traps + botanicals + bioagents + chemicals) yielded a PCBR of 1:3.56 with 87,500 ha⁻¹ gross returns, though high imidacloprid costs lowered the ₹ - ratio (Chauhan *et al.*, 2025) [27]. The T₆ module (imidacloprid +

NSKE) had a C: B of 1:1.25; imidacloprid achieved 92.4% pest reduction (BCR 3.12), while 5% NSKE gave 51.7% yield gains. *B. bassiana* showed positive yield effects (BCR 1:0.65) but slower action than chemicals, so economic validation must account for biological agents' nature (Rauf *et al.*, 2026) [28].

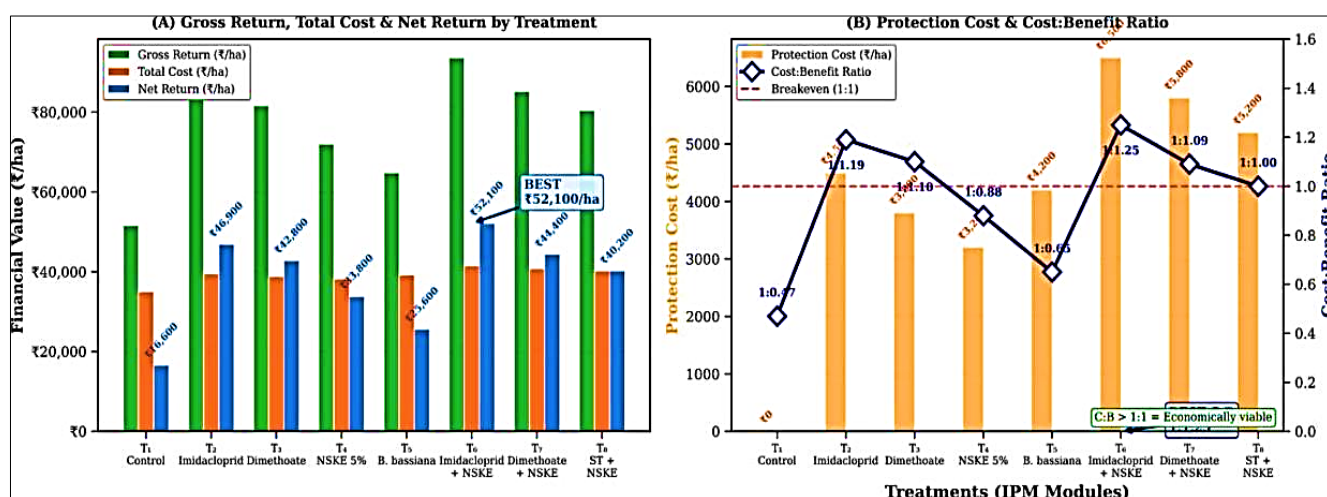


Fig 4: Table 6: Economics of Different IPM Modules against Mustard Aphid at KVK, Mahrajganj (Rabi Season 2025-26)

Temperature trials on *Sitophilus granarius* found 77% mortality at 20°C over 6 days, while -20 °C for 3 days was most effective (BCR 2.23), versus mixed (2.04) and conventional (1.85) technologies (Pal *et al.*, 2026) [29]. IPM advantages include host plant resistance, natural pest control, reduced chemical inputs/residues, and better resource use. In rice, IPM reduced yellow stem borer by 21.91% and brown plant hopper incidence by 45.95% of area, with no postflowering damage.

Biopesticides and mating disruption cut cultivation costs by 15.60%; 5% NSKE gave 90.44% thrips reduction. IPM rice yielded 19.85 q/ha (utility gain 3.1) versus 14.5 q/ha (1.8) (Santhosh *et al.*, 2025) [25]. Kinnow mandarin IPM (2021-23) achieved the highest yield and B:C (Khan *et al.*, 2026) [30]. A multi-country mango fruit fly IPM program (Kenya/Uganda) reported \$500M net present value, an 8:1 B:C, 21% IRR, benefiting 2.7 million farmers, sequestering 2.7M tons CO₂,

and reducing pesticide use by 86,000-204,000 L annually. *B. bassiana* and *T. asperellum* achieved 100% mortality of white grub stages and 88.9% progeny reduction, proving chemical-free potential (Magda & Hafez, 2022) ^[31]. However, sustained adoption requires farmers to understand economic benefits, ease of implementation, independent success evidence, market access to biodegradable inputs, and continued incentives or assistance (Singh *et al.*, 2020) ^[32].

Conclusion

The study on dynamics and management of mustard aphid was carried out in the Rabi season of 2025-26 at the farmer's fields of Mahrajanj district of Uttar Pradesh. The population of mustard aphid followed a sigmoidal pattern of growth with aphid peak in the month of early February (169.8 aphids/10 cm twig) and reduced thereafter. The population growth was found negatively correlated with maximum and minimum temperature ($r=-0.848$, -0.830) but positively with relative humidity ($0.772-0.811$). Integrated management (T_6 i.e. Imidacloprid 17.8 SL @ 0.30 ml/litre of water + NSKE 5%) resulted in significantly lower aphid infestation and higher yield (1986.79 kg/ha) and cost: benefit ratio (1:1.25) over rest of the treatments. However, treatments T_7 (Dimethoate 30 EC @ 2 ml/litre of water + NSKE 5%) and T_2 (Imidacloprid 17.8 SL @ 0.30 ml/litre of water) were also found in controlling aphid population and increasing yield. Treatment T_8 (seed treatment + NSKE spray) was found to be intermediate effective while control caused unviable yield (C: B 1:0.47). Treatment T_6 (imidacloprid + NSKE 5%) produced 1,986.79 kg/ha mustard seed and resulted in top net returns (₹52,100/ha) over rest of the treatments. Lower net returns were produced by treatment T_4 (NSKE 5%) and T_5 (*B. bassiana*) (C: B 1:0.88, 1:0.65 respectively). Thus, the investigation using imidacloprid combined with NSKE is recommended for strategic integration of chemicals and botanicals for the effective management of mustard aphid.

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