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ASSESSMENT OF AVOIDABLE SEED YIELD AND OIL CONTENT LOSSES DUE TO THE INSECT PEST COMPLEX IN INDIAN MUSTARD (*Brassica juncea* L.) UNDER MIDDLE GUJARAT CONDITIONS

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ABSTRACT

A field experiment was conducted at Anand Agricultural University, Anand, Gujarat during *rabi* 2024-25 and 2025-26 to quantify the avoidable losses in seed yield and oil content of Indian mustard (cv. GDM 4) caused by the insect pest complex. A protected (insecticide-treated) plot was compared with an unprotected (untreated) plot. Four pests, *viz.*, the mustard aphid, *Lipaphis erysimi* (Kaltenbach), the mustard sawfly, *Athalia lugens proxima* (Klug), the painted bug, *Bagrada hilaris* (Burmeister) and the leaf miner, *Chromatomyia horticola* (Goureau), infested the crop in succession. Pooled over two seasons, the populations of all four pests were significantly higher in the unprotected plot (aphid 1.23 index, sawfly 0.83 larvae/quadrat, painted bug 0.40 bugs/plant and leaf miner 0.79 mines/3 leaves) than in the protected plot (0.29, 0.10, 0.08 and 0.18, respectively). Protection reduced the pest populations in the order sawfly (87.95%) > painted bug (80.00%) > leaf miner (77.22%) > aphid (76.42%). The protected plot produced a significantly higher seed yield (1921 kg/ha) than the unprotected plot (994 kg/ha), giving an avoidable seed yield loss of 927 kg/ha (48.25%) and a 93.26 per cent increase in yield due to protection. The oil content was also significantly higher under protection (37.19%) than without protection (33.99%), an avoidable oil content loss of 8.60 per cent. The insect pest complex, led by the mustard aphid, thus reduced both the quantity and the quality of mustard produce and timely protection was found essential for realising the yield potential of the crop in middle Gujarat.

Key words : Avoidable loss, *Lipaphis erysimi*, Oil content, Pest complex, Protected plot, Seed yield.

Introduction

Indian mustard, *Brassica juncea* (L.) Czern. & Coss., is the most important *rabi* oilseed crop of India and a major source of edible oil for the country. Its productivity, however, remains far below the genetic potential of the improved varieties and the damage caused by insect pests is one of the main reasons for this gap. About three dozen insect species attack the crop from sowing to harvest, but only a few cause economic damage.

Among these, the mustard aphid, *Lipaphis erysimi* (Kaltenbach), is the most serious. It dominates the insect fauna of the mustard ecosystem, forming more than 90 per cent of all insects recorded in the crop (Yadav *et al.*, 2025), and it multiplies rapidly during the flowering and pod-formation stages (Arvind *et al.*, 2024). Seed yield losses due to the aphid alone have been reported from 10.2 to 61.1 per cent across *B. juncea* cultivars (Dhillon *et al.*, 2022) and as high as 80.0 to 97.6 per cent in unmanaged crops (Patel *et al.*, 2004). Besides the aphid, the mustard sawfly, *Athalia lugens proxima* (Klug), the painted bug, *Bagrada hilaris* (Burmeister) and the leaf miner, *Chromatomyia horticola* (Goureau), attack the crop at different growth stages. Together they form a pest complex whose combined effect on yield is greater than that of any single species.

Most loss estimates in mustard deal with the aphid alone (Kumar *et al.*, 2022; Singh *et al.*, 2024), whereas farmers face the whole pest complex in the field. Information on the loss in oil content, which decides the market value of the produce, is also limited (Sharma *et al.*, 2019). In Gujarat, the available estimate of avoidable loss due to the mustard pest complex is about two decades old (Gami *et al.*, 2004), and no recent estimate is available for middle Gujarat, where both the pest spectrum and the varieties grown have changed. Reliable, location-specific loss figures are needed to justify plant protection inputs and to fix research priorities. The present study was, therefore, undertaken to quantify the avoidable losses in seed yield and oil content of mustard due to the insect pest complex under middle Gujarat conditions.

Materials and Methods

Experimental site and crop

The field experiment was conducted at the Research Farm of the Medicinal and Aromatic Plants Research Station, Anand Agricultural University, Anand, Gujarat, India, during *rabi* 2024-25 and 2025-26. The mustard variety Gujarat Dantiwada Mustard 4 (GDM 4) was sown at a spacing of 45 × 15 cm on 14 November 2024 and 17 November 2025 and harvested on 3 March 2025 and 7 March 2026, respectively. The crop was raised following the recommended package of practices, with a fertiliser dose of 50:50:00 kg N:P:K/ha.

Treatments and layout

The experiment was laid out by the large plot sampling technique with two treatments, *viz.*, a protected (insecticide-treated) plot and an unprotected (untreated) plot, each measuring 15 × 15 m. Ten sectors of 1.35 × 1.5 m were marked within each plot and treated as replications. The protected plot received carbofuran 3 CG @ 2000 g a.i./ha at sowing, followed by foliar sprays of chlorpyriphos 20 EC @ 100 g a.i./ha at 40 days after sowing (DAS), quinalphos 25 EC @ 300 g a.i./ha at 60 DAS and thiamethoxam 25 WG @ 20 g a.i./ha at 80 DAS. The unprotected plot received no insecticide during the crop season.

Observations on pest population

Observations were recorded at weekly intervals from one week after sowing till harvest. The aphid population was assessed on five randomly selected plants per sector using a 0-5 aphid index (Patel *et al.*, 1995), where 0 = plant free from aphids; 1 = only a few aphids with very little injury; 2 = small colonies on a few twigs, no curling or yellowing of leaves; 3 = colonies on almost all twigs, stunted growth, curling and yellowing of leaves; 4 = very heavy population on inflorescence, leaves, stem and siliquae; and 5 = complete drying of plants due to heavy infestation. The average aphid index was worked out as:

Average aphid index = $(0N_0 + 1N_1 + 2N_2 + 3N_3 + 4N_4 + 5N_5)$ / Total number of plants observed, where N_0 to N_5 are the numbers of plants in the respective index classes. The sawfly larvae were counted in five randomly placed quadrats (30 × 30 cm) per sector (50 quadrats per plot). The painted bug (nymphs and adults) was counted on five randomly selected plants per sector (50 plants per plot). For the leaf miner, the number of mines was counted on three leaves per plant, one each from the top, middle and lower canopy, of five randomly selected plants per sector (50 plants per plot).

Seed yield, oil content and avoidable loss

The seed yield of each plot was recorded at harvest and converted to kg/ha. The oil content of the seed was estimated by the Soxhlet extraction method (A.O.A.C., 2000), using 5 g of dried, finely ground seed and petroleum ether (40-60°C) as solvent for 6-8 h. The oil content was calculated as (weight of oil extracted / weight of seed sample) × 100. The avoidable loss in seed yield and in oil content was calculated following Khosla (1977) and the increase in yield due to protection following Pradhan (1964):

$$\text{Avoidable loss (\%)} = [(T - U) / T] \times 100$$

$$\text{Increase in yield (\%)} = [(T - U) / U] \times 100$$

where, T and U are the values in the protected and the unprotected plot, respectively. The per cent reduction in pest population due to protection was calculated as $[(U - T) / U] \times 100$, using the retransformed seasonal means.

Statistical analysis

The pest population data were subjected to square root ($\sqrt{x}$) transformation before analysis. The data of each season were analysed with the ten sectors as replications and pooled analysis over the two seasons was carried out to test the effects of treatment, year and their interaction (Panse and Sukhatme, 1985). The means were compared at the 5 per cent level of significance.

Results and Discussion

Population of the insect pest complex

Mustard aphid : The aphid was the most abundant member of the pest complex. Its seasonal mean was significantly higher in the unprotected plot than in the protected plot in both 2024-25 (1.21 *vs* 0.23 index) and 2025-26 (1.25 *vs* 0.36 index) (Table 1). Pooled over the two seasons, the unprotected plot recorded 1.23 index

Table 1 : Population of insect pests, oil content and seed yield of mustard in protected and unprotected plots (*rabi* 2024-25 and 2025-26).

Treatment	Aphid (aphid index)		Sawfly (larvae/ quadrat)		Painted bug (bugs/plant)		Leaf miner (mines/3 leaves)		Oil content (%)		Seed yield (kg/ha)	
Year	**2024-25**	**2025-26**	**2024-25**	**2025-26**	**2024-25**	**2025-26**	**2024-25**	**2025-26**	**2024-25**	**2025-26**	**2024-25**	**2025-26**
Unprotected plot	1.10 (1.21)	1.12 (1.25)	0.87 (0.76)	0.95 (0.90)	0.54 (0.29)	0.71 (0.50)	0.83 (0.69)	0.95 (0.90)	33.65	34.33	1026	962
Protected plot	0.48 (0.23)	0.60 (0.36)	0.25 (0.06)	0.39 (0.15)	0.24 (0.06)	0.32 (0.10)	0.44 (0.19)	0.42 (0.18)	37.10	37.28	2112	1729
S.Em. ±	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.16	0.21	39	23
C.D. (p=0.05)	0.05	0.06	0.05	0.07	0.05	0.04	0.07	0.05	0.47	0.62	117	68
C.V. (%)	7.29	7.98	10.48	11.15	13.80	7.66	11.22	8.72	1.41	1.84	7.96	7.38

Figures in parentheses are retransformed values; those outside are √x transformed values.

against 0.29 index in the protected plot, a reduction of 76.42 per cent (Table 2, Fig. 1). This was the lowest reduction among the four pests, even though the aphid was the most numerous. The aphid reproduces parthenogenetically with overlapping generations, so that colonies rebuild quickly between two sprays (Arvind *et al.*, 2024). The dominance of the aphid in the mustard pest complex agrees with Yadav *et al.* (2025), who found it to form over 90 per cent of the insect fauna of *B. juncea*. Kumar *et al.* (2022) and Dhillon *et al.* (2022) also reported that timely insecticidal protection checks aphid build-up in mustard.

Mustard sawfly : The sawfly appeared early in the season. Its seasonal mean was significantly higher in the unprotected plot in 2024-25 (0.76 *vs* 0.06 larvae/quadrat) and 2025-26 (0.90 *vs* 0.15 larvae/quadrat) (Table 1). The pooled population was 0.83 larvae/quadrat in the unprotected plot against 0.10 in the protected plot, a reduction of 87.95 per cent, the highest among the four pests (Table 2, Fig. 1). The larvae feed openly on the foliage and are therefore easily reached by contact sprays. Aggarwal and Patel (2023) recorded the same pest as active during December at Anand, which coincides with the early crop stage when its damage was suppressed in the present study. Dotasara *et al.* (2022) similarly observed that timely insecticidal application curtails the foliage-feeding pests of Indian mustard.

Painted bug : The painted bug occurred at a lower density than the aphid and the sawfly. The unprotected plot recorded significantly more bugs than the protected plot in 2024-25 (0.29 *vs* 0.06 bugs/plant) and in 2025-26 (0.50 *vs* 0.10 bugs/plant) (Table 1). The pooled population was 0.40 and 0.08 bugs/plant in the unprotected and protected plots, respectively, a reduction of 80.00 per cent (Table 2, Fig. 1). The painted bug forms only a small fraction of the mustard pest fauna (Yadav *et al.*, 2025), but it can injure seedlings and maturing pods locally. Its effective suppression under protection agrees with Dotasara *et al.* (2022).

Leaf miner : Unlike the sawfly and the painted bug, the leaf miner built up gradually and persisted on the crop for a longer period. Its incidence was significantly higher in the unprotected plot in 2024-25 (0.69 *vs* 0.19 mines/3 leaves) and in 2025-26 (0.90 *vs* 0.18 mines/3 leaves) (Table 1). The pooled values were 0.79 and 0.18 mines/3 leaves, respectively, a reduction of 77.22 per cent (Table 2, Fig. 1). Mines persisted at a low level even under protection because the larva feeds inside the leaf and is less exposed to foliar sprays than the sawfly. Severe, unchecked infestation of this pest can mine 86-93 per cent of the leaf area of mustard (Sahu *et al.*, 2025) and reduce the photosynthetic surface.

Taken together, protection reduced the population of every pest significantly, in the order sawfly (87.95%) > painted bug (80.00%) > leaf miner (77.22%) > aphid (76.42%). The insecticide schedule kept the whole complex at a low level throughout the season, so the protected plot provides a valid estimate of the yield attainable in the absence of pest damage.

Avoidable loss in seed yield

In 2024-25, the protected plot yielded 2112 kg/ha against 1026 kg/ha in the unprotected plot, an avoidable loss of 1086 kg/ha (51.42%). In 2025-26, the corresponding yields were 1729 and 962 kg/ha, a loss of 767 kg/ha (44.36%) (Table 1, Fig. 2a). Both plots yielded less in the second season, which points to less favourable crop growth conditions in that year. Pooled over the two

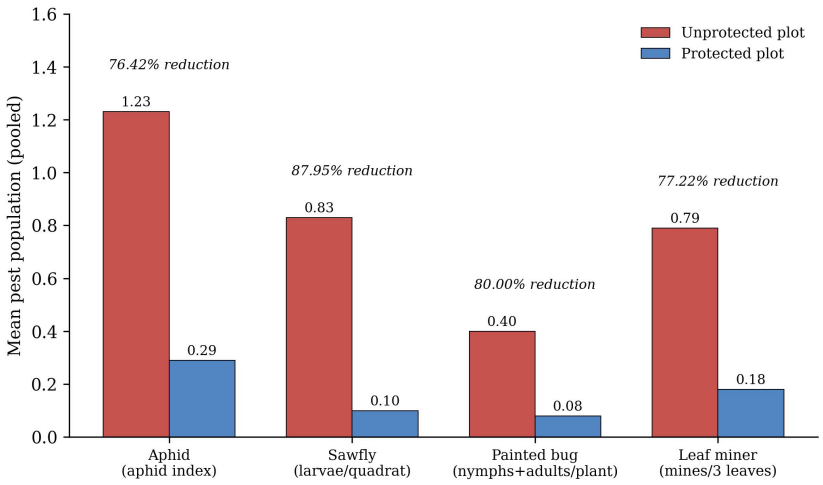


Fig. 1 : Pooled population of the insect pests of mustard in protected and unprotected plots and per cent reduction due to protection (*rabi* 2024-25 and 2025-26).

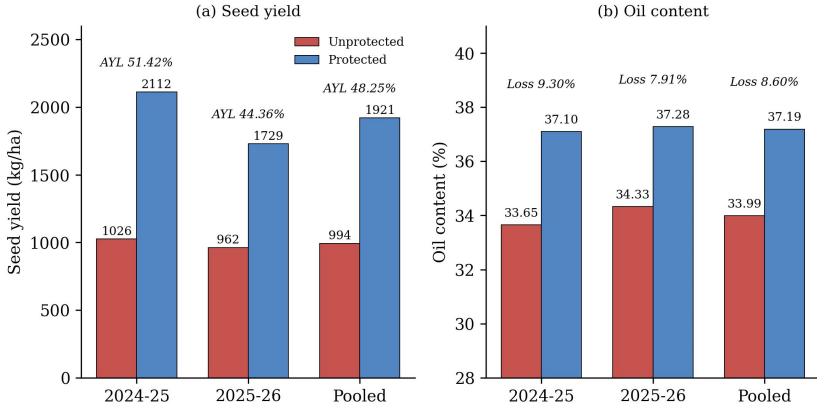


Fig. 2 : Seed yield (a) and oil content (b) of mustard in protected and unprotected plots with avoidable losses (*rabi* 2024-25, 2025-26 and pooled).

seasons, the protected plot gave a significantly higher seed yield (1921 kg/ha) than the unprotected plot (994 kg/ha). The avoidable loss was 927 kg/ha, or 48.25 per cent, and protection increased the yield by 93.26 per cent, *i.e.*, nearly doubled it (Table 2).

This loss is higher than the about 26 per cent reported by Kumar *et al.* (2022) under Haryana conditions and the 37.38 per cent recorded by Gami *et al.* (2004) for the mustard pest complex at Junagadh, Gujarat. It lies within the 10.2 to 61.1 per cent range of preventable losses reported across *B. juncea* cultivars by Dhillon *et al.* (2022) and the 34.62 to 59.33 per cent range due to aphid and sawfly reported by Kumar (2017), and is close to the maximum loss of 58.12 per cent recorded by Singh *et al.* (2024) in susceptible varieties. It is, however, lower than the 80.0 to 97.6 per cent loss documented by Patel *et al.* (2004) in unmanaged mustard sown under unfavourable thermal regimes. Anvesh *et al.* (2026) recorded an even higher pooled loss of 68.30 per cent in Indian mustard. The relatively high loss in the present study reflects the combined pressure of four pests acting one after another through the season on the variety GDM 4. Differences among

Table 2 : Pooled population of insect pests, per cent pest reduction and avoidable losses in seed yield and oil content of mustard (pooled over *rabi* 2024-25 and 2025-26).

Particulars	Aphid (aphid index)	Sawfly (larvae/ quadrat)	Painted bug (bugs/plant)	Leaf miner (mines/ 3 leaves)	Oil content (%)	Seed yield (kg/ha)
Unprotected plot	1.11 (1.23)	0.91 (0.83)	0.63 (0.40)	0.89 (0.79)	33.99	994
Protected plot	0.54 (0.29)	0.32 (0.10)	0.28 (0.08)	0.43 (0.18)	37.19	1921
Pest reduction (%)	76.42	87.95	80.00	77.22	-	-
Avoidable loss (%)	-	-	-	-	8.60	48.25
Increase in yield (%)	-	-	-	-	-	93.26
S.Em. ± (T)	0.03	0.02	0.03	0.05	0.18	32.29
C.D. (p=0.05) (T)	0.06	0.06	0.04	0.06	0.54	92
Year (Y)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Y × T	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)	7.67	10.92	10.43	9.96	1.65	7.87

Sig. = significant at p = 0.05; figures in parentheses are retransformed values; those outside are √x transformed values. Pest reduction (%) was computed on retransformed means.

studies arise from variety, sowing time, pest pressure and agro-climatic conditions.

Avoidable loss in oil content

The oil content was significantly lower in the unprotected plot than in the protected plot in 2024-25 (33.65 *vs* 37.10%) and in 2025-26 (34.33 *vs* 37.28%), corresponding to avoidable losses of 9.30 and 7.91 per cent, respectively (Table 1, Fig. 2b). Pooled over the two seasons, the oil content was 33.99 per cent without protection and 37.19 per cent with protection. The difference of 3.20 percentage points represented an avoidable oil content loss of 8.60 per cent (Table 2).

The aphid and other sap feeders draw assimilates from the plant during pod development and seed filling, so less photosynthate reaches the developing seed and less oil is stored. The present loss of 8.60 per cent falls within the 1.51 to 13.34 per cent reduction in oil content due to aphid reported by Mehta (1984) and is close to the 3.38 to 8.14 per cent range recorded by Sharma *et al.* (2019) in *Brassica* spp. Verma and Singh (1987) reported up to 15 per cent loss in oil content under heavy, unchecked aphid infestation and Malik and Deen (1998) showed that increasing aphid intensity progressively lowers the seed yield, oil content and oil yield of Indian mustard. Since the market price of mustard depends on its oil content, the pest complex causes a double loss to the farmer, in quantity as well as in quality of the produce.

Conclusion

The insect pest complex of aphid, sawfly, painted bug and leaf miner caused an avoidable loss of 48.25 per cent in seed yield and 8.60 per cent in oil content of mustard cv. GDM 4 under middle Gujarat conditions. Insecticidal protection reduced the populations of all four pests by 76 to 88 per cent and nearly doubled the seed yield. The mustard aphid was the most abundant pest and the least suppressed and it should remain the main target of pest management in mustard. Timely protection against the whole pest complex is therefore essential to safeguard both the yield and the quality of mustard in the region.

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Conflict of interest

The authors declare that they have no conflict of interest.

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