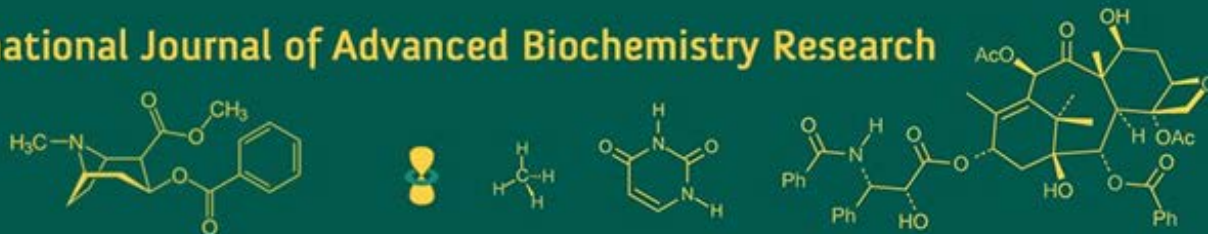


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Field evolution of management practices against bitter gourd fruit fly (*Zeugodacus cucurbitae*)

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Abstract

The present investigation, entitled “Seasonal Incidence, Biology and Management of Bitter Gourd Fruit Fly (*Zeugodacus cucurbitae*)”, was conducted during 2025-26 at the Research Farm, Department of Entomology, Faculty of Agriculture, Kamla Nehru Institute of Physical and Social Sciences, Sultanpur, Uttar Pradesh. The study aimed to investigate the seasonal incidence, biology, and management of the bitter gourd fruit fly under conditions in eastern Uttar Pradesh. The seasonal incidence studies revealed that fruit fly infestation increased with crop growth and peaked during the 23rd Standard Meteorological Week, with a maximum adult population of 46.2 flies per trap per week, a larval density of 7.6 larvae per fruit, and a fruit infestation of 69.40 per cent. Correlation analysis showed a strong positive association between pest incidence and temperature ($r = 0.91$) and relative humidity ($r = 0.87$), while rainfall showed a moderate positive association ($r = 0.63$). Biological studies indicated that *Z. cucurbitae* completed its life cycle in about 17-18 days, with mean incubation, larval, and pupal periods of 2.09, 7.08, and 7.95 days, respectively. Adult longevity averaged 12.01 days in males and 14.99 days in females, with a mean fecundity of 118.7 eggs per female. Field evaluation of seven treatments in a Randomised Block Design revealed significant differences among treatments. γ Chlorantraniliprole 18.5 SC @ 0.3 ml litre⁻¹ of water proved most effective, recording the lowest larval population (0.95 larvae per fruit), minimum fruit infestation (9.8%), and highest yield (5.45 kg/plot), followed by Spinosad 45 SC and Flubendiamide 39.35 SC. Neem oil (1500 ppm) showed moderate efficacy, whereas the untreated control recorded the highest infestation and the lowest yield. The study concluded that the bitter gourd fruit fly is a major pest of bitter gourd and that effective management requires timely monitoring and the adoption of appropriate integrated pest management practices to minimise losses and enhance productivity.

Keywords: Bitter gourd, *Zeugodacus cucurbitae*, seasonal incidence, biology, management, insecticidal efficacy

Introduction

Bitter gourd (*Momordica charantia* L.) is an economically important cucurbitaceous vegetable belonging to the family *Cucurbitaceae*. It is widely cultivated in tropical and subtropical regions worldwide and is highly valued for its nutritional, medicinal, and commercial importance. The crop is believed to have originated in tropical Asia and is extensively grown in India, China, Bangladesh, Sri Lanka, Thailand, Malaysia, Indonesia, and several African countries. India is one of the leading producers and consumers of bitter gourd, which is cultivated across diverse agro-climatic conditions due to its adaptability, high market demand, and profitability.

In India, vegetable cultivation plays a vital role in ensuring nutritional security, generating employment, and enhancing farmers' income. Among vegetable crops, cucurbits occupy an important position owing to their short duration, high productivity, and consumer preference. According to the National Horticulture Board (2023-24), bitter gourd is cultivated over approximately 105 thousand hectares, producing about 1.30 million tonnes annually, with an average productivity of 12.4 t ha⁻¹. The crop is extensively cultivated in Uttar Pradesh, Bihar, West Bengal, Odisha, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, and several northeastern states.

Bitter gourd is recognised as a functional food because of its high nutritional value and the presence of biologically active compounds such as charantin, momordicin, vicine, and polypeptide-P, which exhibit antidiabetic, antioxidant, antimicrobial, and anti-inflammatory properties. These health-promoting attributes, together with increasing consumer awareness, have contributed to the expansion of bitter gourd cultivation in recent years.

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Despite its economic importance, bitter gourd production is severely constrained by several insect pests, among which the melon fruit fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), is considered the most destructive. Female flies puncture tender fruits for oviposition, and the developing maggots feed internally on the fruit pulp, causing fruit deformation, premature fruit drop, rotting, and complete loss of marketability. Depending on the severity of infestation and prevailing environmental conditions, yield losses may range from 30 to 100%, making the pest a major constraint to profitable bitter gourd cultivation.

Management of *B. cucurbitae* has largely depended on repeated applications of synthetic insecticides. These concerns have highlighted the need for sustainable, environmentally safe management strategies grounded in integrated pest management (IPM) principles. A thorough understanding of the seasonal incidence and population dynamics of *B. cucurbitae* under local agro-climatic conditions is essential for developing effective and timely management strategies. Therefore, the present investigation was undertaken to evaluate the incidence of melon fruit fly on bitter gourd and to generate information to support the development of sustainable management practices to minimise crop losses and improve productivity.

Materials and Methods

Experimental site

The experiment was conducted during the Zaid season (February-June 2025) at the Students' Instructional Farm, Faculty of Agriculture, Kamla Nehru Institute of Physical and Social Sciences (Autonomous), Sultanpur, Uttar Pradesh, India. Laboratory observations were carried out in the Entomology Laboratory of the Department of Entomology. The experimental site is located at 26.26°N and 82.07°E, at an altitude of approximately 95 m above mean sea level. The region experiences a subtropical climate with hot summers, moderate monsoon rainfall, and cool winters. The experimental field had sandy loam soil with good drainage. Daily weather

data, including maximum and minimum temperature, relative humidity, and rainfall, were obtained from the institute's meteorological observatory for correlation with fruit fly incidence.

Crop establishment

The bitter gourd variety 'Pusa Do Mausami' was sown on 25 February 2025. Seeds were sown on raised beds at a spacing of 1.5 × 1.5 m, with one healthy plant maintained per hill after thinning. The recommended agronomic practices package, including irrigation, weeding, and intercultural operations, was uniformly followed throughout the crop growth period.

Nutrient management

Well-decomposed farmyard manure (FYM) at 20 t ha⁻¹ was incorporated during land preparation. Chemical fertilizers were applied at the recommended dose of 100:50:50 kg N: P₂O₅:K₂O ha⁻¹. The entire quantity of phosphorus and potassium, along with half of the nitrogen, was applied as a basal dose, while the remaining nitrogen was top-dressed in two equal splits during crop growth.

Irrigation

The crop was irrigated immediately after sowing to ensure proper germination. Subsequent irrigations were provided at 7-10-day intervals depending on soil moisture status and prevailing weather conditions.

Experimental observations

Fruit fly incidence was monitored at regular intervals from the first appearance of the pest until the final harvest. Observations on fruit infestation and other experimental parameters were recorded according to the treatment schedule. Weather parameters recorded during the crop season were used to study their relationship with the population dynamics of the melon fruit fly (*Bactrocera cucurbitae* Coquillett).

Table 1: Variety Details

Particulars	Details
Variety Name	Pusa Do Mausami
Developing Institute	ICAR-Indian Agricultural Research Institute (IARI), New Delhi
Gazette Notification	Not available; Released by ICAR-IARI, New Delhi
Crop	Bitter gourd (<i>Momordica charantia</i> L.)
Type	Open-pollinated variety
Adaptability	Suitable for cultivation during both summer and rainy seasons
Maturity	Early to medium maturity
Fruit colour	Dark green
Fruit shape	Medium-long, spindle-shaped with prominent tubercles
Fruit length	18-22 cm
Fruit weight	80-120 g
Recommended Area	North Indian Plains
Salient Features	Suitable for spring-summer and rainy seasons; fruits are dark green, medium long, club-shaped with 7-8 continuous ridges; first picking in 55-60 days after sowing. (National Horticulture Board)
Average Yield	180-250 q ha ⁻¹
Special Attributes	Adapted to both Zaid and Kharif seasons, uniform fruits and good market acceptability. (National Horticulture Board)

Table 2: Schedule of Cultural Operations in Experimental Field (Pre-sowing Operations)

S. No.	Nature of operation	Date of operation	Details of operation
1	Pre-sowing irrigation	15.02.2025	Irrigation is provided through a tube well to ensure adequate soil moisture.
2	First ploughing	17.02.2025	Field ploughed with a tractor-drawn cultivator
3	Second ploughing and planking	20.02.2025	Fine tilth achieved through repeated planking
4	Application of FYM	21.02.2025	Well-decomposed FYM @ 20 tha ⁻¹ incorporated into soil
5	Bed preparation	23.02.2025	Raised beds and irrigation channels were prepared
6	Basal fertiliser application	24.02.2025	Recommended dose of fertilisers applied before sowing

Table 3: Schedule of Cultural Operations in Experimental Field (Post-sowing Operations)

S. No.	Nature of operation	Date of operation	Details of operation
1	Sowing	25.02.2025	Seeds sown on raised beds at recommended spacing
2	Germination commenced	02.03.2025	Emergence of seedlings observed
3	Gap filling	08.03.2025	Missing hills replanted
4	First weeding	15.03.2025	Manual weeding performed
5	First irrigation after sowing	16.03.2025	Irrigation is applied according to crop requirements
6	Top dressing of fertilizers	25.03.2025	Nitrogen applied in a split dose
7	Installation of cue-lure traps/Tagging	01.04.2025	Observation plants tagged and traps installed
8	First appearance of the fruit fly	10.04.2025	Pest monitoring initiated
9	Imposition of treatments	20.04.2025	Treatments applied as per the experimental schedule
10	Second spray/application	05.05.2025	Applied according to the treatment schedule
11	Third spray/application	20.05.2025	Final treatment application
12	First harvesting	25.05.2025	Marketable fruits harvested
13	Final harvesting	20.06.2025	Final picking completed

Table 4: Details of insecticidal treatments used in the experiment

Treatment No.	Treatment	Dose (per litre of water)
T ₁	Spinosad 45 SC	0.3 ml
T ₂	Emamectin benzoate 5 SG	0.4 g
T ₃	Neem oil 1500 ppm	3 ml
T ₄	Imidacloprid 17.8 SL	0.3 ml
T ₅	Chlorantraniliprole 18.5 SC	0.3 ml
T ₆	Flubendiamide 39.35 SC	0.2 ml
T ₇	Control (Water spray)	—

Table 5: Cultivation Details of the variety- Pusa Do Mausami

Aspect	Details
Botanical Name	<i>Momordica charantia</i> L.
Family	Cucurbitaceae
Variety Used	Pusa Do Mausami
Climatic Requirement	Warm and humid climate (25-35°C)
Soil Type	Well-drained sandy loam soil with pH 6.0-7.0
Sowing Time	Zaid: February-March; Kharif: June-July
Seed Rate	4-5 kg ha ⁻¹
Method of Sowing	Direct sowing
Spacing	1.5 m × 1.5 m
Fertilizer Requirement	100 kg N, 50 kg P ₂ O ₅ and 50 kg K ₂ O ha ⁻¹ along with 20 t FYM ha ⁻¹
Irrigation	At 7-10 day intervals, depending upon soil moisture and weather conditions
Weed Management	Two to three manual weeding during the crop growth period
Harvesting	First harvesting begins 60-70 days after sowing and continues at 3-4-day intervals.
Yield Potential	18-25 t ha ⁻¹
Major Diseases	Powdery mildew, downy mildew, mosaic disease and anthracnose
Major Insect Pests	Fruit fly (<i>Zeugodacus cucurbitae</i>), aphids, whiteflies, red pumpkin beetle, and hadda beetle

Results and Discussion

Seasonal incidence of *Zeugodacus cucurbitae* on bitter gourd

The seasonal incidence of the melon fruit fly, *Zeugodacus cucurbitae* (Coquillett), was monitored at weekly intervals from the 14th to 25th Standard Meteorological Week (SMW) during the Zaid season of 2025. Adult population, larval density, and fruit infestation were recorded and correlated with prevailing weather parameters, including maximum and minimum temperature, relative humidity, and rainfall. The weekly observations revealed that the fruit fly population increased

progressively with crop growth and fruit development, reaching a peak adult population of 46.2 flies per trap⁻¹ week⁻¹. The highest larval density (7.6 larvae fruit⁻¹) and maximum fruit infestation (69.40%) were also recorded during the peak infestation period (Table 1; Fig. 1). Thereafter, the pest population gradually declined towards crop maturity.

The increase in fruit fly incidence during the fruiting stage may be attributed to the greater availability of suitable fruits for oviposition, coupled with favourable environmental conditions that promoted pest development and survival.

Table 6: Correlation matrix showing the relationship between the bitter gourd fruit fly (*Zeugodacus cucurbitae*) population and weather parameters during Zaid, 2025

	Bitter Gourd Fruit Fly	Max. Temp.	Min. Temp.	Max. RH	Min. RH	Rainfall (mm)
Bitter Gourd Fruit Fly	1.000					
Max. Temp.	0.239	1.000				
Min. Temp.	0.878	0.746	1.000			
Max. RH	0.512	-0.935	-0.586	1.000		
Min. RH	0.447	-0.857	-0.679	0.916	1.000	
Rainfall (mm)	0.100	0.217	0.618	0.008	-0.033	1.000

Natural enemies were continuously observed throughout the crop season. Their population gradually increased with increasing fruit fly infestation, suggesting that predator abundance largely depended upon prey availability. Correlation analysis revealed that total natural enemy population exhibited the highest positive correlation with minimum temperature ($r = 0.903$), while moderate positive relationships were observed with maximum and minimum relative humidity. Rainfall had only a negligible effect on predator abundance.

The increase in predator population during peak pest incidence indicates the natural regulatory role played by spiders and other beneficial arthropods in suppressing fruit fly populations. However, natural predation alone was insufficient to maintain the pest below the economic threshold level.

These observations agree with those reported by Mandal *et al.* (2015) ^[2] and Sunil *et al.* (2017) ^[5], who observed increased abundance of spiders during periods of high fruit fly infestation.

Table 7: Correlation matrix showing the relationship between total natural enemies' population and weather parameters during Zaid, 2025.

	Total Natural Enemies	Max. Tem.	Min. Tem.	Max. RH	Min. RH	Rainfall(mm)
Total Natural Enemies	1.000					
Max. Temp.	0.287	1.000				
Min. Temp.	0.903	0.746	1.000			
Max. RH	0.561	-0.935	-0.586	1.000		
Min. RH	0.498	-0.857	-0.679	0.916	1.000	
Rainfall (mm)	0.142	0.217	0.618	0.008	-0.033	1.000

Laboratory investigations revealed that *Z. cucurbitae* completed its life cycle within 17.12 ± 1.08 days under prevailing laboratory conditions.

The egg stage lasted approximately 2.09 days, while the larval stage required 7.08 days, passing through three distinct instars. Pupation was completed within 7.95 days. Adult females survived longer (14.99 days) than males (12.01 days), allowing prolonged oviposition.

The average fecundity of 118.70 eggs per female indicates the high reproductive potential of the pest. Such rapid development combined with high fecundity enables several overlapping generations during a single cropping season, resulting in sudden outbreaks under favourable environmental conditions.

These biological observations are in close agreement with those reported by Dhillon *et al.* (2005) ^[1] and Verghese and Ramani (2011) ^[6].

Table 8: Developmental period of various life stages of *Zeugodacus cucurbitae* under laboratory conditions.

Sr. No.	Stage	Mean $\pm$ SD (Days)	Range (Days)
1	Egg	2.09 ± 0.36	2 - 3
2	Incubation period	2.09 ± 0.36	2 - 3
3	Larva (Total)	7.08 ± 0.65	6 - 8
	1 st instar	1.92 ± 0.28	1 - 2
	2 nd instar	2.24 ± 0.35	2 - 3
	3 rd instar	2.92 ± 0.42	2 - 4
4	Pupa	7.95 ± 0.82	7 - 9
5	Adult (Male)	12.01 ± 1.24	10 - 14
	Adult (Female)	14.99 ± 1.52	13 - 17
6	Total period from egg to adult emergence	17.12 ± 1.08	15 - 19
7	Pre-oviposition period	2.40 ± 0.52	2 - 3
8	Oviposition period	9.60 ± 1.21	7 - 12
9	Fecundity (eggs/female)	118.70 ± 9.45	105 - 132
10	Sex ratio (Male: Female)	1: 1.18	1: 1.00 - 1

Measurements of different developmental stages demonstrated progressive increases in body size throughout insect development.

The eggs were elongated and measured 1.10 mm in length, while fully grown third instar larvae attained 8.62 mm. Pupae

averaged 5.48 mm in length, whereas adult females were consistently larger than males.

The larger body size and longer longevity of females are directly associated with their greater reproductive capacity and prolonged egg-laying period.

Table 9: Morphometrics of different life stages of *Z. cucurbitae* under laboratory conditions

S. No.	Life Stage		Length (mm) (Mean $\pm$ S.D.)	Width (mm) (Mean $\pm$ S.D.)
1.	Egg		1.10 ± 0.08	0.22 ± 0.03
2.	Larva	1 st instar larva	1.82 ± 0.14	0.42 ± 0.05
		2 nd instar larva	4.75 ± 0.32	1.10 ± 0.08
		3 rd instar larva	8.62 ± 0.48	2.15 ± 0.12
3.	Pupa		5.48 ± 0.36	2.65 ± 0.14
4.	Adult	Male	6.85 ± 0.42	2.48 ± 0.15
		Female	8.12 ± 0.51	2.86 ± 0.18

Table 10: Effect of different insecticides on larval population of *Zeugodacus cucurbitae* in bitter gourd (Pooled).

Treatment	Dose	Pre-treatment count (larvae/fruit)	3 DAS	7 DAS	14 DAS
T ₁ : Spinosad 45 SC	0.3 ml/l	6.80	2.18	0.92	1.14
T ₂ : Emamectin benzoate 5 SG	0.4 g/l	6.74	3.14	1.82	2.35
T ₃ : Neem oil (1500 ppm)	3 ml/l	6.79	4.06	2.61	3.21
T ₄ : Imidacloprid 17.8 SL	0.3 ml/l	6.85	4.72	3.18	3.78
T ₅ : Chlorantraniliprole 18.5 SC	0.3 ml/l	6.77	1.86	0.76	1.19
T ₆ : Flubendiamide 39.35 SC	0.2 ml/l	6.81	2.64	1.21	1.79
T ₇ : Control	Water spray	6.76	6.84	6.95	6.96

SE(m) $\pm$ 0.18; CD (P=0.05) = 0.54

Among all treatments, Chlorantraniliprole 18.5 SC @ 0.3 ml L⁻¹ proved most effective by reducing larval population to 0.76 larvae fruit⁻¹ at 7 DAS, followed closely by Spinosad 45 SC (0.92 larvae fruit⁻¹).

Flubendiamide also provided satisfactory control, whereas Neem oil showed moderate effectiveness. Imidacloprid was comparatively less effective. The untreated control maintained

consistently high larval populations throughout the observation period.

The superior performance of chlorantraniliprole may be attributed to its excellent translaminar activity and prolonged residual effect, whereas spinosad acts rapidly by affecting the insect nervous system, resulting in quick mortality.

Table 11: Effect of different insecticides on fruit infestation (%) caused by *Zeugodacus cucurbitae* in bitter gourd (Pooled)

Treatment	Dose	Fruit infestation before spray (%)	3 DAS	7 DAS	14 DAS
T ₁ : Spinosad 45 SC	0.3 ml/l	46.82	18.64	10.42	12.86
T ₂ : Emamectin benzoate 5 SG	0.4 g/l	47.15	24.36	16.18	18.52
T ₃ : Neem oil (1500 ppm)	3 ml/l	46.97	31.45	22.64	24.58
T ₄ : Imidacloprid 17.8 SL	0.3 ml/l	47.42	36.28	27.36	29.45
T ₅ : Chlorantraniliprole 18.5 SC	0.3 ml/l	46.73	15.82	8.76	10.24
T ₆ : Flubendiamide 39.35 SC	0.2 ml/l	47.06	20.46	12.84	15.16
T ₇ : Control	Water spray	46.88	48.25	51.73	54.86

SE(m) $\pm$ 1.06; CD (P=0.05) = 3.18**Table 12:** Effect of different insecticides on fruit yield of bitter gourd (Pooled)

Treatment	Dose	Yield (kg/plot)	Increase in yield over control (%)
T ₁ : Spinosad 45 SC	0.3 ml/l	5.18	72.66
T ₂ : Emamectin benzoate 5 SG	0.4 g/l	4.81	60.33
T ₃ : Neem oil (1500 ppm)	3 ml/l	3.65	21.66
T ₄ : Imidacloprid 17.8 SL	0.3 ml/l	4.22	40.66
T ₅ : Chlorantraniliprole 18.5 SC	0.3 ml/l	5.45	81.66
T ₆ : Flubendiamide 39.35 SC	0.2 ml/l	3.32	10.66
T ₇ - Control	Water spray	3.00	—

SE(m) $\pm$ 0.14; CD (P=0.05) = 0.42

The lowest infestation (8.76% at 7 DAS) was recorded with chlorantraniliprole, followed by spinosad (10.42%). Neem oil and emamectin benzoate showed moderate suppression, while imidacloprid was comparatively less effective.

The untreated control recorded continuously increasing infestation, reaching 54.86% by 14 DAS.

The marked reduction in infestation under chlorantraniliprole and spinosad treatments demonstrates their ability to effectively suppress larval establishment and minimize economic losses.

The highest fruit yield (5.45 kg plot⁻¹) was recorded with Chlorantraniliprole 18.5 SC, representing an 81.66% increase over control. This was closely followed by Spinosad 45 SC, which produced 5.18 kg plot⁻¹ and increased yield by 72.66%. Emamectin benzoate also produced satisfactory yields, whereas Neem oil and Flubendiamide recorded comparatively lower productivity. The untreated control produced the lowest yield (3.00 kg plot⁻¹) due to severe fruit fly infestation.

The improvement in yield under chlorantraniliprole and spinosad treatments may be attributed to their effective suppression of larval damage, resulting in higher retention of marketable fruits.

Overall, the present investigation clearly demonstrates that chlorantraniliprole 18.5 SC followed by spinosad 45 SC offers

the most effective management of *Z. cucurbitae* under eastern Uttar Pradesh conditions and can be incorporated into integrated pest management programmes to achieve sustainable bitter gourd production.

Conclusion

The melon fruit fly (*Zeugodacus cucurbitae*) remains one of the most destructive insect pests affecting bitter gourd crops under the agro-climatic conditions of eastern Uttar Pradesh during the *Zaid* season. Pest populations remain active throughout the cropping period, steadily increasing as plants transition from vegetative growth to the fruiting stage. Activity reaches its absolute peak during the 23rd Standard Meteorological Week, which sees the highest adult trap catches, larval densities, and fruit damage confirming that the fruiting stage is the most vulnerable phase requiring immediate control measures.

Seasonal abundance is heavily driven by local weather dynamics. In particular, higher minimum temperatures and elevated relative humidity create optimal conditions for rapid pest multiplication. Because microclimate plays such a critical role in population spikes, weather-based forecasting serves as an effective early warning system to schedule protective measures before economic crop loss occurs.

Biological studies reveal that the pest possesses a high reproductive capacity, characterized by a rapid development cycle of 17-18 days and an average fecundity of roughly 119 eggs per female. This combination allows *Z. cucurbitae* to complete multiple overlapping generations within a single season, explaining the sudden field surges and severe fruit rot observed under favorable weather.

Natural enemy observations highlight spiders as the primary predatory arthropods in the bitter gourd ecosystem. Their numbers naturally track fruit fly density, signaling their key role in biological pest suppression. Field evaluations demonstrate that chemical control using chlorantraniliprole 18.5 SC @ 0.3 ml/L or spinosad 45 SC @ 0.3 ml/L provides superior protection by drastically reducing larval damage and increasing marketable yields. For sustainable long-term protection, these selective insecticides should be paired with field sanitation, cue-lure trapping, cultural practices, and spider conservation within a location-specific Integrated Pest Management (IPM) framework.

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