# MODERN PROTECTION AND MANAGEMENT TECHNOLOGIES FOR MILLETS AND PULSES

**1st Edition**

**N. Murugan, N.Vairam, L. Ramazeame, R. Nisha,
B. Rex, T. Thamizharasu, N. Santhoshraj**

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# Modern Protection and Management Technologies for Millets and Pulses

**1st Edition**


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# FOREWORD

Integrated Pest Management (IPM) has emerged as an essential approach for ensuring sustainable agricultural practices and improving human livelihoods. In recent decades, factors such as climate change, rapid globalization, and the increased movement of people and commodities have accelerated the spread of invasive insect species across geographical boundaries. This has led to considerable disturbances in natural ecosystems. At the same time, these changes have intensified pest-related challenges in agricultural systems by promoting secondary pest outbreaks, pest resurgence, and the development of resistance to commonly used insecticides. Such biological pressures significantly impact agricultural productivity, causing extensive damage to crops in the field as well as during storage. In addition, they adversely affect forests, livestock, poultry, and even human health. Studies indicate that approximately 20–25% of agricultural produce is lost due to pest infestations both before and after harvest.

The first edition of *Modern Protection and Management Technologies for Millets and Pulses* aligns with this objective by presenting the economic dimensions of entomology in a clear, structured, and easily understandable manner for students and learners. Entomology, the scientific study of insects, is an expansive field owing to the enormous diversity of insect species, which make up the largest group of living organisms on Earth. This discipline encompasses a wide range of topics that naturally occur within ecosystems and is deeply rooted in fundamental scientific concepts. The interactions between insects and humans further add to the complexity of the field, making it highly interdisciplinary, dynamic, and economically important. These interactions are closely tied to human activities and vary across different spatial and temporal scales. Consequently, entomology has gained increasing importance and responsibility in addressing challenges related to agriculture, environment, and public health, thereby contributing to sustainable human development. This highlights the critical need to apply scientific principles of entomology, particularly through IPM strategies, as they are indispensable for maintaining agricultural productivity and ensuring human well-being.

We extend our best wishes to the authors and the book for effectively spreading entomological knowledge for the advancement of agriculture and human life.

# PREFACE

The book *Modern Protection and Management Technologies for Millets and Pulses* is an effort to address these challenges by presenting advanced, sustainable, and practical approaches to crop protection. It focuses on modern pest management strategies that combine scientific innovation with ecological sustainability. The book highlights the importance of integrated approaches, including biological control, host plant resistance, cultural practices, and the judicious use of pesticides, to manage pest populations effectively. Special emphasis is given to emerging technologies such as biopesticides, nanotechnology-based formulations, precision agriculture tools, and digital pest surveillance systems. These advancements not only enhance the efficiency of pest control but also reduce the environmental footprint of agricultural practices. The book also addresses key challenges such as pest resistance, changing pest dynamics due to climate change, and the need for farmer awareness and capacity building. This volume is intended to serve as a comprehensive guide for students, researchers, and agricultural professionals. For students, it provides a strong conceptual understanding of pest management principles along with exposure to modern technologies shaping the future of agriculture. For farmers and extension workers, it offers practical, field-oriented solutions that can improve crop yield, reduce losses, and promote sustainable farming practices.

The future of millets and pulses lies in the adoption of innovative, eco-friendly, and technology-driven pest management strategies. By integrating traditional knowledge with modern scientific advancements, it is possible to ensure long-term productivity and sustainability of these vital crops. This book aims to contribute to that vision by encouraging informed decision-making and fostering a deeper understanding of crop protection technologies.

We extend our sincere thanks and appreciation to Skyfox Publishing Group, Thanjavur, for their unwavering support and dedicated efforts in publishing the first edition of this book in 2026. Their contribution has been instrumental in bringing this work to fruition.

We look forward to criticisms and constructive suggestions for the improvement of the book.

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**CONTENTS**

**ROOT APHIDS IN RAGI**

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**Abstract**

*Eleusine coracana* (Finger millet), known as ragi, is a nutrient-rich food in Asia. It is said to have higher calcium content than milk and most cereals. India, being the lead producer, Karnataka stands first, followed by Tamil Nadu, Maharashtra, and Uttarakhand. Studies show that five species of aphids cause great losses in hilly areas like Shimla and Himachal Pradesh. It is relatively low in the southern parts of India. Ragi root aphid (*Tetraneura nigriabdominalis*), one among the aphid species, causes stunting, yellowing, and wilting in patches, though the infestation remains low. This review compiles the position, morphology, ecological factors, damage, symptoms, and management strategies of the root aphid in ragi.

**Keywords:** Ragi, root aphid, wilting, characters, management strategies.

**Introduction**

*Eleusine coracana* (Finger millet), also known as Kezhvaragu, Keppai in Tamil Nadu, Marua in Bihar, Nagli in Gujarat, Koovaragu in Karnataka, Mandua in Uttarakhand, is extensively grown and cultivated in more than 25 countries in Asia and Africa. India, as a major producer, contributes nearly 60% of the total world production. Finger millet grows in different climatic regions and has the highest productivity compared to other millets. It stands $4^{th}$ in millets after sorghum, pearl millet, and foxtail millet. The nutritional content has been recognized as a potential solution to malnutrition and hidden hunger all over the world. Proteins, fats, minerals, and carbohydrates, dietary fibres, essential amino acids, and minerals in sufficient amounts. Widely used by celiac patients as they are free of gluten and maintain good health by improving digestion. Their Popularity and consumption have increased among people in recent decades. Farmers and scientists are in an indispensable situation to develop new technologies and methodologies to increase the overall production and nutrient quality of the crop to meet rising demands. (Gull et al., 2014; Dhanushkodi et al., 2023).

Ragi remains a staple food in dry areas around the world; however, the production and productivity keep declining. Identifying constraints among the farmers is essential for a smooth technology transfer and diffusion. The major constraints comprise small land holdings, poor agricultural practices, socio-economic factors, infestation of pests and diseases, and limited technologies. Also, millet crops like ragi receive less attention from farmers and the research community, being classified as an underutilized crop (Kasule et al.,2023). Among the biotic constraints, insect pests play a major role, with nearly 57 pests infesting finger millet, resulting in a reduction of productivity. Pink stem borer is considered the major pest of ragi in the regions of Karnataka, Tamil Nadu, Odisha, and Andhra Pradesh. The district of Bastar in Chhattisgarh, a major cultivating area for finger millet, is one of the leading producers. The finger millet grown in these areas faces pest problems in all phases of the crop (Sharma et al.,2022). Minor pests such as flea beetles, earhead caterpillars, cutworms, spider mites, and root aphids also reduce the ability of the crop to maintain stable yields, due to unfavourable conditions. This review aims to explain the taxonomic position, morphology, host, distribution, damage, symptoms, and management practices of ragi root aphid (*Tetraneura nigriabdominalis*), a minor pest in ragi.

**Pest Identity and Taxonomy**

**Scientific name:** *Tetraneura nigriabdominalis* (Sasaki)

**Common name:** Ragi root aphid, ragi pink aphid **Order:** Hemiptera

**Family:** Aphididae

**Subfamily:** Eriosomatinae

*Tetraneura nigriabdominalis* (Sasaki) is commonly known as the root aphid, infests the genus *Ulmus* and the grass family such as paddy, maize, sorghum and finger millet. It forms galls in the *Ulmus* tree. Generally the species live in a mutual association with black ants. The ants gather for the honeydew scecreted by aphids, and in turn the ants help the aphids to maintain their colonies by preventing them from predators and parasitoids.

**Host Range:**

The root aphid species commonly associated with ragi (*Eleusine coracana* L.) belongs to the genus *Tetraneura*, particularly *Tetraneura nigriabdominalis* (sometimes referenced under the group including *Tetraneura akinire*) which colonizes the roots of many grass and cereal species. This aphid has been reported feeding on diverse gramineous hosts such as rice (*Oryza sativa* L.), maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench) and various wild grasses, indicating a broad host range within the family Poaceae (Wilson, 2006; Turner et al., 2023). *T. nigriabdominalis* alternates between primary hosts (elm trees) and secondary hosts (grasses and cereals), where it feeds on root sap and can damage plant vigor (Turner et al., 2023). In addition to cereals, related root aphids such as *Rhopalosiphum rufiabdominale* (rice root aphid) are highly polyphagous and infest plants across multiple families, including Poaceae, Rosaceae, and Solanaceae, demonstrating the general propensity of root aphids to exploit a wide host range outside of a single crop species (Holman, 2009; Database of Aphids, 2025).

**Origin:**

Although specific studies focusing exclusively on the biogeographic origin of the ragi root aphid complex are limited, *Tetraneura nigriabdominalis* and related taxa are thought to have originated in the **Far East (China, Japan, Korea)** before spreading to other regions through host plant movement and environmental adaptation (InfluentialPoints, 2024). The distribution pattern implies that East Asia may be a center of origin for many grass-feeding root aphids, with subsequent dissemination influenced by global cereal cultivation.

**Distribution:**

*Tetraneura nigriabdominalis* exhibits a **global distribution**, having been recorded across Southwest Asia, Europe, Africa, Australia, and the Americas, where its presence is documented in agricultural and grassland ecosystems (Turner et al., 2023). The species' range reflects its adaptability to diverse climatic zones and host plants. In India, root aphids on ragi and other cereals have been reported widely, especially in ragi-growing states where traditional cultivation provides continuous hosts (Slideshare presentation on finger millet root aphid, 2025). The widespread occurrence of root aphids in regions such as southern and southeastern Europe and expansion into new areas further demonstrates their capacity for range expansion (Turner et al., 2023).

In summary, root aphids affecting ragi are **polyphagous**, with host plants spanning multiple grasses and cereals; they are **evolutionarily linked to East Asia** as a likely origin; and they have **established a broad global distribution** through ecological adaptability and agricultural connectivity.

**Morphology**

Root aphids infesting ragi (*Eleusine coracana* L.) belong mainly to the family Aphididae (Hemiptera) and are characterized by their soft, delicate bodies and sap-sucking feeding habit. Species reported from millets, including *Tetraneura nigriabdominalis*, are typically small, measuring about 1.5–2.5 mm in length, with a globular to pear-shaped body adapted for a subterranean lifestyle (Blackman & Eastop, 2000). The body colour varies from pale yellow to brownish or pinkish, often influenced by age, host plant, and environmental conditions.

A key diagnostic feature of root aphids is the presence of **piercing–sucking mouthparts** (stylets) that enable them to extract phloem sap from roots and basal stem tissues (Dixon, 1998). Like other aphids, they possess paired **cornicles (siphunculi)** on the posterior abdomen, although these structures are often shorter and less conspicuous in subterranean species (Holman, 2009). Antennal segments are well developed, and compound eyes are present but less prominent due to the underground habitat. Wingless (apterous) forms dominate root colonies, while winged (alate) forms are occasionally produced for dispersal when population density or environmental stress increases (Blackman & Eastop, 2000). Nymphs resemble adults in general body form but are smaller and lack fully developed appendages, making differentiation between life stages difficult without close observation.

**Life Cycle**

Root aphids associated with ragi reproduce predominantly through **viviparous parthenogenesis**, a reproductive strategy in which females give birth to live nymphs without mating (Dixon, 1998). This mode of reproduction allows rapid population buildup, particularly under favorable soil temperature and moisture conditions. The life cycle generally consists of **four nymphal instars**, after which the insect reaches adulthood. Under warm tropical conditions, the nymphal period is relatively short, enabling multiple overlapping generations within a single cropping season (Blackman & Eastop, 2000).

Developmental rate and fecundity are strongly influenced by temperature. Studies on *Tetraneura* species indicate that higher temperatures significantly shorten developmental duration and increase reproductive output, whereas cooler temperatures prolong nymphal development and reduce population growth (Agarwala & Dixon, 1992). Adult females may live for several days to a few weeks and produce numerous offspring during their lifespan. Sexual forms and egg-laying stages are rarely reported in tropical cropping systems, suggesting that asexual reproduction dominates throughout the year in ragi-growing regions (Dixon, 1998).

**Phenology**

The phenology of root aphids in ragi is closely linked to **crop growth stage, soil temperature, and moisture availability**. Infestations commonly begin during the early vegetative phase of the crop, when newly developed roots provide suitable feeding sites (Holman, 2009). Population levels often peak during dry or moisture-stress conditions, as reduced soil moisture suppresses natural enemies and favors aphid survival and colonization (Kindlmann & Dixon, 1999).

Seasonal fluctuations in aphid populations are primarily driven by temperature, with warmer periods supporting faster generation turnover and higher infestation intensity (Agarwala & Dixon, 1992). Continuous cultivation of ragi or other cereal hosts can further stabilize aphid populations by ensuring uninterrupted host availability. Although detailed phenological studies specific to ragi are limited, general aphid ecology suggests that root aphids persist in the soil across seasons and rapidly exploit favorable conditions, making them a recurring pest problem in rainfed millet ecosystems (Dixon, 1998).

**Symptoms**

Root aphids infesting ragi (*Eleusine coracana* L.) cause damage primarily by sucking phloem sap from the roots and basal stem tissues. This feeding activity interferes with the normal absorption and translocation of water and nutrients, leading to a gradual decline in plant vigor

(Dixon, 1998). Unlike foliar aphids, root aphids remain concealed below the soil surface, and therefore the damage becomes apparent only after physiological stress symptoms appear on the aerial parts of the plant.

Early symptoms include pale green to yellow discoloration of leaves, reduced tillering, and overall stunted growth. As infestation progresses, affected plants exhibit wilting even under adequate soil moisture conditions, indicating impaired root function rather than drought stress (Blackman & Eastop, 2000). In severe cases, seedlings may fail to establish properly and can collapse or dry prematurely. Infestations are typically uneven within the field, resulting in patchy crop stands that reduce overall productivity (Holman, 2009). Root aphids also produce honeydew while feeding, which attracts ants that form a mutualistic association with the aphids. Ant attendance enhances aphid survival and further intensifies damage by protecting colonies from natural enemies (Kindlmann & Dixon, 1999). Chronic infestation during early growth stages can lead to poor panicle emergence, reduced grain filling, and significant yield loss, particularly in rainfed and nutrient-poor soils (Dixon, 1998).

**Field Detection**

Detection of root aphids in ragi is challenging due to their subterranean habit and the non-specific nature of above-ground symptoms. Field diagnosis therefore requires a combination of visual plant symptoms and direct examination of the root zone. Plants showing unexplained yellowing, stunting, and wilting in localized patches should be carefully uprooted for inspection (Blackman & Eastop, 2000).

On gentle removal of soil around the roots, aphid colonies may be observed clustered along the primary and secondary roots or near the basal portion of the stem. The insects appear as small, soft-bodied, pale-coloured aphids, often accompanied by ants moving in and out of the soil (Holman, 2009). The presence of ants near affected plants is considered a strong indirect indicator of root aphid infestation and can serve as a practical field clue for early diagnosis (Kindlmann & Dixon, 1999).

Another key indicator is the persistence of wilting and nutrient-deficiency-like symptoms even after irrigation or fertilizer application. Such responses suggest root impairment caused by sap-sucking pests rather than abiotic stress (Dixon, 1998). In some cases, fine soil particles may appear glued together around roots due to honeydew secretion, further confirming aphid activity. Early and accurate detection through these indicators is essential for timely management, as delayed recognition often leads to extensive underground population buildup and irreversible crop damage.

**Damaging Stage of the Pest**

In root aphids infesting ragi, **both nymphs and adults** are damaging stages of the pest. These stages feed continuously on phloem sap extracted from roots and basal stem tissues using piercing–sucking mouthparts (Dixon, 1998). Unlike many foliar pests, root aphids remain active below the soil surface throughout most of their life cycle, allowing uninterrupted feeding and prolonged damage to the host plant.

Nymphs begin feeding soon after birth and pass through four instars, during which they contribute significantly to root injury due to their increasing nutritional demand (Blackman & Eastop, 2000). Adult females, which reproduce viviparously, are particularly damaging as they not only extract sap but also give rise to large colonies within a short period, leading to rapid population buildup (Agarwala & Dixon, 1992). Continuous sap removal weakens the root system, reduces water and nutrient uptake, and disrupts normal physiological processes in ragi plants.

Damage is most severe during the **seedling and early vegetative stages**, when root systems are still developing and the plant's tolerance to stress is low. Heavy infestations during this stage can result in poor establishment, stunted growth, and even plant mortality, ultimately causing yield losses (Holman, 2009). Since feeding occurs underground, the pest can remain active for long durations before symptoms become visible, making these damaging stages particularly destructive.

**Preventive Methods**

Preventive management of root aphids in ragi focuses on reducing initial infestation, minimizing favorable conditions for population buildup, and strengthening crop resilience. **Cultural practices** play a major role in prevention. Crop rotation with non-host crops helps break the pest life cycle by removing continuous availability of suitable hosts (Dixon, 1998). Avoidance of monocropping and maintenance of field sanitation by removing weed hosts and crop residues can further reduce aphid carryover between seasons (Holman, 2009).

Soil and moisture management are also critical preventive measures. Well-drained soils and avoidance of prolonged dry stress reduce aphid survival, as root aphid populations often increase under dry, sandy soil conditions (Kindlmann & Dixon, 1999). Balanced fertilizer application, particularly avoiding excessive nitrogen, helps prevent lush root growth that may attract sap-feeding pests (Blackman & Eastop, 2000).

The **management of ant populations** is another key preventive strategy, as ants protect root aphids from natural enemies in exchange for honeydew. Disrupting ant movement through field sanitation and physical barriers reduces aphid survival and spread (Way, 1963). Encouraging natural enemies such as predatory beetles and entomopathogenic fungi through reduced pesticide use and improved soil biodiversity also contributes to long-term prevention (Dixon, 1998).

Preventive measures are most effective when implemented early in the cropping season, before aphid populations establish underground colonies. An integrated approach combining cultural, ecological, and soil-based practices provides sustainable suppression of root aphids in ragi without heavy reliance on chemical control.

**Cultural and Mechanical Methods**

Cultural and mechanical practices form the foundation for managing root aphids in ragi, as these methods reduce pest establishment and multiplication without disturbing the agro-ecosystem. Since root aphids survive and proliferate in continuous host availability, **crop rotation** with non-host crops such as pulses or oilseeds is an effective preventive strategy that disrupts their life cycle (Dixon, 1998). Avoidance of monocropping and incorporation of crop diversification reduce the persistence of aphid populations in the soil.

**Field sanitation** plays an important role in minimizing infestation. Removal of volunteer plants, grassy weeds, and crop residues that can act as alternate hosts prevents carryover of aphids between seasons (Holman, 2009). Proper land preparation, including deep summer ploughing, exposes aphids and associated ants to desiccation and predation, thereby lowering initial population levels (Blackman & Eastop, 2000).

**Soil moisture management** is another crucial cultural practice. Root aphid infestations are often aggravated under dry soil conditions; therefore, maintaining optimum soil moisture through timely irrigation reduces aphid survival and multiplication (Kindlmann & Dixon, 1999). Balanced fertilization, particularly avoiding excessive nitrogen application, helps prevent soft and succulent root growth that favors sap-feeding insects (Dixon, 1998).

Among mechanical methods, **uprooting and destruction of heavily infested plants** during early stages prevents the spread of aphids to healthy plants. Disturbance of ant nests around the root zone also reduces aphid protection, as ants play a major role in safeguarding root aphids from natural enemies (Way, 1963). These low-cost practices are especially useful in smallholder ragi cultivation systems.

**Biological Methods**

Biological control of root aphids in ragi relies on conserving and augmenting natural enemies and using biopesticides that are safe to the soil ecosystem. Predators such as **ladybird beetles (Coccinellidae)** and **lacewings (*Chrysoperla* spp.)** are known to suppress aphid populations, although their impact on subterranean aphids is indirect and enhanced when ant activity is minimized (Dixon, 1998). Conservation of these predators through reduced chemical pesticide use is strongly recommended.

**Entomopathogenic fungi** have shown promising results against soil-dwelling aphids. *Beauveria bassiana* and *Metarhizium anisopliae* infect aphids through the cuticle and cause mortality under favorable moisture conditions (Shah & Pell, 2003). Soil application or drenching with *Beauveria bassiana* @ **$2 \times 10^8$ conidia/g formulation at 2.5 kg/ha**, mixed with well-decomposed farmyard manure, has been reported to reduce aphid populations in soil-inhabiting pests (Shah & Pell, 2003). Similarly, *Metarhizium anisopliae* can be applied @ **2.5 kg/ha** through soil incorporation or root-zone drenching.

Botanical insecticides also play a role in biological management. **Neem-based formulations**, due to their antifeedant and growth-regulating properties, are effective against aphids and safe to beneficial organisms. Soil drenching with neem oil @ **3–5 ml/L of water** or neem cake application @ **250 kg/ha** at sowing has been recommended to suppress root aphid populations and associated ants (Isman, 2006). Neem cake additionally improves soil health and promotes beneficial microbial activity.

Successful biological control requires early application and favorable environmental conditions, particularly adequate soil moisture. Integration of biological methods with cultural practices enhances their effectiveness and provides sustainable suppression of root aphids in ragi ecosystems.

**Chemical Methods**

Chemical control of root aphids in ragi is considered a **supportive and need-based approach** within integrated pest management, particularly when infestation exceeds economic tolerance levels and other methods fail to provide adequate suppression. Since root aphids are subterranean pests, **soil application or root-zone drenching** is more effective than foliar spraying (Blackman & Eastop, 2000).

Systemic insecticides belonging to the neonicotinoid and organophosphate groups have been reported effective against soil-dwelling aphids due to their ability to translocate within the plant system (Dixon, 1998). **Imidacloprid 17.8 SL** can be applied as a soil drench at **0.3 ml/L of water**, directing the solution near the root zone to ensure uptake by the plant (IRAC, 2011). Similarly, **Thiamethoxam 25 WG** applied as soil drenching @ **0.25 g/L of water** has been shown to reduce aphid populations effectively in cereal crops (Jalali et al., 2015).

Granular insecticides are particularly suitable for managing early infestations. Application of **Phorate 10G @ 10 kg/ha** or **Carbofuran 3G @ 33 kg/ha** at sowing has been reported to provide protection against soil pests, including root aphids, during the initial growth stages of cereals (Kranthi, 2014). However, due to environmental and safety concerns, the use of highly toxic molecules should be carefully regulated and restricted to severe infestations only.

Chemical interventions should always be **targeted and minimal**, as indiscriminate use can disrupt natural enemies and soil microflora, leading to secondary pest outbreaks and resistance development (Kindlmann & Dixon, 1999). Therefore, chemical control must be integrated with cultural and biological practices rather than used as a standalone strategy.

**Conclusion**

Root aphids are emerging as an economically important but often neglected pest of ragi due to their hidden, subterranean feeding habit and non-specific damage symptoms. Effective management of this pest requires an **integrated pest management (IPM) approach** that emphasizes prevention, early detection, and ecological balance rather than sole reliance on chemical control (Dixon, 1998).

Cultural practices such as crop rotation, field sanitation, balanced nutrition, and proper soil moisture management form the first line of defense against root aphid infestation. Mechanical methods like removal of heavily infested plants and disruption of ant colonies further reduce pest survival and spread. Biological control through conservation of natural enemies and application of entomopathogenic fungi and neem-based products enhances long-term suppression while maintaining soil health (Shah & Pell, 2003; Isman, 2006).

Chemical methods should be employed only when pest pressure is high and crop damage becomes economically significant. Even then, selective and systemic insecticides applied as soil treatments are preferred to minimize non-target effects. The integration of these methods ensures sustainable management of root aphids, reduces environmental risks, and supports stable ragi production in rainfed and resource-limited farming systems.

In conclusion, a well-planned IPM strategy combining **cultural, biological, mechanical, and judicious chemical methods** offers the most effective and environmentally responsible solution for managing root aphids in ragi ecosystems.

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# CLIMBING CUTWORM IN RAGI

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**Abstract**

Finger millet (Eleusine coracana L.), commonly known as ragi, is an important rainfed millet crop in India, but its productivity is greatly affected by insect pests during the early stages of growth. Among these, the climbing cutworm (Spodoptera spp.) is a serious defoliator causing significant damage at the seedling and vegetative stages. The larvae feed actively on foliage during night hours, resulting in leaf skeletonisation, reduced photosynthetic area, and stunted plant growth, which may lead to severe yield losses under heavy infestation. Favorable climatic conditions, continuous cropping, and poor field sanitation further enhance pest incidence. This article outlines the pest identity, nature and symptoms of damage, biology, and favorable conditions, with special emphasis on integrated pest management strategies. Adoption of cultural, mechanical, biological, and judicious chemical control measures is essential for effective and sustainable management of climbing cutworm in ragi cultivation.

**Keywords:** Finger millet; Ragi; Climbing cutworm; Spodoptera spp.; Defoliator; Integrated pest management (IPM); Biological control; Rainfed agriculture

## Introduction

Finger millet (Eleusine coracana L.), commonly known as ragi, is an important millet crop cultivated widely in India under rainfed conditions. During the early stages of crop growth, ragi is attacked by several insect pests, among which the climbing cutworm is a serious and destructive pest. This pest is particularly damaging during the seedling and vegetative stages, causing heavy defoliation and sometimes complete loss of young plants (Reddy, 2017).

## Pest Identity

The climbing cutworm is commonly known as climbing cutworm or ragi cutworm. The scientific name of the pest is Spodoptera exigua (Hübner) or Spodoptera litura (Fabricius) in some regions, belonging to the order Lepidoptera and family Noctuidae. It is a polyphagous pest and feeds on several cereal, pulse, and vegetable crops including ragi (David & Ananthakrishnan, 2004).

**Nature of Damage**

The larvae of climbing cutworm feed voraciously on ragi leaves. Young larvae scrape the green matter, while older larvae cut the leaves and feed from the margins, leaving only the midrib. Unlike ordinary cutworms, this pest climbs the plant at night and feeds on foliage, hence the name "climbing cutworm" (Atwal & Dhaliwal, 2015). Severe infestation leads to skeletonisation of leaves, reduced photosynthetic area, and stunted plant growth.

**Symptoms of Damage**

Affected ragi plants show irregular holes on leaves, ragged leaf margins, and defoliation. In severe cases, only the midrib remains. Damage usually appears in patches in the field. Larvae hide in soil cracks or plant debris during the daytime and become active at night (Prakash & Rao, 2018).

**Life Cycle**

The female moth lays eggs in clusters on the underside of leaves, covered with hair-like scales. The eggs hatch in 3–5 days. The larval stage lasts for about 14–20 days and passes through 5–6 instars. Fully grown larvae are greenish to dark brown with longitudinal stripes. Pupation occurs in the soil, and the pupal stage lasts about 7–10 days. The entire life cycle is completed in about 30–40 days under favorable conditions (Reddy, 2017).

**Favorable Conditions**

Warm temperature, high humidity, continuous cropping, and presence of weeds favor the multiplication of climbing cutworm. Late sowing and poor field sanitation increase the severity of infestation in ragi fields (Dhaliwal et al., 2010).

**Management Practices**

**Cultural Methods**

Deep summer ploughing helps to expose pupae and larvae to natural enemies. Removal of weeds and crop residues reduces egg-laying sites. Timely sowing and maintenance of proper plant population help the crop escape severe damage (Atwal & Dhaliwal, 2015).

**Mechanical Methods**

Hand-picking and destruction of larvae during early stages is effective in small fields. Light traps can be installed to attract and kill adult moths. Collection of egg masses and larvae during early infestation reduces pest population (Prakash & Rao, 2018).

**Biological Methods**

Application of neem seed kernel extract (NSKE) 5% or neem oil 3% reduces larval feeding. Release of natural enemies like Trichogramma chilonis helps in controlling egg stages. Spraying of Bacillus thuringiensis (Bt) is effective against early instar larvae (Dhaliwal et al., 2010).

**Chemical Control**

When infestation crosses the economic threshold level, spraying of Chlorpyriphos 20 EC @ 2.5 ml/L or Quinalphos 25 EC @ 2 ml/L is recommended. Newer insecticides like Emamectin benzoate 5 SG @ 0.4 g/L are also effective against larvae. Chemical control should be used judiciously as part of IPM (Reddy, 2017).

**Conclusion**

Climbing cutworm is an important defoliator of ragi, especially during early crop stages. Effective management depends on early detection and adoption of integrated pest management practices. Combining cultural, mechanical, biological, and need-based chemical methods ensures sustainable control of the pest and minimizes yield loss (Atwal & Dhaliwal, 2015).

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# GHUJHIA WEEVIL IN RAGI

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**Abstract**

Finger millet (*Eleusine coracana*), an important nutri-cereal of India, is increasingly affected by early-season insect pests under changing cropping systems. Among them, the Ghujhia weevil, *Tanymecus indicus* (Coleoptera: Curculionidae), traditionally recognized as a pest of rabi cereals such as wheat and barley, has emerged as an occasional but economically significant pest in ragi, particularly during the seedling stage. Adult weevils cause characteristic damage by cutting or scraping seedlings at the collar region, leading to deadheart symptoms, patchy crop stands, and potential yield loss. The pest survives in soil through egg, larval, and pupal stages, with population build-up closely associated with minimal tillage, continuous cereal cultivation, and synchronization of sowing with adult emergence. This paper provides a comprehensive account of the pest's identity, distribution, biology, damage symptoms, field detection, and economic threshold level, with emphasis on its relevance in ragi-based farming systems. Various management strategies, including preventive, cultural, mechanical, biological, organic, and chemical approaches, are discussed under an integrated pest management (IPM) framework. Emphasis is placed on early detection and adult-stage management to achieve effective and environmentally sustainable control of Ghujhia weevil in finger millet.

**Keywords:** Ghujhia weevil, *Tanymecus indicus*, finger millet, seedling pest, soil-dwelling insects, integrated pest management.

## Introduction

Finger millet (*Eleusine coracana*), commonly known as ragi, is one of the most important small millets cultivated in India, particularly in rainfed and marginal agro-ecosystems. It plays a vital role in food and nutritional security due to its high calcium, dietary fiber, and micronutrient content. Ragi is predominantly grown by small and resource-poor farmers and is valued for its resilience to drought and poor soils. However, despite its hardy nature, ragi is vulnerable to several insect pests, especially during the early stages of crop growth, which can significantly affect plant establishment and final yield. In recent years, changes in agronomic practices such as continuous cereal-based cropping, reduced tillage, and residue retention have altered pest dynamics in millet ecosystems. One such pest gaining attention is the Ghujhia weevil, *Tanymecus indicus* Marshall (Coleoptera: Curculionidae). Although this species has long been recognized as a serious pest of wheat, barley, and mustard, its occurrence on millets, including ragi, has been increasingly reported, particularly at the seedling stage. In finger millet, the pest acts mainly as a stand-reducing insect, causing damage soon after crop emergence.

The adult weevils are surface-active feeders that cut or scrape the stem near the collar region of young seedlings, resulting in wilting, deadheart formation, and drying of plants. Such damage often appears in patches, leading to uneven crop stands and, in severe cases, necessitating re- sowing. The immature stages remain concealed in the soil, feeding on roots and completing development in earthen chambers, which makes management difficult and allows the pest to persist across seasons. Given the economic importance of finger millet and the increasing relevance of *T. indicus* under millet-based cropping systems, a clear understanding of its biology, damage pattern, and management options is essential. This review focuses on the pest status of Ghujhia weevil in ragi, highlighting its identification, life cycle, symptoms of damage, field detection, and integrated management strategies. Emphasis is placed on sustainable and IPM-based approaches to minimize crop loss while reducing dependence on chemical insecticides.

**Pest Identity and Taxonomy**

**Common Name :** Ghujhia weevil

**Scientific Name** : *Tanymecus indicus*

**Order** : Coleoptera

**Family** : Curculionidae

**Subfamily** : Brachyderinae

**Host Range**

*Tanymecus indicus* has historically been recorded on rabi cereals such as wheat, barley and mustard; several surveys and pest compendia also list millets (ragi) and other cereals as occasional hosts under favourable field conditions. In millet systems, damage is most severe when sowing coincides with adult activity and where seedbeds are sown in conserved residues or in no-till situations. Finger millet is reported as an incidental host, particularly at seedling stage.

**Origin and Distribution**

*Tanymecus indicus* Marshall is an **indigenous weevil species of the Indian subcontinent**, long recognized as a pest in cereal-dominated farming systems. Although it was initially reported mainly on wheat and other rabi crops, recent entomological surveys have documented its presence on millets, including finger millet (*Eleusine coracana*), particularly during early crop growth stages. The species is **widely prevalent across different agro-climatic zones of India**, ranging from northern plains to central and southern regions. Its continued occurrence is closely linked to soil-based survival of immature stages and farming practices such as repeated cereal cultivation and minimal soil disturbance. Under suitable environmental and cropping conditions, populations may build up locally, resulting in sporadic infestations in millet fields.

**Morphology and Diagnostic Characters**

The adult *Tanymecus indicus* is a small to medium-sized weevil measuring approximately **5–8 mm in length**, with a robust, oval body and a **short, broad rostrum** typical of entimine weevils (Singh & Sharma, 2021). The body is generally **greyish-brown to dark brown**, with earthy mottling that provides effective camouflage against the soil background; the elytra bear distinct longitudinal striations (Rathod et al., 2020). Antennae are geniculate with a compact club, and the legs are stout, adapted for movement on soil surfaces (Patel et al., 2020). The larva is a **C-shaped, creamy white, apodous grub** with a well-developed brown head capsule, adapted for subterranean root feeding (Singh & Sharma, 2021). Pupation occurs in the soil, where the insect forms an **exarate pupa inside an earthen cell**, showing visible developing appendages (Reddy et al., 2023). The combination of soil-dwelling immature stages and adult seedling-cutting behavior serves as a key diagnostic feature distinguishing *T. indicus* from other early-season millet pests (Rathod et al., 2020).

**Life Cycle**

*Tanymecus indicus* follows a complete metamorphosis and a single annual generation: adults emerge from the soil with the onset of monsoon rains (June–July), feed and mature sexually by October, and then mate and lay 6–76 eggs in 5–11 installments in soil crevices; the egg stage lasts about 6–7 weeks, followed by grubs that feed in soil for roughly 10–18 days,larvae can take a longer period (≈3 months) to complete development under field conditions, before pupating in earthen chambers 15–60 cm deep for 7–9 weeks, after which the next generation of adults emerging by June–July, causing damage to young crops especially during October–November when rabi seedlings appear.(Eagri, 2020)

**Symptoms**

Damage caused by *Tanymecus indicus* is most evident during the **seedling to early vegetative stages** of ragi, when adult weevils feed at or just above the soil surface (Reddy et al., 2023). Adults **cut or scrape the stem near the collar region**, resulting in characteristic **deadheart symptoms**, wilting, and eventual drying of young plants (Rathod et al., 2020). Affected fields show **patchy crop stands and reduced plant population**, and severe infestations may necessitate re-sowing (Patel et al., 2020). Larval feeding on roots occurs below ground and may cause **stunting and poor plant vigor**, although this damage is usually less conspicuous than adult feeding (Singh & Sharma, 2021). The extent of damage is strongly influenced by sowing time, soil conditions, and synchronization of crop emergence with peak adult activity (Reddy et al., 2023).

**Field Detection**

Field detection of *Tanymecus indicus* is most effective during the **early morning or late evening**, when adults are active on the soil surface near emerging seedlings (Rathod et al., 2020). Infested ragi fields exhibit **patchy gaps in plant stand**, with seedlings cleanly cut at the collar region and minimal leaf feeding, which helps differentiate ghujhia weevil damage from that of cutworms or other pests (Singh & Sharma, 2021). Adults can be located by lightly disturbing soil around damaged seedlings, where they hide in cracks or under clods during the day (Patel et al., 2020).

The **economic threshold level (ETL)** is generally considered to be **1–2 adult weevils per square meter or about 5–10% seedling damage**, particularly during the seedling stage, beyond which economic loss may occur (Reddy et al., 2023; Singh & Sharma, 2021). Detection of active adults along with fresh seedling cutting at or above this threshold indicates the need for immediate IPM intervention to prevent stand loss and yield reduction (Reddy et al., 2023).

**Movement and Multiplication**

*Tanymecus indicus* adults exhibit **limited dispersal ability** and predominantly move along the soil surface, spreading slowly within cropped areas rather than migrating over long distances (Singh & Sharma, 2021). During warmer parts of the day, adults remain hidden in soil crevices or beneath plant residues, becoming active mainly during cooler hours for feeding (Rathod et al., 2020). Reproduction occurs in the soil, where females deposit eggs near the base of host plants, and the larvae complete their development underground on plant roots (Patel et al., 2020).

Population increase is closely associated with **favorable agronomic practices**, such as repeated cultivation of cereals or millets and minimal soil disturbance, which enhance survival of soil stages (Reddy et al., 2023). Because all immature stages remain protected below ground, the pest can persist between cropping seasons and may reach damaging levels when environmental conditions and crop growth stages coincide (Singh & Sharma, 2021).

**Damaging Stage of Pest**

In *Tanymecus indicus*, the **adult stage is the most economically damaging**, particularly during the seedling and early vegetative stages of ragi (Reddy et al., 2023). Adult weevils feed at or near the soil surface, cutting or scraping the stem at the collar region, which leads to deadheart formation and loss of plant stand (Rathod et al., 2020). Although the larvae feed on roots below ground, their damage is generally less visible and contributes mainly to reduced plant vigor rather than direct plant mortality (Singh & Sharma, 2021). Pupae do not cause any damage to the crop. Therefore, management strategies are primarily directed against the adult stage during the early crop growth period to prevent economic losses (Patel et al., 2020)

**Preventive methods**

**Crop rotation** with non-host crops (legumes or oilseeds) disrupts the pest life cycle by eliminating suitable oviposition and larval development sites in soil. **Use of healthy, well-cleaned seed** ensures uniform germination and rapid seedling establishment, reducing vulnerability to adult cutting. **Avoidance of staggered or delayed sowing** is recommended, as late-sown ragi often coincides with peak adult activity of Ghujhia weevil, increasing seedling mortality. **Field sanitation**, including removal of volunteer cereals and grassy weeds along bunds and field margins, prevents carry-over of adults between seasons. Preventive practices are repeatedly highlighted in millet pest reviews as the most sustainable first line of defense (Reddy et al., 2023; Singh & Sharma, 2021).

**Cultural and Mechanical methods**

Plowing fields during the hot summer months (April–May) exposes the larvae and pupae to solar heat and avian predators, significantly reducing the population for the next season. Growing ragi with non-host or repellent crops like **mustard, linseed, or wheat** can lower the overall infestation density. In the early stages of infestation, hand-picking adult weevils from young seedlings and destroying them is a localized but effective control. Rotating ragi with non-host crops prevents the weevil from establishing a permanent niche in the soil. Avoiding broad-spectrum chemicals helps preserve natural predators like **spiders and coccinellid beetles**, which are known to inhabit ragi ecosystems and help balance pest populations. Install 10–15 T-shaped perches per acre **immediately after sowing** to encourage predatory birds to hunt surface-active weevils. Although labor-intensive, mechanical measures are effective when combined with cultural practices, particularly during early crop stages (Patel et al., 2020). Multiple field surveys and millet IPM reviews confirm that cultural manipulation significantly reduces Ghujhia weevil incidence without chemical inputs (Rathod et al., 2020; Reddy et al., 2023).

**Biological methods**

250 kg per hectare (approximately 100 kg per acre).**Crop Stage:** Incorporate into the soil during the **final land preparation** (pre-sowing) to deter egg-laying and larval development.

**Dose:** 3% to 5% concentration (30–50 ml per liter of water).**Crop Stage:** Foliar spray at the **seedling stage** (roughly 10–15 days after emergence) to prevent adults from feeding on tender leaves. Neem Seed Kernel Extract 5% can also reduce adult feeding on foliage. Extracts from **garlic, chili**, or other pungent plants applied to the foliage can discourage adult weevils from feeding on tender shoots. Soil drenching with Entomopathogenic Nematodes (EPN) (e.g., Steinernema or Heterorhabditis species) can be highly effective against the soil-dwelling larval and pupal stages. Application of Entomopathogenic Fungi like Beauveria bassiana (White Muscardine Fungus) 5–10 g per liter of water for foliar spray or 1–2 kg per acre for soil drenching.

Crop Stage: Apply as a soil drench at sowing or transplanting to target larvae. Use foliar sprays during the seedling stage (10–30 days after sowing) when adult weevils typically emerge and Metarhizium anisopliae (Green Muscardine Fungus):Dose: 8–10 g per liter of water for soil drenching or 1.5–2 kg mixed with 100 kg of Farm Yard Manure (FYM) per acre.Crop Stage: Best applied as a pre-sowing soil treatment or at the seedling stage to control root-dwelling grubs and emerging adults. Although large-scale field validation in ragi is limited, biological control is strongly recommended as part of long-term sustainable IPM (Kumar et al., 2021; Singh et al., 2022).

**Chemical method**

Soil application at sowing or planting has been found effective in reducing earlystage infestation by targeting soil-dwelling stages of Tanymecus indicus. Application of Phorate 10G at 10 kg $ha^{-1}$ in the seed furrows during sowing helps suppress emerging adults and larvae present in the soil (Patel et al., 2020; Singh & Sharma, 2021). Similarly, Cartap hydrochloride 4G applied at 10 kg per acre has been reported to provide effective protection to young seedlings by controlling subterranean stages of the pest (Rathod et al., 2020). **Foliar application after crop emergence** is primarily aimed at managing the economically damaging adult stage. Spraying **Chlorpyriphos 20 EC at 2.5 ml $L^{-1}$ of water**, around 10 days after emergence, has been shown to significantly reduce adult population and seedling damage when applied during peak activity periods (Patel et al., 2020; Reddy et al., 2023). **Carbaryl 50 WP at 1 kg $ha^{-1}$,** diluted in approximately 500 L of water, is another recommended option for controlling adult weevils feeding near the soil surface (Rathod et al., 2020). Dusting with **Malathion 5% D at 25 kg $ha^{-1}$** has been traditionally practiced in cereal systems and remains effective against surface-active adults in early crop stages (Singh & Sharma, 2021). In addition, **Lambda-cyhalothrin 2.5 EC applied at 1 ml $L^{-1}$** has been reported as an effective foliar insecticide providing rapid knockdown of adult weevils when infestation crosses the economic threshold level (Reddy et al., 2023).

**Conclusion**

Research consistently indicates that adult-stage management at the seedling phase is critical for controlling Ghujhia weevil in ragi. An integrated approach combining preventive, cultural, mechanical, biological, and need-based chemical measures provides effective and environmentally sustainable control. Over-reliance on chemicals is discouraged due to soil persistence and non-target effects.

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**GRAM POD BORER IN RAGI**

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**Abstract**

Finger millet (*Eleusine coracana*) is a hardy grain that's a super nutritious annual herb plant. It is a tetraploid and self-pollinating species probably evolved from its wild relative Eleusine africana. It grows great where it doesn't rain much. Usually, bugs don't mess with it too much, but sometimes the gram pod borer (*Helicoverpa armigera*) shows up and causes trouble, particularly during the flowering and grain development stages. The larvae feed on developing grains while they're growing, which means less food later and worse quality. This paper is all about how to handle these pests using different methods.

**Key words :** Finger millet, gram pod borer, grain damage, biology of pest, control measures.

**Introduction**

Finger millet is an annual self-pollinated tetraploid cereal crop grown for its nutritious seeds, mostly in semi-arid regions of Africa and Asia. It is sometimes known as ragi, an important crop of smallholder farmers in India, Nepal, and the highlands of eastern and southern Africa. This gluten-free cereal is known for being super nutritious, which makes it a great way to deal with poor nutrition. Growing finger millet helps in two ways: it feeds rural families and helps them earn a living. It's full of things like calcium and iron. It's a really important food, mainly for farmers who live where it's dry. Most of the time, finger millet can handle bugs better than other grains. But if the weather is just right for pests, or if other yummy crops are nearby, problems can pop up. The gram pod borer loves munching on stuff like beans and cotton, but it will hit finger millet if it gets the chance. And if they get into the grain heads, it can be bad news for the harvest if you don't do anything about it.

**Scientific classification**

**Common name:** Gram pod borer

**Scientific name:** *Helicoverpa armigera*

**Order:** Lepidoptera **Family:**

Noctuidae **Subfamily:**

Heliothinae

**Origin and distribution**

There are two types of this species. You'll find Helicoverpa armigera armigera in central and southern Europe, temperate Asia, and Africa. Helicoverpa armigera conferta is from Australia and Oceania. The first type showed up in Brazil not too long ago and has moved across a lot of South America and into the Caribbean. These guys migrate, so they can even get as far as Scandinavia and other places up north.

**Life cycle**

The female bug can lay hundreds of eggs all over the plant. If the weather is good, these eggs can hatch into larvae in about three days, and the whole life cycle wraps up in about a month. The eggs are spherical and 0.4 to 0.6 millimetres in diameter, and have a ribbed surface. The eggs are first seen in white then later becoming greenish colour. The larvae grow for about 13 to 22 days, getting up to 40 mm long by their sixth stage. They come in different colors, but are usually greenish-yellow or reddish-brown. Their heads are yellow with a few spots. You'll see three dark stripes down their back and a light yellow stripe along their sides, just under the breathing holes. The underside is light-colored. These larvae can be pretty feisty, sometimes they eat other bugs and even each other! If you bother them, they'll drop off the plant and curl up on the ground. They turn into pupae inside a silk cocoon for about 10 to 15 days, buried 4–10 cm deep in the ground.

**Host plants**

Helicoverpa armigera isn't picky. It is a highly polyphagous species. It eats a lot of different plants over 180 types. The most important crop hosts are tomato, cotton, pigeon pea, chickpea, rice, sorghum, and cowpea. Finger millet is more like a snack for them. They usually go for it when their favorite foods are close by or when there are just too many borers around.

**Symptoms and damage**

The larvae are the problem. The young ones eat the flowers and soft stuff. The older ones bore into the grain heads and eat the developing grains. You'll see holes, webbing, and bug poop (frass) on the grain heads. If it's really bad, the grains get wrecked, and you get less food. It's important to catch these pests early. Look for moths flying around at dusk and check the grain heads for eggs and larvae. Signs include damaged flowers, holes in grains, bug poop, and chewed-up grain heads. Traps can help you keep tabs on the moth population.

**Movement and multiplication**

Moths can fly far to find food. They have lots of babies, which grow fast. Since they can eat many different crops, they can keep coming back to finger millet fields. Warm weather helps them spread even faster. The larva stage is the bad one because the later stages eat the grain heads. Then it causes severe yield loss. It is not a major pest in finger millet but once it comes, creates major effects on plants.

**Integrated pest management**

**Cultural method:** To manage pests, farmers can plant trap crops like cowpea, sunflower, maize, or marigold alongside their main crops. It's a good idea to switch to cereal crops or other plants that pests don't like to slow down their multiplication. When planting, give plants more room, and clear out weeds and leftover plant bits. Also, putting up bird perches and making good homes for pest predators can really help keep those pest numbers down..

**Mechanical method:** Farmers with small plots can pick off and kill the eggs and young caterpillars. Because it requires more time and labours. Low-cost options include hand-picking adults early in the morning, beating plants over sheets for removal, and physical destruction of egg clusters. For smallholders, edge targeted removal reduces initial colonization.

**Biological method:** Release of Trichogramma chilonis in borer infested field for 6 times @ 50,000 parasitized eggs per hectare soon after appearance of moth in field. Spray Bt. based formulation like DIPEL or BIOLEP @ 3gm per lit water during evening time at 10 days interval. Spray neem based pesticides such as Margosom or Neemarin or Biomultineem @ 5ml per liter water.

**Conclusion**

It can cause serious problems for finger millet and it have wide range of host plants. We can reduce the damage by finding them early, using good farming practices, encouraging natural enemies, and spraying when needed. The important part is to manage them well and your farm will be good for a long time.

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**TERMITES IN RAGI**

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**Abstract**

Termites are among the most destructive soil-dwelling insect pests affecting dryland agriculture, including ragi (*Eleusine coracana*), particularly under rainfed and semi-arid conditions. In India, termite species such as *Odontotermes obesus* Rambur and *Microtermes obesi* Holmgren have been frequently reported to cause damage to ragi by feeding on roots and basal stem portions, resulting in wilting, plant mortality, and yield reduction (Rana et al., 2021; ICAR, 2018). Termite infestation is closely associated with climatic factors such as prolonged dry spells following rainfall, light-textured soils, and presence of undecomposed organic matter in the field (Verma & Rana, 2019). Due to their cryptic and subterranean habit, termite damage often goes unnoticed until severe crop loss occurs (Hill, 2020). Understanding termite biology, ecology, and seasonal activity is essential for timely detection and effective management. This assignment synthesizes information from research articles, ICAR publications, and agricultural technology portals to provide a comprehensive overview of termite pests of ragi, including taxonomy, morphology, life cycle, damage symptoms, field detection, and management strategies with special emphasis on integrated pest management (IPM) approaches (Krishna et al., 2013; TNAU, 2020).

**Keywords:** Termites; *Odontotermes obesus*; *Microtermes obesi*; ragi; finger millet; soil insect pests; dryland crops; integrated pest management

**Introduction**

Ragi (*Eleusine coracana* L.), commonly known as finger millet, is one of the most important minor millets cultivated in India and several parts of Africa, primarily under rainfed and marginal farming conditions. It plays a crucial role in food and nutritional security due to its high calcium, iron, dietary fibre, and essential amino acid content, making it especially valuable for rural and tribal populations (ICAR, 2018; FAO, 2019). India is the largest producer of ragi, with major cultivation concentrated in Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Odisha, and parts of Maharashtra, where the crop is grown in low-input systems (Rana et al., 2021). Despite its reputation as a hardy and drought-tolerant crop, ragi is susceptible to several insect pests that can significantly affect crop establishment, growth, and yield (Hill, 2020).

Among the insect pests affecting ragi, soil-dwelling pests such as termites pose a serious and often underestimated threat. Termites are social insects that live in organized colonies and feed primarily on cellulose-rich materials, including living plant tissues, crop residues, and organic matter present in the soil (Krishna et al., 2013). In ragi cultivation, termites mainly attack the roots and basal portions of the stem, leading to wilting, drying, and eventual death of plants, particularly during early crop stages (ICAR, 2018). Damage caused by termites is often patchy and difficult to detect at early stages due to their concealed subterranean feeding habit, which frequently results in sudden crop failure without obvious external symptoms (Verma & Rana, 2019).

The severity of termite infestation in ragi is closely linked to agro-climatic conditions such as prolonged dry spells, light-textured soils, low soil moisture, and the presence of undecomposed crop residues (Rana et al., 2021). Termite activity generally increases after rainfall followed by dry weather, as these conditions favour tunnelling and foraging behaviour (Hill, 2020). Changing agricultural practices, including reduced tillage, continuous cropping, and residue retention, have further contributed to increased termite incidence in dryland farming systems (ICAR, 2018). Climate change, particularly erratic rainfall patterns and rising temperatures, is also expected to exacerbate termite problems in millet-based cropping systems (FAO, 2019).

Termite infestation in ragi not only leads to yield loss but also affects crop uniformity and economic returns, especially for small and marginal farmers who depend on the crop for subsistence (Rana et al., 2021). Due to their polyphagous nature and wide host range, termites persist in agricultural landscapes even during fallow periods, making their management challenging (Krishna et al., 2013). Therefore, a thorough understanding of termite species, biology, damage mechanisms, seasonal activity, and management strategies is essential for developing effective and sustainable control measures. This assignment aims to provide a comprehensive review of termites in ragi by synthesizing information from research publications, ICAR reports, and agricultural extension portals, with particular emphasis on integrated pest management approaches for long-term control.

**Pest Identify and Taxonomy**

**Common name** : Termites

**Scientific name :** *Odontotermes obesus*

**Order** : Blattodea

**Family :** Termitidae

**Subfamily :** Macrotermitinae

**Host Range**

Termites are highly polyphagous pests with a very wide host range, which contributes significantly to their persistence and economic importance in agricultural ecosystems. Species such as *Odontotermes obesus* and *Microtermes obesi* infest numerous cultivated crops including cereals, millets, pulses, oilseeds, sugarcane, cotton, vegetables, and plantation crops (Rana et al., 2021; ICAR, 2018). Among cereals, wheat, rice, maize, sorghum, pearl millet, and finger millet (ragi) are commonly affected, particularly during early crop growth stages (Verma & Rana, 2019). In addition to cultivated crops, termites also feed on grasses, weeds, forest vegetation, and organic debris present in soil, which allows them to survive even during fallow periods (Krishna et al., 2013). The ability of termites to utilize dead plant residues and cellulose-rich materials enables them to maintain large colonies near agricultural fields (Hill, 2020). In ragi-based cropping systems, termite infestation is often higher when the crop follows cereals or sugarcane, due to the abundance of leftover stubbles and organic matter (ICAR, 2018). Termites also infest nursery seedlings and young transplants, leading to establishment failure (TNAU, 2020). Their broad host range makes crop rotation alone insufficient for termite management, necessitating integrated approaches that reduce habitat suitability and food availability (Rana et al., 2021).

**Origin and distribution**

The termite species infesting ragi, particularly *Odontotermes obesus* and *Microtermes obesi*, are native to tropical and subtropical regions of Asia and have evolved under warm climatic conditions with seasonal rainfall patterns (Krishna et al., 2013). These species are widely distributed across the Indian subcontinent, including India, Pakistan, Sri Lanka, Nepal, and Bangladesh (Hill, 2020). In India, termites are prevalent in dryland and semi-arid agro- ecological zones where low soil moisture and high temperatures favour subterranean activity (ICAR, 2018). States such as Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Madhya Pradesh, Rajasthan, and Odisha report frequent termite incidence in ragi and other rainfed crops (Rana et al., 2021). Termite populations are strongly influenced by soil type, with sandy loam and light-textured soils being more conducive to colony establishment and tunnelling (Verma & Rana, 2019). Changes in land use, reduced flooding, and increased residue retention under conservation agriculture have further expanded termite distribution in cultivated areas (ICAR, 2018). Climate change, particularly prolonged dry spells and erratic rainfall, is expected to increase termite incidence and damage severity in millet-based cropping systems (Hill, 2020).

**Morphology and distribution**

Termites are small to medium-sized, soft-bodied insects that are generally pale white to light brown in colour, an adaptation to their subterranean lifestyle (Krishna et al., 2013). A termite colony is composed of distinct castes, including workers, soldiers, reproductives (alates), queen, and king, each with specialized morphology and function (Hill, 2020). Worker termites are wingless, blind, and possess well-developed mandibles for feeding on plant material and constructing galleries; they are responsible for most crop damage (ICAR, 2018). Soldiers are characterized by enlarged heads and strong mandibles or nasute snouts used for colony defense (Verma & Rana, 2019). Reproductive forms are darker in colour and possess two pairs of equal-sized wings during swarming, which later break off after mating (Krishna et al., 2013). In the field, termite infestation in ragi can be diagnosed by the presence of mud- plastered earthen galleries on the soil surface and around the basal portions of plants (TNAU, 2020). Plants affected by termites often show hollowed stems near the base and absence of feeder roots upon uprooting (ICAR, 2018). These diagnostic characters help distinguish termite damage from other soil pests such as white grubs or root borers (Hill, 2020).

**Life Cycle and Phenology**

Termites exhibit an incomplete metamorphosis, with their life cycle consisting of egg, nymph, and adult stages, all of which occur within the colony environment (Krishna et al., 2013). The queen lays thousands of eggs over her lifetime, ensuring continuous colony growth and persistence in agricultural fields (Hill, 2020). Eggs hatch into nymphs, which later differentiate into various castes such as workers, soldiers, or reproductives based on colony requirements and environmental conditions (Verma & Rana, 2019). Worker termites remain active throughout the year and are primarily responsible for foraging, feeding, and nest construction, making them the most damaging stage in ragi cultivation (ICAR, 2018). Phenologically, termite activity in ragi fields is strongly influenced by seasonal climatic conditions, particularly soil moisture and temperature (Rana et al., 2021). Swarming of winged reproductives generally occurs during the onset of monsoon or immediately after rainfall, facilitating dispersal and establishment of new colonies (Krishna et al., 2013). Peak infestation in ragi is commonly observed during dry periods following rains, when termites intensify feeding on crop roots due to reduced availability of decaying organic matter (Verma & Rana, 2019). Understanding termite phenology helps in predicting infestation periods and implementing timely management practices (ICAR, 2018).

**Symptoms and Damage**

Termite damage in ragi is primarily subterranean and often remains unnoticed until visible symptoms appear above ground (Hill, 2020). The earliest symptom includes yellowing and wilting of young seedlings, which gradually progress to drying and plant death under severe infestation

(ICAR, 2018). Termites feed on roots and basal stem tissues, disrupting water and nutrient uptake, leading to stunted growth and poor tillering (Rana et al., 2021). In affected plants, the stem base becomes hollow, weak, and brittle, making the plants easy to uproot (Verma & Rana, 2019). Patchy crop failure is a characteristic symptom, as termite colonies damage clusters of plants within their foraging range (TNAU, 2020). Mud-plastered earthen galleries around plant bases and on soil surfaces are typical signs of termite activity in ragi fields (Hill, 2020). In severe cases, complete plant loss occurs during early growth stages, resulting in poor crop establishment and significant yield reduction (ICAR, 2018). Termite damage is often confused with drought stress, highlighting the need for careful field diagnosis (Rana et al., 2021).

**Field Detection**

Early detection of termite infestation in ragi fields is challenging due to their concealed feeding habit below the soil surface (Hill, 2020). Regular field scouting is essential, particularly during dry periods following rainfall, when termite activity is at its peak (ICAR, 2018). Key indicators include uneven plant growth, sudden wilting, and drying of plants in localized patches (Verma & Rana, 2019). Presence of earthen tunnels or mud galleries on the soil surface, around plant bases, or on exposed roots serves as a reliable diagnostic indicator (TNAU, 2020). On uprooting affected plants, damaged or missing roots and hollowed stem bases can be observed, often with termites present nearby (Rana et al., 2021). Baiting techniques using wooden sticks, cardboard, or crop residues buried in soil can be used to monitor termite populations and activity levels (Hill, 2020). Such detection methods help in assessing infestation severity and deciding the need for intervention, thereby preventing unnecessary pesticide application (ICAR, 2018). Timely identification of termite hotspots allows targeted management and reduces overall crop loss in ragi cultivation (Verma & Rana, 2019).

**Movement and Multiplication**

Termites exhibit both localized and long-distance movement, which plays a critical role in their spread and population build-up in ragi fields. Local movement primarily occurs through underground tunnel networks constructed by worker termites, enabling them to forage over large areas while remaining protected from predators and desiccation (Krishna et al., 2013). These subterranean galleries allow termites to move from existing colonies to crop root zones without surface exposure, resulting in gradual but extensive infestation within a field (Hill, 2020). Long-distance dispersal occurs through swarming of winged reproductives (alates), usually triggered by the onset of monsoon rains or sudden increases in soil moisture (Rana et al., 2021). After mating flights, alates shed their wings and establish new colonies in suitable habitats, often near cultivated fields with abundant organic matter (Verma & Rana, 2019). Colony multiplication is continuous due to the high egg-laying capacity of the queen, which can produce thousands of eggs over her lifetime (Krishna et al., 2013). Agricultural practices such as residue retention, minimum tillage, and monocropping favour termite multiplication by providing shelter and food resources (ICAR, 2018). Thus, both natural dispersal mechanisms and agronomic factors contribute to the rapid spread and persistence of termite populations in ragi ecosystems (Hill, 2020).

**Damaging Stage of Pest**

Among the various castes present in a termite colony, the worker caste is the most destructive stage responsible for crop damage in ragi (ICAR, 2018). Worker termites actively feed on living plant tissues, particularly roots and basal stem portions, which are rich in cellulose and nutrients (Verma & Rana, 2019). Their continuous feeding disrupts vascular tissues, leading to impaired water and nutrient transport and eventual plant death (Rana et al., 2021). Unlike other insect pests that cause visible feeding injury, termite workers feed internally and below ground, making early detection difficult (Hill, 2020). Soldiers play no direct role in crop damage and are primarily involved in colony defense, while reproductives are responsible for colony establishment and expansion (Krishna et al., 2013). The damaging activity of worker termites is most pronounced during dry conditions, when they intensify feeding on live plants due to reduced availability of decaying organic matter (ICAR, 2018). Understanding the role of the worker caste is essential for designing effective management strategies targeting the most destructive stage of the pest (Verma & Rana, 2019).

**Preventive Methods**

Preventive management is a crucial component of termite control in ragi, as it aims to reduce the risk of infestation before significant damage occurs (ICAR, 2018). Removal of termite mounds in and around fields prior to sowing helps reduce initial pest pressure (Rana et al., 2021). Proper land preparation, including deep ploughing during summer, exposes termite colonies to heat, predators, and desiccation, thereby lowering their survival (Hill, 2020). Avoidance of excessive crop residues and undecomposed organic matter in fields helps reduce termite food sources (Verma & Rana, 2019). Maintaining optimal soil moisture through timely irrigation discourages termite activity, as termites prefer dry soil conditions (ICAR, 2018). Crop rotation with less susceptible crops and synchronized sowing can also reduce termite incidence (TNAU, 2020). Preventive measures are environmentally safe and cost-effective, forming the foundation of integrated termite management in ragi cultivation (Rana et al., 2021).

**Cultural and Mechanical Methods**

Cultural and mechanical practices are essential components of termite management in ragi (*Eleusine coracana*) because they reduce termite population and prevent crop damage in an environmentally safe and sustainable manner (ICAR, 2018; Rana et al., 2021). These practices work by disrupting termite habitat, reducing food availability, and exposing colonies to natural enemies and environmental stressors. Removal of crop residues, stubbles, and other organic debris from fields before sowing reduces the availability of food sources for termites. Termites feed extensively on decomposing plant matter, and clearing these residues limits their survival and colony establishment in ragi fields (Verma & Rana, 2019; TNAU, 2020). Ploughing the field during summer exposes termite colonies, eggs, and workers to sunlight, predators, and desiccation. This practice significantly reduces termite populations in the soil and decreases the chances of infestation in subsequent crops (Hill, 2020; ICAR, 2018). Visible termite mounds or earthen nests in and around fields should be mechanically destroyed or removed before sowing. Breaking the mounds disrupts colony integrity and exposes termites to natural mortality factors (Rana et al., 2021). Rotating ragi with less susceptible crops or intercropping with legumes can reduce termite infestation by interrupting their food supply and altering the field microenvironment. Termites are less likely to establish in fields with non-preferred hosts (ICAR, 2018; Verma & Rana, 2019). Sowing ragi at the onset of the monsoon ensures rapid seedling establishment, making the crop less vulnerable to early termite attack. Young seedlings are more susceptible to termite feeding; early sowing helps them escape critical damage periods (TNAU, 2020). Where feasible, temporary flooding or maintaining higher soil moisture in fields can suppress termite activity because termites prefer dry conditions. Increased soil moisture reduces their tunnelling and foraging behaviour (Hill, 2020). Incorporating sand layers, coarse soil, or ash around the root zone of seedlings acts as a mechanical barrier, making it difficult for termites to reach the plant base (ICAR, 2018).

**Biological Methods**

Biological control of termites in ragi focuses on the use of natural enemies and microbial agents that suppress termite populations without harming the environment (Rana et al., 2021). Entomopathogenic fungi such as *Metarhizium anisopliae* and *Beauveria bassiana* have been widely studied for termite management due to their ability to infect and kill worker termites under suitable soil conditions (Kumar et al., 2022). These fungi penetrate the termite cuticle, multiply within the body, and eventually cause death, thereby weakening the colony (Hill, 2020). Application of fungal formulations to soil or termite mounds has shown promising results in reducing termite activity in dryland crops (Verma & Rana, 2019). Predators such as ants, birds, and certain beetles also contribute to natural regulation of termite populations (Krishna et al., 2013). Conservation of natural enemies through reduced pesticide use enhances the effectiveness of biological control (ICAR, 2018). Although biological methods alone may not provide immediate control, they are valuable components of integrated pest management due to their sustainability and minimal environmental impact (Rana et al., 2021).

**Chemical Methods**

Chemical control is an important component of termite management in ragi, especially under high infestation where preventive and cultural measures may not suffice (TNAU Agritech Portal, 2025). The main goal is to reduce termite populations in the soil, around root zones, or near colonies, thereby preventing damage to seedlings and young plants. Seed treatment with systemic insecticides like imidacloprid (0.1% solution) protects emerging seedlings by creating a toxic zone around roots, preventing early termite attacks (TNAU Agritech Portal, 2025). Systemic insecticides translocate into the roots and provide protection during the vulnerable early stages of crop growth.

Soil treatment with termiticides is another widely recommended method. Chemicals such as lindane 1.6 D or safer alternatives create a barrier in the soil that kills or repels termites before they reach plant roots (TNAU Agritech Portal, 2025). Such treatments are usually applied in the planting rows before sowing. Soil drenches or localized sprays with insecticides like chlorpyrifos or fipronil target foraging termites directly. These chemicals act through contact and ingestion, disrupting termite nervous systems and causing mortality (AgriBot, 2025). These applications are most effective when termites are actively feeding near the root zone. In some cases, baiting systems with slow-acting termiticides are used. Termites feed on the bait and carry it back to the colony, reducing colony numbers over time (AgroPages, 2025). While more commonly used in structural termite control, baiting can be adapted for field crops like ragi under severe infestation conditions. While chemical methods are effective, indiscriminate use can harm soil health, non-target organisms, and the environment. Persistent organochlorines, once widely used, are now restricted or banned due to their toxicity (Academic Journal, 2025). Modern management emphasizes judicious, targeted application, integrated with cultural and biological strategies, to achieve sustainable termite control in ragi cultivation.

**Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) is the most effective and sustainable approach for managing termite infestation in ragi, as it combines multiple compatible strategies to keep pest populations below economic injury levels while minimizing environmental impact (ICAR, 2018). IPM for termites emphasizes prevention, monitoring, and need-based intervention rather than sole reliance on chemical control (Rana et al., 2021). Cultural practices such as deep summer ploughing, timely sowing, crop rotation, and residue management form the foundation of termite IPM by reducing suitable habitats and food sources (Verma & Rana, 2019). Regular field monitoring using visual inspection and baiting techniques helps in early detection of termite activity and identification of infestation hotspots (Hill, 2020). Biological control agents like *Metarhizium anisopliae* and *Beauveria bassiana* are incorporated to suppress termite populations in an eco-friendly manner and maintain soil biodiversity (Kumar et al., 2022). Chemical control is used only as a last resort, through seed treatment or localized soil application of recommended insecticides, thereby reducing non-target effects and pesticide residues (ICAR, 2018). Farmer awareness and adoption of IPM practices play a crucial role in long-term termite management and sustainable ragi production (Rana et al., 2021).

**Conclusion**

Termites constitute a serious but often underestimated constraint in ragi cultivation, particularly under dryland and rainfed agro-ecosystems. Species such as *Odontotermes obesus* and *Microtermes obesi* cause significant damage by feeding on roots and basal stems, leading to plant wilting, patchy crop loss, and yield reduction (ICAR, 2018; Rana et al., 2021). Their concealed subterranean habit and year-round activity make early detection and management challenging (Hill, 2020). Understanding the biology, life cycle, damage symptoms, and seasonal activity of termites is essential for designing effective control strategies (Krishna et al., 2013). Preventive and cultural practices form the backbone of termite management, while biological and chemical methods provide supportive control when required (Verma & Rana, 2019). Integrated Pest Management offers a holistic, environmentally safe, and economically viable solution for managing termites in ragi (ICAR, 2018). Adoption of IPM practices will not only reduce yield losses but also promote sustainable agriculture and soil health in millet-based farming systems (Rana et al., 2021).

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**APHIDS ON WHEAT**

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**Abstract**

Aphids constitute one of the most important sap-feeding insect pests of wheat and are responsible for considerable qualitative and quantitative yield losses worldwide. They attack wheat at different growth stages and form dense colonies on leaves, stems and ear heads. Aphids remove plant sap, disturb source–sink relationships and adversely affect photosynthesis. They also excrete honeydew that promotes the growth of sooty mould and interferes with normal physiological functions. In addition to direct damage, many aphid species act as efficient vectors of viral diseases such as barley yellow dwarf virus which further increases yield loss. Because of rapid parthenogenetic reproduction, short generation time and ability to survive on several alternative hosts, aphids can build up to outbreak levels within a short time under favorable environmental conditions. This assignment presents detailed information on the taxonomy, host range, morphology, life cycle, symptoms of damage and various management strategies with emphasis on integrated pest management for sustainable wheat production.

**Keywords**: Wheat aphids, Sitobion avenae, Rhopalosiphum padi, Schizaphis graminum, Honeydew, Barley yellow dwarf virus, IPM, Biological control

**Introduction**

Wheat (Triticum aestivum L.) occupies a premier position among food crops of the world. In many countries it forms the staple diet and major source of carbohydrates and plant protein. To meet the growing demand of the increasing population, protection of wheat from biotic and abiotic stresses is highly essential. Among insect pests, aphids have attained the status of key pests due to their high reproductive potential, wide host range and ability to transmit important plant viruses. Losses due to aphids depend on wheat variety, stage of attack, climatic conditions and associated pathogens but can be substantial when heavy infestations coincide with the grain filling stage. Recent changes in climate, particularly warm winters and extended dry periods, favor aphid survival and multiplication which makes their management still more challenging. Therefore, a clear understanding of their biology and behavior is fundamental for designing eco-friendly management strategies.

**Pest identity and taxonomy**

**Kingdom:** Animalia **Phylum:**

Arthropoda

**Class:** Insecta

**Order:** Hemiptera

**Family:** Aphididae

Several aphid species are known to infest wheat, of which Sitobion avenae (English grain aphid), Rhopalosiphum padi (Bird cherry–oat aphid) and Schizaphis graminum (Greenbug) are economically important. These species differ in color and feeding preference but their basic biology is similar. Correct identification at species level helps in understanding seasonal abundance and selecting appropriate management options. Aphids possess piercing-sucking mouthparts adapted for feeding from phloem tissues and exhibit polymorphism with both winged (alate) and wingless (apterous) forms in the population.

**Host range**

Wheat aphids are polyphagous and feed on a number of cereal crops and grasses. In addition to wheat, they are frequently recorded on barley, oats, rye, maize, sorghum and several wild Poaceae species. Availability of alternative hosts during off-season enables aphids to bridge the period between crops and return to wheat when the crop is sown. The existence of such a broad host base contributes to their persistence and makes eradication practically impossible. Knowledge of host range is thus useful for planning cultural practices including crop rotation and destruction of alternate hosts around fields.

**Origin and distribution**

Aphids associated with wheat are cosmopolitan in nature and distributed throughout temperate and subtropical wheat-growing regions of the world. They are widely reported from Asia, Europe, Africa, Australia, North and South America. In India, aphids are commonly found in north-western plains, central India and parts of the eastern region where cool and dry weather prevails during rabi season. Long-distance migration of winged adults with wind currents helps in rapid spread to new areas and colonization of fresh crops, accounting for their wide distribution pattern.

**Morphology and diagnostic characters**

Adult aphids are soft-bodied, pear-shaped insects generally measuring 1–3 mm in length. Body color varies among species and may appear light green, yellowish-green, brown or nearly black. The most distinguishing features include long antennae and a pair of tube-like structures called cornicles on the posterior part of the abdomen through which defensive secretions are released. Both winged and wingless morphs occur in the same species. Winged forms possess transparent wings with few veins and are mainly responsible for dispersal, whereas wingless forms remain aggregated in colonies on plant parts. Nymphs resemble adults in appearance but are smaller and wingless. Presence of sticky honeydew and associated ants around colonies further helps in quick field identification.

**Life cycle and phenology**

Aphids exhibit complicated life cycles involving both sexual and asexual reproduction depending on climate and host availability. Under tropical and subtropical conditions prevalent in many wheat areas, reproduction is predominantly parthenogenetic and viviparous in which females directly give birth to live nymphs without egg laying. Each female produces several nymphs per day and completes its life cycle within 1–2 weeks, resulting in many overlapping generations during a single season. In temperate regions, sexual forms may appear at the end of the season and lay overwintering eggs on alternative hosts. Population build-up is greatly influenced by temperature, humidity and host plant stage. Peak infestation is generally observed from tillering to ear head emergence, although heavy populations may persist up to grain filling stage when weather remains favorable.

**Symptoms and damage**

The earliest symptom of aphid injury is mild yellowing followed by downward curling of leaves. As colonies expand, plants exhibit reduced vigor, poor tillering and general stunting due to continuous sap withdrawal. When ear heads are attacked, grains fail to develop fully and remain shriveled, leading to reduced test weight. Secretion of honeydew creates a sticky layer on leaves and ear heads over which sooty mould develops as a black coating that hampers photosynthesis. Ants are often seen attending aphid colonies to collect honeydew. Apart from direct feeding damage, aphids act as vectors of several viral diseases, notably barley yellow dwarf virus, which can cause serious epidemics even at relatively low aphid densities. Overall effects include reduction in plant height, spike length, number of grains per spike and ultimately yield.

**Field detection and key indicators**

Regular field scouting is essential for early detection of aphid infestations. Colonies are usually found on the undersurface of leaves, on stems near nodes and on developing ear heads. Presence of sticky honeydew, sooty mould and ants is a reliable indicator of infestation. Yellow sticky traps may be used to detect arrival of winged aphids in fields. Farmers are advised to examine at least 20–25 plants randomly in different parts of the field to estimate average population. Early recognition through systematic surveillance allows timely implementation of management tactics before populations exceed economic threshold levels.

**Movement and multiplication**

Aphids multiply extremely fast because of parthenogenetic reproduction and short generation time. Wingless individuals remain grouped in dense colonies and are responsible for local spread within the field. Crowding, deterioration of host plant quality or adverse environmental conditions stimulate the production of winged morphs. These winged aphids disperse actively by flight and passively over long distances by wind currents. Such efficient dispersal mechanisms, together with high fecundity, enable aphids to colonize new wheat fields rapidly and cause sudden outbreaks. Favorable temperatures between 18–25°C and relatively dry weather further accelerate multiplication.

**Damaging stage of pest**

Both nymphs and adults constitute the damaging stages of wheat aphids. All active stages possess piercing and sucking type mouthparts which penetrate phloem tissues to withdraw sap. Continuous feeding leads to loss of plant nutrients and water, disturbance in physiological processes and increased susceptibility to pathogens. Since aphids feed in colonies, the cumulative effect of their feeding results in pronounced injury, especially when ear heads are colonized during grain filling stage.

**Preventive methods**

Preventive strategies aim at avoiding or minimizing the chances of aphid buildup. Selection of tolerant or resistant wheat varieties suited to local conditions is the first line of defense. Timely sowing helps the crop escape peak aphid incidence. Balanced fertilizer application, particularly avoiding excessive nitrogen, reduces the likelihood of heavy infestation as succulent growth favors aphids. Maintenance of field sanitation by removal of volunteer wheat plants and alternative hosts around bunds and irrigation channels is also important. Adoption of crop rotation with non-host crops breaks the continuous availability of hosts and suppresses aphid populations.

**Cultural and mechanical methods**

Cultural practices such as deep summer ploughing help in exposing and destroying resting stages and weeds that serve as alternate hosts. Proper plant spacing and adequate irrigation promote healthy crop growth which can better tolerate aphid attack. Mechanical methods like clipping of heavily infested tillers and destruction of infested ear heads may be adopted in small plots or seed production fields. Spraying a strong jet of water can physically dislodge aphids from plants in garden situations. Installation of yellow sticky traps aids in monitoring and partial mass trapping of alate forms.

**Biological methods**

Aphids are naturally suppressed by a rich complex of predators, parasitoids and pathogens. Common predators include ladybird beetles (Coccinella spp.), green lacewings (Chrysoperla spp.), syrphid fly larvae and spiders that feed voraciously on both nymphs and adults. Parasitic wasps such as Aphidius spp. lay eggs inside aphids leading to formation of characteristic mummies. Entomopathogenic fungi like Verticillium and Beauveria species occasionally cause natural epizootics. Conservation of these natural enemies through reduced and selective insecticide use is an essential component of sustainable aphid management.

**Chemical method**

When aphid population exceeds the economic threshold level and natural control is inadequate, chemical control may be required. Selective systemic insecticides recommended by local agricultural authorities may be used as foliar sprays or seed treatments. Care should be taken to rotate chemicals with different modes of action to delay development of resistance. Sprays must ensure good coverage of ear heads and lower leaf surfaces where colonies reside. Unnecessary and prophylactic applications should be avoided to protect beneficial organisms and prevent residues on the produce.

**Integrated pest management (IPM)**

Integrated pest management emphasizes the combination of different compatible tactics to keep aphid populations below the economic injury level with minimum environmental impact. Major IPM components for wheat aphids include regular monitoring, use of resistant varieties, adjustment of sowing time, maintenance of field sanitation, conservation of natural enemies and need-based application of selective insecticides. Farmers should be educated to recognize early symptoms and adopt threshold-based interventions rather than routine spraying. Implementation of IPM not only reduces production costs but also safeguards ecosystem health and grain quality.

**Conclusion**

Aphids pose a persistent challenge to wheat production throughout the world. Their ability to multiply rapidly, disperse over long distances and transmit viral diseases makes them highly destructive pests. However, a thorough understanding of their biology and ecology coupled with adoption of integrated management strategies can effectively minimize losses. Emphasis should be placed on preventive and biological approaches with chemicals used only as a last resort. Sustainable management of wheat aphids is critical for securing higher productivity and ensuring food and nutritional security for the growing population.

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## ARMY WORM IN WHEAT

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### Abstract

Wheat, Triticum aestivum L., ranks high in the list of staple food crops in India, making a substantial contribution to Indian food security. But wheat yield in India gets hampered by several insect pests, which attack wheat at different developmental stages. In this regard, the army worm, Mythimna separata Walker (Lepidoptera: Noctuidae), is a serious defoliator, which can cause extensive damage to wheat in favorable climatic conditions. The larval form of the army worm is a voracious eater of wheat, often moving in a body from one field to the next, akin to the invasion of an army. The effect of a heavy infestation is complete defoliation, decreased photosynthetic area, reduced grain filling, and consequently, reduced yields. The conditions often associated with such outbreaks include cloudy conditions, high humidity, and large-scale cereal production. This paper highlights the aspects related to the identification, occurrence, hosts, morphological characteristics, life cycle, damage symptoms, detection in the field, and economic thresholds of the army worm in wheat. Integrated pest management procedures related to preventative, cultural, mechanical, biological, and chemical controls are also discussed in this paper.

**Keywords:** Army worm, Mythimna separata, wheat, defoliator, outbreak pest, integrated pest management

### Introduction

Wheat (Triticum aestivum L.); the second major cereal crop after rice in India, constitutes the main diet of a vast number of people. This crop is grown extensively on irrigated and rainfed areas in the northern, central, and western parts of the country. Although improvement and agrotechnology developments are accrued by this crop, productivity often declines because of insect, disease, and abiotic factors. In insects, defoliators are one of the most damaging pests, as they affect the leaf area directly responsible for photosynthesis. The army worm Mithimna separata , is one of the most damaging defoliators in wheat The pest has its name due to the behavior exhibited by its larvae, which march from one farm to another in large numbers in search of food if it becomes scarce. The larvae were observed to feed at night while hiding during the day. This makes it difficult for early detection. Dense infestations lead to skeletonization of leaves while, in worse cases, crop failure is realized. As wheat is of significant economic value and the potential damage that army worm can cause, it is essential to know the biology, ecology, and methods of managing the army worm. This review paper gives an extensive explanation of the incidence of army worm in wheat and the methods of managing it.

**Pest Identity and Taxonomy**

**Common name:** Army worm

**Scientific name:** Mythimna separata Walker

**Class:** Insecta

**Family:** Noctudae

**Host**

Rangepicture Boxiger, Mythimna separata is polyphagous, with preference for cereal plants. Wheat (Triticum aestivum) - major host, Rice (Oryza sativa), Maize (Zea mays), Barley / Hordeum, Oats and other Graminaceae. Wild grasses as well as volunteer cereals serve as alternative hosts, which allow the pest to survive between seasons.

**Origin and Distribution-Restoration**

The army worm is a distributed species in Asia, including India, China, Japan, and Southeast Asia. The worm is also reported in India in major wheat-growing states, including: Punjab, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar. The occurrence of these outbreaks is sporadic. It has also been observed that climatic conditions, especially overcast skies and high humidity, play an influencing role.

**Morphology and description:**

The eggs are small, spherical in shape with a creamy white color, and are always found in clusters on the underside of the leaf. They are usually smoothed over with scales of hair-like material from the female's body. Caterpillars are in the form of cylinders without hairs and are 3–4 cm long. They are greenish-brown in color and have stripes along the body. This stage of the insect's life cycle is most harmful. Pupation takes place in the soil within earth cocoons. The coloration of the pupae is reddish brown. Adults are medium-sized with brownish-colored forewings and light-colored hindwings. There is a dark spot on the forewing.

**Life Cycle**

Mythimna separata exhibits cyclic metamorphosis, Egg stage: 3-5 days, Larval stage: 14 to 21 days, Pupal stage: 7-12, Adult stage: 7-10 days, Several overlapping generations exist within a year. The maximum population is present during the vegetative stage of wheat, especially during cool & moist conditions.

**Symptoms**

Symptoms may vary**,** The early instar larvae scratch the leaf surface. Maturity larvae feed extensively, leading to defoliation**,** Leaves are skeletonized or completely consumed**,** Heavy infestation will leave only leaf midribs intact. Less tillering & poor grain filling**,** In some cases, the larvae migrate in large numbers to the adjacent fields.

**Movement and Multiplication**

The army worm larvae show mass movement when food becomes scarce. The adults have strong flight capability, hence migrate over longer distances. Cereal monocropping, with grass weeds being present, favors army worm build-up.

**Management Measures**

Planting of wheat at appropriate times**,** Control of grassy weeds and volunteer cereals**,** Excessive nitrogen fertilization**,** Crop rotation with non-host crops**,** To address the potential problems and issues that**,** Deep Summer Plowing to expose Pupae**,** Handling, larval collection, and larval destruction in early stages**,** The role of light traps in monitoring moths**,** There have been studies whether using Bird perches**,** Protection of natural enemies such as birds, spiders, and parasitic wasp, Addition of Bt @ 1-2 g/L**.** Utilization of Nuclear Polyhedrosis Virus specific to Army Worm. Chemical control measures should be resorted to only after crossing the ETL. Chlorpyriphos 20 EC @ 2, Quinalphos 25 EC @ 2 ml/L, Lambda-cyhalothrin 5 EC @ 1, Emamectin benzoate 5 SG @ 0. Spray should be done in late evening when the larvae are most active. Firstly, army worm control should be done through a combination of cultural, biological, and chemical control methods. Monitoring, conservation, and control measures must be done early to ensure effective control of the worms.

**Conclusion**

This worm is a powerful defoliator of wheat. It has the potential to cause heavy damage to the crop in the event of an outbreak. It is important to detect the worm and adopt IPM practices to avoid damage. It is essential to stress the need for control measures through a biological approach in combination with chemical control to manage the worm.

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**PODBORER IN WHEAT**

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**Abstract**

**Wheat** (*Triticum aestivum L.*) is one of the most important cereal crops cultivated throughout the world and serves as a primary source of food security. Among the various biotic constraints limiting wheat productivity, insect pests play a major role. Pod borer, *Helicoverpa armigera*(Hubner), though mainly known as a pest of pulses and oilseeds, has emerged as an occasional but economically significant pest of wheat, particularly during the ear head stage. The larval stage feeds on developing grains by boring into spikelets, causing direct yield loss and deterioration of grain quality. Changing climatic conditions, continuous cropping systems, and reduced natural enemy activity have favored the survival of this pest in wheat ecosystems. This assignment presents a comprehensive account of pod borer infestation in wheat, covering its identity, distribution, biology, damage symptoms, and integrated pest management strategies with emphasis on sustainable control measures.

**Keywords**: Pod borer, *Helicoverpa armigera,* wheat, ear head pest, integrated pest management.

**Introduction**

Wheat is an important cereal-based crop that is grown extensively in India as well as other parts of the world. It assumes a prime role in ensuring food security around the globe because of its high contents of carbohydrates as well as protein. Rabi-season wheat is primarily grown in India, both under irrigation and rainfed conditions. Even though there is a shift towards modern agricultural technology, the growth of wheat is adversely affected by a few important insect pests. Among these pests, pod borer or gram pod borer, Helicoverpa armigera, is prominently known for its polyphagous behavior. Even though it is mainly found in chickpea, pigeon pea, cotton, and tomato, its attack on wheat has been on the rise in recent times. This pest mostly targets wheat plants in their reproductive phase, where ear head formation takes place, along with the development of grains in the milky to dough stage. The larvae feed Inside the spikelets and consume the grains, resulting in shriveled grains and reduced grain weight. There can be an economic yield loss due to severe infestation. It is, therefore, imperative that the biology and mode of damage caused by the pod borer on wheat be completely known.

**Pest Identity and Taxonomy**

**Common name:** Pod borer / Gram pod borer

**Scientific name:** *Helicoverpa armigera* (Hubner)

**Order**: Lepidoptera

**Family**: Noctuidae

**Host Range**

*Helicoverpa armigera* is a highly polyphagous pest with a host range exceeding 180 plant species. Major hosts include chickpea, pigeon pea, cotton, tomato, sunflower, maize, sorghum, and wheat. In wheat-based cropping systems, the pest generally shifts from nearby pulse or vegetable crops to wheat when alternative hosts are unavailable. Wheat acts as an occasional host, particularly during the ear head stage.

**Origin and Distribution**

*Helicoverpa armigera* is **distributed over Asia, Africa, Europe, and Australia**. In India, this pest is found in most agro climates and wheat-growing areas. This pest can survive on a variety of host crops and weeds available throughout the year, thus providing an opportunity to buildup populations seasonally.

**Morphology and Diagnostic Characters**

The egg is spherical, creamy white, and laid singly on leaves or ear heads. The larva is greenish to brown with longitudinal dark stripes on the body and a light-colored head capsule. Fully grown larvae measure about 35–40 mm in length. The pupa is brown and found in the soil inside an earthen cell. Adult moths are medium-sized with pale brown forewings bearing a dark spot, while the hind wings are lighter with a dark marginal band.

**Life Cycle and Phenology**

*Helicoverpa armigera* has a process of total metamorphosis, including the stages of egg, larva, pupa, and adult. One female can lay 500-1000 eggs. The egg stage lasts 3-5 days, the larval stage 14-21 days, and the pupal stage 7-15 days depending on the temperature. Multiple generations can be witnessed within a year, making this pest a seasonal problem.

**Symptoms and Damage**

The **wheat larvae exert direct damage on wheat by tunneling into ear heads**, thereby damaging the grains that are yet to form. In most cases, the wheat larvae can damage several spikelets. Infected ear heads exhibit holes, partially consumed grains, as well as the droppings of the larvae. Heavy infection leads to light grains. **1st instar** - feed superficially on tender leaves, glumes, and spikelets, Causes pinhole type of feeding marks. **2nd instar** - Begins feeding on young spikelets and developing grains.Small irregular holes observed on young spikelets. **3rd instar** - Larvae initiate boring into ear heads, Visible feeding on grains in the spike, Yield loss starts at this stage. **4th Instar** - Feeding on varied grains within a spike, Large feeding holes on spikelets, High rate of frass production on ear heads and leaves, Ear heads may begin to dry prematurely. **5th instar** -Entirely developed larva causes greatest damage, Destroys several grains, Ear heads turn reed-like and empty, shrivelled, or broken, Spikes turn wh itish to straw-colored before ripening.

**Field Detection and Economic Threshold Level**

Field detection requires crop observation, observation of larvae in the ear heads by visual detection, and pheromone traps for the detection of the female moths. Economic threshold level is usually considered at 1-2 larvae per meter or 5-10 percent damage to the ear heads.

**Movement and Multiplication**

Larvae are actively feeding and can shift from one spikelet to another on the same ear head. Adult specimens are good flyers, shifting from one field to another in search of hosts. Easy access to hosts enables fast multiplication of hosts.

**Damaging Stage of Pest**

The life stage that is most destructive is the larval stage and directly results in yield damage by feeding on grains. The egg stage, pupae stage, and adult stage do not directly damage the crop.

**Preventive Methods**

Crop rotation, appropriate sowing, uprooting crop residue, and.destroying the alternate hosts can minimize the occurrence of pests. Proper fertilization and avoiding over-use of nitrogen.

**Cultural preventive methods**

Cultural control practices for the pod borer pest species in wheat are: Summer ploughing to eliminate soil-based pupae, Sowing wheat when the soil is still moist to evade the peak density of the pest, Crop rotation to disrupt the life cycle of the pest, and proper fertilizer practices that do not give the wheat excess nitrogen, Irrigation practices that ensure the wheat remains healthy, and Cropping the wheat together with other plants like mustard or linseed to reduce the incidence of the pest, and Crop rotation to resist the attack caused by the pest since the rotated crops are not their hosts. Prevention and control measures for the gramineous stem borer pest species are different based on the culture and economic levels.

**Mechanical and physical methods**

Hand picking and destruction of larvae during early stages and use of bird perches (10-15 per hectare) in the field and attraction of birds that eat insects, and light traps for monitoring and reduction of adult moth populations, and use of crop rotation and biological control, Hand picking and destruction of larvae during early stages and practice of regular field inspections. Pheromone traps (5–8 per hectare) to monitor male moth activity, Helps in early detection and timely preventive action, Replace lures every 3–4 weeks.

**Biological preventive methods**

*Trichogramma chilonis* **-**Parasitizes the eggs of pod borer and prevents larval emergence.

Release rate: 50,000–100,000 parasitoids per hectare at weekly intervals. *Campoletis chlorideae* Attacks early larval stages (1st–3rd instar) Reduces larval population before serious damage occurs.**Predators** Ladybird beetles, Green lacewings (Chrysoperla carnea), Spiders and predatory bugs Feed on eggs and small larvae of pod borer. *Bacillus thuringiensis (Bt)* Kills larvae after ingestion **,**Effective on 1st–2nd instar larvae. Spraying Neem-based products **(NSKE 5% or Neem oil 3%)** at early stages. Use of HaNPV (*Helicoverpa armigera NPV)* @ 250 LE/ha.

**Botanical methods**

Spraying Neem seed kernel extract (NSKE) 5% before flowering.Use of plant-based repellents reduces egg laying by moths.

**Chemical methods**

Apply insecticides only after crossing ETL (1–2 larvae per meter row length).Preferred insecticides:Emamectin benzoate 5 SG @ 0.4 g/l, Chlorantraniliprole 18.5 SC @ 0.3 ml/l, Spinosad 45 SC @ 0.3 ml/l, Avoid repeated use of the same chemical to prevent resistance.

**Integrated Pest Management**

Integrated Pest Management in Pod Borer in Wheat is an eco-friendly and cost-effective method using cultural, mechanical, biologically, and chemically integrated approaches that maintain the pest population at levels below the economic threshold level while causing less environment damage. IPM is commenced through preventive cultural methods including deep summer ploughing to eliminate the presence of pupae in the soil, appropriate sowing timings to avoid the peak occurrence of the pest, rotation of crops with non-host plants, field sanitation, appropriate fertilizer application, and optimal irrigation in order to promote proper crop growth. Regular scanning in the fields through scouts, pheromone traps, and light traps help in the detection of the pest. Methods like manual removal of pests by hand picking and crushing, and the use of bird perches aid in reducing pest populations. Biological controls: These comprise most of the IPM approaches and include the use of egg parasitoids such as Trichogramma chilonis , use of natural enemies such as ladybird beetles, lacewings, and spiders, and the use of microbes like Helicoverpa armigera NPV, Bacillus thuringiensis , and neem-based biotics. Chemical control, however, is employed only when the pest population exceeds the economic threshold level (1-2 larvae per meter of row lengths or 5-10% ear head damage). Insecticides are applied at the prescribed concentration and time to avoid damaging beneficial insects, thereby preventing the development of resistance. Therefore, IPM for pod borer in wheat ensures effective management of the pest, conservation of pesticides, protection of natural enemies, as well as sustainable crop production.

**Conclusion**

Pod borer, Helicoverpa armigera, while an occasional pest of wheat, has the potential to cause yield loss under optimum conditions. Early monitoring and subsequent implementation of integrated pest management strategies are therefore important for sustainable and eco-friendly control of this pest.

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# BROWN WHEAT MITE

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**Abstract**

The brown wheat mite (Petrobia latens Müller) is an important sporadic pest of wheat, particularly under dryland and drought-stressed conditions. It has emerged as a significant constraint to wheat productivity in arid and semi-arid regions where rainfall is erratic and irrigation is limited. Both nymphs and adults feed on leaf tissues by piercing epidermal cells and extracting cell sap, resulting in stippling, bronzing, and premature leaf senescence. Severe infestations may lead to plant desiccation and considerable yield losses. The pest exhibits rapid population buildup under favorable conditions and survives adverse seasons through diapause eggs. Due to its small size and cryptic behavior, early detection is difficult, often resulting in delayed management interventions. Understanding the biology, ecology, damage symptoms, and population dynamics of P. latens is crucial for effective pest management. Integrated Pest Management (IPM) strategies that emphasize preventive and cultural practices, conservation of natural enemies, and judicious use of acaricides are recommended for sustainable control. This assignment reviews the taxonomy, morphology, life cycle, damage symptoms, and integrated management strategies of brown wheat mite based on available scientific literature, research findings, and agricultural extension resources (Jeppson et al., 1975; UC IPM, 2023; Kogan & Turnipseed, 1987).

**Key words**: Brown wheat mite; Petrobia latens; Wheat pest; Acari; Tetranychidae; Life cycle; Drought-associated pest; Leaf stippling; Integrated Pest Management (IPM)

## Introduction

Wheat (Triticum aestivum L.) is one of the most important cereal crops globally, serving as a primary food source for a large proportion of the world's population. However, wheat productivity is affected by several biotic stresses, including insect pests and mites. Among mite pests, the brown wheat mite (Petrobia latens) has gained importance due to its association with dry climatic conditions and rainfed agriculture (Jeppson et al., 1975). Unlike many insect pests, mites often remain unnoticed until damage becomes severe, making them difficult to manage effectively. Brown wheat mite infestations are particularly prevalent in seasons with prolonged drought, high temperatures, and low relative humidity (UC IPM, 2023). The pest damages wheat by feeding on leaf tissues, leading to reduced photosynthetic efficiency and overall plant vigor. Economic losses are often underestimated due to misidentification of damage as nutrient deficiency or drought stress. Increasing climate variability and expanding dryland farming systems have further enhanced the pest's significance. Hence, comprehensive knowledge of its biology, ecology, and management is essential for devising sustainable pest control strategies. This section provides a foundation for understanding the pest's importance in wheat agro-ecosystems (Kogan & Turnipseed, 1987; Oklahoma State University Extension, 2022).

**Pest identification and taxonomy**

The brown wheat mite belongs to the class Arachnida and order Acari, distinguishing it from true insects. Taxonomically, it is classified under the family Tetranychidae, which includes several economically important plant-feeding mites (Jeppson et al., 1975). The scientific name of the pest is Petrobia latens Müller. Members of this genus are characterized by their dark coloration, long legs, and ability to thrive under dry environmental conditions. Adult mites possess four pairs of legs, while larval stages have three pairs, a key diagnostic feature differentiating immature mites from adults. The pest is often confused with other spider mites; however, P. latens can be identified by its dark brown to black body color and relatively longer forelegs. Accurate identification is crucial, as management practices differ between mite species. Misidentification can lead to inappropriate pesticide use and poor control outcomes. Taxonomic clarity supports precise pest diagnosis, monitoring, and implementation of integrated pest management strategies (UC IPM, 2023; Borror et al., 1992). HOST RANGE Brown wheat mite primarily infests wheat but is known to feed on a wide range of host plants. Apart from wheat, it attacks barley, oats, rye, and other small grains, making it a serious pest in cereal-based cropping systems (Jeppson et al., 1975). The mite has also been reported on non-cereal hosts such as alfalfa, cotton, sorghum, onions, lettuce, and various grasses. These alternate hosts play a crucial role in sustaining mite populations during off-season periods. Volunteer wheat plants and grassy weeds act as reservoirs, facilitating carryover of populations to subsequent cropping seasons. Host plant stress, particularly moisture stress, enhances susceptibility to mite infestation. The pest's ability to survive on diverse hosts contributes to its persistence and sporadic outbreak nature. Understanding the host range is essential for designing cultural and preventive strategies such as crop rotation and weed management.

Effective removal of alternate hosts significantly reduces initial infestations in wheat fields (UC IPM, 2023; Kansas State University Extension, 2021).

**Origin and distribution**

The brown wheat mite (Petrobia latens Müller) is believed to have originated in temperate and semi-arid regions where dry climatic conditions prevail. Early records suggest its presence in Europe and parts of Central Asia, from where it spread to other wheat-growing regions of the world through trade and movement of infested plant material (Jeppson et al., 1975). At present, P. latens is widely distributed across North America, Europe, Asia, Australia, and parts of Africa. The pest is particularly abundant in regions characterized by low rainfall, sandy or loamy soils, and prolonged dry spells during the cropping season (Kogan & Turnipseed, 1987). In India, brown wheat mite infestations have been reported mainly from the north-western wheat belt, including Punjab, Haryana, Rajasthan, western Uttar Pradesh, and parts of Madhya Pradesh. Its occurrence is more pronounced in rainfed wheat ecosystems and under delayed irrigation schedules. Seasonal drought and reduced soil moisture favor population buildup and survival. The pest shows sporadic outbreak behavior rather than consistent annual occurrence, often linked with specific weather patterns. Climate change and increasing frequency of drought events are expected to expand its geographical range and economic importance. Knowledge of its origin and distribution is essential for regional risk assessment and formulation of location-specific management strategies

**Morphology**

The brown wheat mite is a very small arachnid, measuring approximately 0.4–0.6 mm in length, making it difficult to detect with the naked eye. Adult mites are dark brown to black in color, a distinguishing feature that differentiates them from other spider mites, which are often lighter or reddish in appearance (Jeppson et al., 1975). The body is oval and somewhat flattened, adapted for movement on leaf surfaces. Adults possess four pairs of legs, with the front pair noticeably longer than the others, aiding in identification. Larvae are smaller and have only three pairs of legs, while nymphs gradually develop the fourth pair. Eggs are initially reddish when laid and later turn white, especially when entering diapause. Diapause eggs are often deposited in soil cracks, clods, or crop residues, allowing survival during unfavorable hot summer conditions. The absence of webbing on plants is another key diagnostic character, unlike many other tetranychid mites. Under magnification, feeding punctures on leaves appear as fine stippling patterns. Accurate morphological identification using a hand lens or microscope is essential for distinguishing P. latens from other mite pests and for implementing appropriate management practices (Borror et al., 1992; UC IPM, 2023).

**Life cycle**

The life cycle of the brown wheat mite (Petrobia latens) is closely synchronized with seasonal climatic conditions, particularly temperature and moisture availability. The mite undergoes egg, larval, nymphal, and adult stages, completing several generations within a single wheat-growing season (Jeppson et al., 1975). Eggs are laid either on leaf surfaces or in soil crevices and crop residues. Under favorable cool and dry conditions, eggs hatch within 5–7 days. The larval stage, possessing three pairs of legs, feeds actively on leaf tissues before molting into nymphs. Nymphal stages resemble adults but are smaller and gradually develop the fourth pair of legs. The total life cycle from egg to adult can be completed within 10–14 days, enabling rapid population multiplication (UC IPM, 2023). Adult mites are highly active feeders and reproduce continuously during winter and early spring. As temperatures rise and soil moisture declines, females lay diapause eggs capable of surviving hot summer conditions. These diapause eggs remain dormant until favorable conditions return in the next cropping season. Population peaks generally occur during periods of drought stress and decline rapidly following rainfall or irrigation. Understanding the phenology of P. latens is essential for timing monitoring and management interventions effectively (Kogan & Turnipseed, 1987; Kansas State University Extension, 2021).

**Symptoms**

Damage caused by the brown wheat mite results from its feeding behavior, which involves piercing leaf epidermal cells and extracting cell contents. Initial symptoms appear as fine whitish or yellow stippling on the upper surface of leaves, often mistaken for nutrient deficiency or moisture stress (Jeppson et al., 1975). As feeding continues, affected leaves develop a characteristic bronzed or scorched appearance. Severe infestations lead to curling, drying, and premature senescence of leaves. The reduction in photosynthetic area significantly affects plant growth and grain filling, resulting in yield loss. Damage is more pronounced during periods of low soil moisture and high temperatures, which favor mite activity and stress the host plant simultaneously. Unlike insect pests, brown wheat mites do not chew tissues or produce visible frass, making damage less conspicuous in early stages. Under heavy infestations, entire fields may appear drought-stricken even when adequate nutrients are present. Yield losses are often indirect and underestimated due to delayed diagnosis. Prolonged infestations during the tillering and heading stages can cause maximum economic damage.

Accurate identification of damage symptoms is therefore critical for timely management (UC IPM, 2023; Oklahoma State University Extension, 2022).

**Field detection**

Field detection of the brown wheat mite (Petrobia latens) is challenging due to its minute size and cryptic behavior. Visual symptoms on wheat foliage often resemble drought stress or nutrient deficiency, leading to misdiagnosis (Jeppson et al., 1975). Early detection relies on careful field scouting, particularly during dry weather conditions when mite populations are likely to increase. Leaves should be examined closely using a hand lens (10× or higher magnification) to observe mites on the leaf surface. When disturbed, mites tend to move rapidly or drop from the plant, which can be a useful indicator of their presence (UC IPM, 2023). The appearance of stippling, bronzing, or silvery discoloration on leaves serves as a primary field indicator. Infestations usually start at field margins or in patches where plants are under moisture stress. Absence of webbing distinguishes brown wheat mite infestations from those caused by other spider mites. Soil cracks and crop residues should also be examined for the presence of eggs. Regular monitoring during tillering and early heading stages is critical for timely intervention. Accurate field diagnosis enables effective decision-making and prevents unnecessary pesticide applications (Kansas State University Extension, 2021; Oklahoma State University Extension, 2022).

**Movement and multiplication**

The movement and multiplication of brown wheat mite populations are strongly influenced by environmental conditions, particularly temperature, humidity, and soil moisture. Mites typically emerge from diapause eggs in the soil or crop residues at the onset of favorable cool conditions (Jeppson et al., 1975). Once active, they move onto wheat plants by crawling, as they lack wings or long-distance dispersal mechanisms. Population buildup occurs rapidly due to short generation time and continuous reproduction during favorable periods. Dry weather accelerates multiplication, while rainfall and irrigation significantly suppress mite populations by dislodging individuals from plants (UC IPM, 2023). The pest often migrates from alternate hosts such as weeds or volunteer wheat into newly planted fields. Within a field, mites spread from infested plants to neighboring plants, forming localized hotspots. Multiplication is highest during winter and early spring when conditions are optimal. As temperatures rise sharply, females lay diapause eggs, ensuring population survival through adverse seasons. Understanding movement and multiplication patterns aids in predicting outbreaks and implementing timely preventive measures (Kogan & Turnipseed, 1987; Kansas State University Extension, 2021).

**Damaging stage of the pest**

In brown wheat mite (Petrobia latens), both the immature and adult stages are phytophagous and capable of causing economic damage to wheat crops. However, the nymphal and adult stages are considered the most damaging due to their higher feeding activity and longer duration on the host plant (Jeppson et al., 1975). Larvae begin feeding soon after hatching, puncturing epidermal cells and extracting cellular contents, but their impact is relatively limited due to smaller body size. As mites progress to nymphal and adult stages, feeding intensity increases substantially. Adults possess well-developed mouthparts that enable continuous sap extraction from leaf tissues. Feeding damage accumulates over time, leading to extensive stippling, chlorophyll loss, and reduced photosynthetic efficiency. Damage is most severe when high populations coincide with moisture stress, particularly during tillering and early grain-filling stages of wheat (UC IPM, 2023). Prolonged feeding by nymphs and adults results in leaf bronzing and premature senescence. Since both stages remain exposed on leaf surfaces, they contribute cumulatively to yield reduction. Understanding the damaging stages is critical for determining economic threshold levels and timing management practices effectively (Kogan & Turnipseed, 1987; Kansas State University Extension, 2021).

**Preventive methods**

Preventive management forms the foundation of brown wheat mite control, particularly in dryland wheat production systems. Preventive strategies aim to reduce the likelihood of infestation before populations reach damaging levels. Avoidance of continuous wheat monocropping is one of the most effective preventive measures, as it disrupts the pest's life cycle (Jeppson et al., 1975). Removal of volunteer wheat plants and grassy weeds eliminates alternate hosts that sustain mite populations during the off-season. Selection of tolerant or stress-resistant wheat varieties can indirectly reduce mite damage by improving plant vigor under drought conditions. Maintaining adequate soil moisture through timely irrigation helps suppress mite activity and prevents population buildup (UC IPM, 2023). Proper field sanitation, including destruction of crop residues where diapause eggs may survive, also contributes to prevention. Avoiding excessive nitrogen fertilization prevents lush growth that may favor mite colonization under dry conditions. Preventive practices are cost-effective and environmentally safe compared to curative chemical control. Integration of these measures into routine agronomic practices significantly reduces the risk of severe infestations (Kansas State University Extension, 2021; Oklahoma State University Extension, 2022).

**Cultural and mechanical methods**

Cultural and mechanical methods play a crucial role in reducing brown wheat mite (Petrobia latens) populations and minimizing crop damage without relying on chemical inputs. Timely irrigation is one of the most effective cultural practices, as adequate soil moisture discourages mite activity and reproduction (UC IPM, 2023). Fields under rainfed conditions are more prone to infestation; therefore, moisture conservation practices such as mulching and proper land leveling help suppress outbreaks. Crop rotation with non-host crops reduces carryover populations and disrupts the pest's life cycle (Jeppson et al., 1975). Deep summer ploughing exposes diapause eggs present in soil cracks and residues to high temperatures and predators, reducing survival rates. Mechanical removal of volunteer wheat plants and grassy weeds eliminates alternate hosts that act as reservoirs for mites. Balanced fertilization improves plant vigor and tolerance to feeding damage. Avoidance of late sowing, which often coincides with dry spells, also reduces infestation risk. These methods are environmentally safe, economically viable, and form an essential component of integrated mite management strategies (Kansas State University Extension, 2021; Oklahoma State University Extension, 2022).

**Biological methods**

Biological control of brown wheat mite relies primarily on the conservation of natural enemies rather than classical biological control programs. Several predatory mites belonging to the family Phytoseiidae are known to feed on phytophagous mites and contribute to natural population regulation (Kogan & Turnipseed, 1987). Generalist predators such as ladybird beetles, lacewings, and predatory thrips may also prey on mite stages, particularly under low to moderate infestations. Entomopathogenic fungi have been reported to infect mite populations under favorable humidity conditions, although their role in wheat ecosystems is limited due to dry climates (Jeppson et al., 1975). Cultural practices that reduce pesticide use help conserve these beneficial organisms. Avoidance of broad-spectrum insecticides is critical, as such chemicals often eliminate predators and lead to secondary pest outbreaks. Biological control alone may not provide complete suppression but contributes significantly when integrated with cultural and preventive measures. Conservation-based biological control enhances sustainability and reduces dependency on chemical acaricides (UC IPM, 2023).

**Chemical methods**

Chemical control of brown wheat mite (Petrobia latens) is considered a supplementary measure and should be adopted only when mite populations exceed economic threshold levels. Because mites are not insects, conventional insecticides often provide poor control and may worsen infestations by destroying natural enemies (Jeppson et al., 1975). Selective acaricides or sulfur-based compounds have been reported to reduce mite populations effectively when applied at the early stages of infestation. Sulfur dust or wettable sulfur formulations are commonly recommended due to their acaricidal action and relatively lower impact on beneficial organisms (UC IPM, 2023). Chemical sprays are most effective when mites are actively feeding on foliage, particularly during nymphal and adult stages. Proper coverage of leaf surfaces is essential due to the mites' small size and cryptic location. Applications during cooler parts of the day improve efficacy. Excessive or repeated use of chemicals may lead to resistance development and secondary pest outbreaks. Hence, chemical control should be used judiciously and integrated with non-chemical practices. Farmers are advised to follow label recommendations and safety precautions to minimize environmental contamination. Chemical intervention is most effective when used as part of an integrated pest management program rather than as a standalone measure (Kogan & Turnipseed, 1987; Oklahoma State University Extension, 2022).

**Integrated pest management (IPM)**

Integrated Pest Management (IPM) is the most sustainable approach for managing brown wheat mite infestations in wheat ecosystems. IPM focuses on a combination of preventive, cultural, biological, and chemical measures based on regular monitoring and economic thresholds (Kogan & Turnipseed, 1987). Early-season scouting using hand lenses helps detect mite populations before visible damage becomes severe. Cultural practices such as crop rotation, removal of volunteer wheat, timely irrigation, and deep ploughing form the backbone of IPM strategies. Conservation of natural enemies through reduced pesticide use enhances biological regulation of mite populations. Chemical control is employed only when necessary and using selective acaricides to minimize non-target effects. Weather-based forecasting and understanding pest phenology assist in predicting outbreaks and optimizing management timing. Farmer awareness and training are critical components of successful IPM adoption. Implementation of IPM reduces production costs, environmental risks, and pesticide residues in food grains. Long-term adoption of IPM ensures sustainable wheat production under changing climatic conditions (UC IPM, 2023; Kansas State University Extension, 2021).

**Conclusion**

The brown wheat mite (Petrobia latens) is a significant pest of wheat, particularly in dryland and drought-prone agro-ecosystems. Its small size, rapid multiplication, and close association with moisture stress make early detection and management challenging. Feeding by nymphs and adults causes stippling, bronzing, and premature senescence of leaves, ultimately reducing yield and grain quality. Understanding the pest's taxonomy, morphology, life cycle, and damage symptoms is essential for accurate diagnosis and effective control. Preventive and cultural practices form the foundation of management, while biological control contributes to natural regulation. Chemical control should be used judiciously and only when economically justified. Integrated Pest Management offers a holistic, environmentally sound, and economically viable strategy for long-term control of brown wheat mite. Adoption of IPM practices will become increasingly important under climate change scenarios characterized by frequent droughts. Sustainable management of P. latens is therefore essential for ensuring stable wheat production and food security (Jeppson et al., 1975; UC IPM, 2023).

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**WHITE GRUB IN WHEAT**

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**Abstract**

Wheat is one of the most important staple food crops of India and plays a crucial role in ensuring the country's national food security. Advances made in crop production technologies have little impact on improving wheat productivity due to several biotic stresses; among them, insect pests are great threats to yield loss. White grubs, the larval stage of scarab beetles belonging to the family Scarabaeidae, are amongst the most destructive soil-dwelling pests of wheat. These grubs feed on underground plant parts, especially roots, contributing to a poor plant stand, yellowing, wilting, and patchy failure of the crop. Such damage is more pronounced in light-textured soils and rainfed situations. The assignment covers white grub infestation in wheat with respect to its identity,
distribution, host range, morphology, life cycle, nature of damage, symptoms, economic threshold level, and integrated pest management strategies with emphasis on sustainable and eco-friendly control measures.

**Key words:** White grub, Holotrichia spp., wheat, soil insect pest, root feeder, integrated pest management

**Introduction**

Wheat is the second most important cereal crop of India after rice and is grown on a large scale during the rabi season both under irrigated and rainfed conditions. It is one of the major sources of carbohydrates and protein for a significant section of the population. India is one of the world's top wheat-producing countries, with its main wheat-producing states being Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, and Bihar. Wheat is a crop that is attacked by several insect pests during different stages of growth, including termites, aphids, armyworms, cutworms, and white grubs. Of these, white grubs are highly destructive because they attack the crop below the soil surface, thus their detection in the early stages of infestation is not easily possible. They inflict serious damage during the seedling to tillering stages by feeding on the roots, resulting in the drying of plants, thereby reducing yields. In endemic areas, white grubs can cause up to 40–80 percent crop loss if not managed properly.White grubs are polyphagous pests with a wide host range and long life cycle, and hence management is challenging. Biology, ecology, and damage pattern need to be understood for developing an integrated pest management strategy in wheat ecosystems.

**Identity and Taxonomy of Pests**

**Common Name:** White grub

**Scientific Name:** *Holotrichia spp.*

**Order:** Coleoptera

**Family:** Scarabaeidae

White grubs represent the larval stages of scarab beetles that are more commonly known as June beetles or May beetles.

**Host Range**

The white grubs are highly polyphagous and attack widely cultivated crops as well as wild plants. Major hosts include: Wheat (Triticum aestivum) Rice Maize Sugarcane Groundnut Pulses and vegetables Grasses and weeds Presence of alternative hosts and weeds in and around wheat fields helps to survival and buildup of white grub populations.

**Origin and Distribution**

White grubs are distributed throughout India, occurring almost in all agro-climatic zones. However, the states where they are particularly serious include Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, and Punjab. Incidence of white grubs is closely related to the monsoon rains and light sandy soils. Presence of trees neem, peepal, ber, and babul around fields provides resting sites and also a site for oviposition by the adults.

**Morphology**

Adult beetles are medium to large-sized insects that are brown or dark brown in color, measuring about 18–25 mm in length. Their body is robust, with club-shaped antennae and strong legs. Adults are nocturnal, and flying around lights is a common sight during the early monsoon season. The larva is creamy white, C-shaped, thick-bodied with well-developed brown head capsule and strong mandibles. The full-grown grub measures about 30–40 mm length. Three larval instars are present. Pupation takes place in the soil within an earthen cell. The pupae are yellowish-brown and inactive.

**Life Cycle**

White grubs have complete metamorphosis, egg–larva–pupa–adult. The Egg stage: During the early monsoon, female beetles lay eggs in moist soil in the first fortnight at a depth of 5–10 cm. The incubation period is 7–14 days. The larval period lasts for 2–4 months depending on the species and prevailing environmental conditions. This is the third instar grub that is considered most injurious. Pupation occurs in the soil and lasts 2–3 weeks. Adults emerge with the advent of the monsoon, feed on foliage at night, mate, and lay eggs. Adults survive for about 1–2 months. In most species, one generation is completed in a year.

**Nature of Damage and Symptoms** :White grubs are responsible for damaging wheat due to their root feeding habit beneath the soil surface of wheat. Wilt and sudden drying out of seedlings and young plants The affected plants can easily be pulled out. Yellowing and poor tillering Uneven appearance of the field

Severe root pruning results in a dead plant. Damage during the early wheat growth stages is more pronounced.

**Detection**

Patchy drying of wheat crop, There are C-shaped grubs in the soil around the roots. Adult beetle activity around lights during monsoon .Loosened soil around injured plants ETL - Economic Threshold Level 1–2 white grubs per square meter of soil or 10 percent plant mortality in the field

The most injurious stage of the pest is the larval stage, white grub, especially the third instar.

**Preventative and Cultural Practices**

Deep summer ploughing to bring grubs and pupae to the surface. Sowing of wheat timely. Weed removals and alternate host plants Rotation with non-host crops, Avoidance of wheat cultivation close to beetle host trees. Mechanical and Physical Methods Light traps for collecting adult beetles Hand collection and destruction of beetles from host trees Flood irrigation for grub eradication in soil.

**Control Methods**

Application of biocontrol agents like entomopathogenic fungi: Metarhizium anisopliae and *Beauveria bassiana*. Application of entomopathogenic nematodes Conservation of birds and other natural enemies. Chemical control should be done only when the infestation is serious and ETL is crossed. Soils application of Chlorpyriphos 20 EC @ 2.5 L/ha Phorate 10 G @ 10 kg/ha (where permitted) Imidacloprid application to the soil at recommendation rate. Seed treatment with suitable systemic insecticides. For the integrated management of white grubs in wheat, culture, mechanical, biological, and need-based application of chemical methods should be adopted. Stress should be given on prevention by summer ploughing, control of beetles, and biological agents to reduce the dependency on chemical insecticides for environmental safety.

## Conclusion

It has major soil-dwelling pests of wheat that can cause severe yield losses if not managed. Due to the fact that these insects carry out their activities below the ground, it is critical to make early diagnoses and implement some preventive measures. This can be through the use of integrated pest management practices that help reduce white grub populations, protecting wheat yields and enhancing sustainable agriculture.

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# APHIDS IN TENAI

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**Abstract**

Foxtail millet (Tamil: Tenai; *Setaria italica*) is one of the important small millets cultivated extensively in India and several Asian countries, primarily under rainfed and low-input agricultural systems. The crop is valued for its short duration, adaptability to marginal lands, tolerance to moisture stress and increasing demand as a nutritionally rich health food. However, despite its hardy nature, Tenai productivity is often limited by insect pest problems, among which aphids have emerged as a major and recurring constraint. Aphids are phloem-feeding insects that multiply rapidly under favourable climatic conditions, especially during dry weather accompanied by moderate temperatures. In foxtail millet, the corn leaf aphid (*Rhopalosiphum maidis*) is the most dominant species, though other aphids such as *Aphis craccivora* and *Schizaphis graminum* are occasionally associated depending on agro-ecological conditions. Aphids inflict damage by continuous sap extraction from leaves, stems and developing ear heads, resulting in leaf curling, chlorosis, reduced vigour and poor panicle development. Millets are widely regarded as climate-smart cereals due to their ability to grow successfully under limited rainfall, high temperatures and poor soil fertility. Among them, foxtail millet (Setaria italica L.), locally known as Tenai in Tamil Nadu, plays an important role in dryland agriculture of southern India and other parts of Asia. The crop is characterized by short duration, low water requirement and minimal dependence on external inputs, making it suitable for resource-poor farmers. In recent years, foxtail millet has gained renewed importance because of its high nutritional value, including dietary fibre, minerals and bioactive compounds, contributing to food and nutritional security. Despite its inherent hardiness, Tenai is affected by several insect pests at different growth stages. Important pests include stem borers, shoot flies, leafhoppers, mealybugs and aphids. Among these, aphids have become increasingly important due to their rapid reproductive potential and ability to cause both direct and indirect damage. Aphids colonize tender plant parts such as young leaves, leaf sheaths and panicles, where they feed on phloem sap. Continuous feeding weakens plants, leading to stunted growth, leaf deformation, chlorosis and reduced tillering, ultimately affecting yield. In addition to direct feeding damage, aphids excrete honeydew that favours the growth of sooty mould fungi on leaf surfaces. This black coating interferes with photosynthesis and reduces plant vigour and grain quality. More critically, aphids are efficient vectors of viral diseases, transmitting pathogens that can cause severe yield losses. Damage is particularly severe when infestation occurs during the seedling and early reproductive stages, when plants are highly sensitive to stress. Considering the expanding cultivation of millets and the influence of changing climatic conditions on pest dynamics, a clear understanding of aphid biology, population behaviour and damage patterns in foxtail millet is essential.

**Keywords**: Tenai, foxtail millet, *Setaria italica*, aphids, *Rhopalosiphum maidis*, *Aphis craccivora*, life cycle, ETL, integrated management

## Introduction

Millets are widely regarded as climate-smart cereals due to their ability to grow successfully under limited rainfall, high temperatures and poor soil fertility. Among them, foxtail millet (Setaria italica L.), locally known as Tenai in Tamil Nadu, plays an important role in dryland agriculture of southern India and other parts of Asia. The crop is characterized by short duration, low water requirement and minimal dependence on external inputs, making it suitable for resource-poor farmers. In recent years, foxtail millet has gained renewed importance because of its high nutritional value, including dietary fibre, minerals and bioactive compounds, contributing to food and nutritional security. Despite its inherent hardiness, Tenai is affected by several insect pests at different growth stages. Important pests include stem borers, shoot flies, leafhoppers, mealybugs and aphids. Among these, aphids have become increasingly important due to their rapid reproductive potential and ability to cause both direct and indirect damage. Aphids colonize tender plant parts such as young leaves, leaf sheaths and panicles, where they feed on phloem sap. Continuous feeding weakens plants, leading to stunted growth, leaf deformation, chlorosis and reduced tillering, ultimately affecting yield. In addition to direct feeding damage, aphids excrete honeydew that favours the growth of sooty mould fungi on leaf surfaces. This black coating interferes with photosynthesis and reduces plant vigour and grain quality. More critically, aphids are efficient vectors of viral diseases, transmitting pathogens that can cause severe yield losses. Damage is particularly severe when infestation occurs during the seedling and early reproductive stages, when plants are highly sensitive to stress. Considering the expanding cultivation of millets and the influence of

changing climatic conditions on pest dynamics, a clear understanding of aphid biology, population behaviour and damage patterns in foxtail millet is essential. Such knowledge forms the foundation for developing effective, economical and environmentally safe management strategies within an IPM framework, thereby enhancing productivity and sustainability of Tenai cultivation.

**Pest, origin and distribution**

**Common name**: Corn leaf aphid / Millet aphid

**Scientific name**: *Rhopalosiphum maidis*

**Order**: Hemiptera

**Family**: Aphididae

**Origin**: Central America (Neotropical region)

**Distribution**: Widely distributed across India and other tropical and subtropical regions of Asia, Africa, Europe, Australia and the Americas

**Host range**

The aphids on tenai (foxtail millet) have a broad host index and are thus termed polyphagous pests. They, apart from tenai, can be found on a number of cereal crops and millets including sorghum, pearl millet, finger millet, maize, wheat, barley, oats, and even rice, though this is occasional. Apart from these crops, aphids can be found on a number of grasses and weeds like *Setaria spp*, *Cynodon dactylon, Echinochloa spp., Panicum spp*., and *Digitaria spp.,* which are their alternate and additional hosts, respectively, during the off-season periods. Some fodder grasses and sugarcane can be their additional or secondary hosts. This adaptability to many hosts ensures them a year-round existence, seasonal movement into tenai, and extensive injury caused due to reduction in sap and due to transmission of viral diseases, resulting in decreased crop development and growth.

**Morphology and Diagnostic Characters**

Aphids that bug tenai (foxtail millet) are tiny, squishy bugs that are part of the Aphididae family. The grown-up aphids are usually 1–3 mm long and shaped like pears. They can be green, yellowish-green, brown, or black, depending on what kind they are. They have fragile bodies made of sections, with a head, middle, and back part. Their antennae are long and thin, usually the same length or longer than their bodies, which helps to tell them apart. Aphids have mouths like needles that they stick into plants to suck out juices from leaves, stems, and the grain heads. One way to tell if it's an aphid is by looking for two tiny tubes on their backs called cornicles (siphunculi). . They spout off substances to shield themselves, and you can observe them with a magnifying glass. They also have a cauda on the back of their body, which is in the shape of a finger or knob which assists in identifying the species. Some aphids will be winged (alate), while some will not be winged (apterous). The species with wings possess two pairs of transparent wings that enable them to fly to new plants. Baby aphids look just like the adult ones but are smaller and don't have wings.

**Life Cycle and Phenology**

Foxtail millet-attacking aphids are closely associated with foxtail millet growth. Typically they are found in regions appear when the plant is still young. These pests continue to infest the plant until the grains are developing. Aphid numbers Boom when it's cool and somewhat humid, mainly during early morning hours and towards the end of the season. However, excessive rain and very hot conditions hinder their growth. If other grasses are present nearby. The aphids can hang around there when it is not millet season and later migrate to the foxtail millet. Aphids mature rapidly. In fact, they undergo no complete metamorphosis, such as in butterflies. Female aphids can give birth without mating and give live offspring. One female can give births to 30-80 children in her life. The young ones transform four times, each time consuming roughly 1-2 days. They grow up in a week or ten days if everything is in order. Some aphids have wings; some do not. The winged ones show up when there are too many aphids around or when the plants aren't doing well, so they can move to find new plants. Because they reproduce so quickly, there can be many generations during the season, which can suddenly cause big problems for the millet fields.

**Symptoms**

Small colonies appear on the underside of tender leaves and leaf sheaths. Initial symptoms include mild yellowing and localized chlorosis, which often go unnoticed. Dense aphid colonies cause leaf curling, crinkling and stunted growth. Give rise to a tacky surface and fosters the growth of sooty mould, which decreases photosynthetic activity. Excesses during spawning and reproduction result in undesirable panicle excretion, decrease grain filling, malformed ear heads and premature drying of leaves. Presence of winged aphids signifies the presence of overcrowding. Overcrowding allows the rapid transmission of the virus. The economic losses will be maximum when the time of infestation matches the growth phase of the seedlings along with the first reproductive phase.

## Management

### Cultural management

Timely sowing helps the crop escape peak aphid activity and, as a result, reduces the infestation pressure. Optimum plant spacing improves air circulation and creates unfavourable condition promote the optimal conditions for multiplication of this small insect. On the other hand, balanced fertilization is critical since excessive nitrogen promotes lush growth that is appealing to aphids. Removal of weeds and volunteer plants eliminates alternate hosts and reduces carry-over populations. Crop rotation with non-cereal crops and

Intercropping with pulses or oilseeds interferes with the colonization process of the aphids and improves ecological diversity. Proper irrigation reduces stress among plants due to aphid attack. Physical management. Early removal and destruction of heavily infested plant parts helps reduce aphid population build-up. Spraying water with force can dislodge aphids from plants during early infestation stages. Yellow sticky traps are useful for monitoring aphid activity and early detection.

### Biological management

Predators such as coccinellid beetles (*Coccinella, Menochilus, Cheilomenes spp*.), chrysopid larvae (*Chrysoperla zastrowi sillemi)* and syrphid fly larvae actively feed on aphids. Parasitoids like Aphidius and Lysiphlebus species parasitize aphids, resulting in the formation of aphid mummies. Entomopathogenic fungi such as *Lecanicillium lecanii*, *Beauveria bassiana* and Metarhizium anisopliae naturally suppress aphid populations under favourable conditions. Neem-based products such as NSKE 5%, neem oil 2–3% and azadirachtin (300–1500 ppm) effectively reduce aphid feeding, reproduction and population growth and are compatible with IPM.

### Chemical control

Imidacloprid 17.8 SL – 0.3 ml/L, Thiamethoxam 25 WG – 0.25 g/L, Acetamiprid 20 SP – 0.2 g/L, Dimethoate 30 EC – 2.0 ml/L, Methyl demeton 25 EC – 2.0 ml/L, Chlorpyriphos 20 EC – 2.5 ml/L, Sprays should be applied at the first appearance of aphids and repeated only if necessary, preferably during early morning or late evening hours.

**Integrated Pest Management (IPM) approaches**

An effective IPM strategy for aphid management in Tenai includes preventive cultural practices, regular field monitoring, conservation of natural enemies, need-based use of selective insecticides and adoption of eco-friendly methods such as biopesticides. Emphasis on resistance management, rotation of insecticide modes of action and development of aphid- resistant cultivars is essential for long-term sustainability

**Conclusion**

Aphids constitute a major and persistent pest problem in foxtail millet, causing yield losses through direct sap feeding, honeydew-induced sooty mould development and transmission of viral diseases. "Infestation during early stages of growth and reproduction causes significant and irreparable harm. Sustainable control of aphids in Tenai necessitates an that is, an integrated approach encompassing cultural practices, biological control, and judicious chemical use. Investments in research for region-specific ETLs, host plant resistance, and Climate-related pest dynamics, together with the right support from extension services, will ensure eco-friendly and economically feasible management of aphids, hence promoting productivity and sustainability of foxtail millet cultivation

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# CLIMBING CUTWORM IN THENAI

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**Abstract**

Foxtail millet *Setaria italica*, commonly referred to as Thenai, is an esteemed small millet grown on a large scale under semi-arid to rainfed conditions of India for its short duration, drought tolerance ability, and higher nutritional values. Nonetheless, many insect species are known to cause damage to this crop at juvenile stages of plant development; of these, "climbing cutworm" assumes prominent importance being one of the most problematic insect species causing hindrance to seedling emergence of foxtail millet. Climbing cutworm, *Agrotis ipsilon* (Blackcutworm) (Lepidoptera: Noctuidae), is a polyphagan insect with habit of living inside soil; their larvae are not readily traceable during daytime hours but are observed to actively ascend to plant surfaces at night to feed upon leaves, shoots, and neck areas of plants. A high level of damage causes significant damage to seedlings of foxtail millet through cutting of seedlings, defoliation of plants, stand reduction, and reduction of crop production. This article is an effort to give an intensive description of the insect species of foxtail millet with relevance to their identity, geographic location of damage, plant insect interaction-changes of plant metabolism influencing insect population increase-post-insect infestation plant changes to estimate actual insect damage to crops; also at an economic injury level of damage.

**Keywords**: Climbing cutworm, *Agrotis ipsilon*, foxtail millet, thenai, seed.

## Introduction

Thenai ,is one of the oldest varieties of millets grown in India, and an important one at that, in terms of being a source of food or nutritional security, especially in the case of small scale farmers. The reasons for its value are its ability to grow in poor soil, low water requirement, and the presence of a number of nutrients like dietary fiber, protein, and key minerals. It is a crop that grows in rainfed conditions; thus, in recourse to ensuring that the crop does not face any threats from biotic factors at a young growth stage, there are a number of Thenai varieties developed. The reasons for preferring Thenai can be attributed to the factors

In spite of its resilience, foxtail millet has some insect pests that attack the crops mainly when they are in the seedling and vegetative phases of growth. These pests include the climbing cutworm, which has recently proved to be serious soil insect pests that lead to considerable loss of plant density. It is even more serious when the growing of cereals is continuous; there is less tillage; or the planting of the crops matches the emergence of the soil insects (Singh & Sharma, 2021).

Climbing cut worm, *Agrotis ipsilon* (Blackcut worm), is an evening-active, polyphagous insect, and its host range comprises cereals, millets, pulses, oilseeds, and vegetables. In thenai, the larvae tend to crawl onto plants during night and subsequently eat nascent leaves and new stalks, thereby sometimes severing seedlings at the base, causing deadheart disease (Rathod et al., 2020). As the insect's juveniles lie hidden underground, control measures should be immediate since the juveniles cannot be detected above the ground. Given the rising status of millets and the potential damage by climbing cutworm, it has become necessary to understand the biology, damage pattern, and management methods of this pest. This paper will deal specifically with the pest status of climbing cutworm in Foxtail Millet, especially in IPM perspectives.

**Pest Identification and Taxonomy**

**Common name:** Climbing cutworm/Blackcut worm

**Scientific Name:** *Agrotis ipsilon*

**Order:** Lepidoptera

**Family:** Noctuidae

**Subfamily**: Noctuinae

**Host Range**

*Agrotis ipsilon* can be referred to as a very polyphagous pest. Cereals such as wheat, rice, maize, sorghum, and millet in plants such as foxtail millet, finger millet, pearl millet, legumes, oil crops, vegetables, and weeds are used as hosts by this pest. This takes place according to Atwal & Dhaliwal (2015). Thenai lose the greatest amount of damage when in the seedling stage when sown at a time when the larvae are in plenty.

**Origin and Distribution**

The black cutworm *Agrotis ipsilon* is universally distributed and very widespread in Asia, Africa, Europe, and the America. In India, it is found in various Agro-climatic regions and is quite pesticious in rainfed as well as irrigated cereal cropping systems (Singh & Sharma, 2021).

This could be largely because it has soil-stages in its life cycle and various hosts throughout the year.

**Morphology and Diagnostic Characters**

The adult form of the *Agrotis ipsilon* moth is medium-sized and has a wingspan of between 40 and 50 mm. The wings are dark brown to black with distinct kidney markings, while the hindwings are coloured and have darker edges (Hill, 2008). The adults are nocturnal and become non-active during the day. The caterpillar is a smooth greasy cylindrical caterpillar that is dark grey to brown in colour and reaches a length of up to 40-45mm when fully grown. When threatened, the caterpillar develops a typical 'C' shape that is a distinct characteristic of cutworms (Atwal & Dhaliwal, 2015). The pupae develop in the soil within an earthen cell.

**Life Cycle and Phenology**

*Agrotis ipsilon* exhibits a process of complete metamorphosis. The female moth deposits the egg singly or in a mass on soil or weeds or residues left behind by agriculture. The egg stage lasts 4-7 days. The duration of the larval stage lasts for 25-40 days with 5-6 instars; during this stage, the larvae stay under soil at night (Singh & Sharma, 2021). The pupation process takes place in the soil with a depth of 5–10 cm and a period of about 10–15 days. Overlapping generations can occur in a year depending on temperature and availability of hosts. In the case of foxtail millet, larval growth is associated with early crop growth and renders the crop extremely susceptible to attack during the early stages of growth as stated in Reddy et al. (2018).

**Symptoms and Damage**

Climbing cutworm damage is most destructive during the seedling to young vegetative stage of the thenai. The larvae feed nocturnally by cutting the seedlings in the collar region or by climbing the plant to feed on the leaves and young shoots (Rathod et al., 2020). Symptoms displayed include cut or chopped seedlings, wilted crops, dead hearts, or uneven spacing in the field. Sometimes, extensive parts of the crop can be damaged, requiring re-sowing. Mature caterpillars can lead to defoliation, reducing crop vigor and potential (Atwal & Dhaliwal, 2015).

**Field Detection and Key Indicators**

Field detection should be done either in the early morning hours or in the evening hours. Evidence such as uprooted seedlings, looseness of soil at the base, and larvae embedded immediately below the soil are major signs (Singh & Sharma, 2021). Light traps can be used to determine the movement of adult moths. The economic threshold level (ETL) is considered to be 1-2 larvae per square meter or 5-10% damage to seedlings beyond which control is desirable (Reddy et al., 2018).

**Movement and Multiplication**

*Agrotis ipsilon* larvae have restricted movement and are confined within the field area. The adult flies have short flight ranges where they deposit eggs in suitable wet soil with plants that act as hosts. Weeds, crop intensification, and low tillage are environmental factors that contribute to increasing populations (Hill, 2008). The larval stage is most damaging. The young instar larvae indulge in leaf feeding, and older instar larvae damage seedlings at ground level, resulting in maximum economic loss. The adult stage does not cause direct damage to crops. (Atwal & Dhaliwal, 2015).

**Control Measures**

Use of crop rotation with non-host plants, timely planting, proper land preparation, and sanitation of fields can also contribute to a decline in the cutworm population. Weeds and crop residues can be cleared because they serve as eggs and larval shelter sites (Reddy et al., 2018).

Deep summer ploughing makes the larvae and pupae susceptible to predators and dehydration. By manual destruction of the larvae during the early stages of infestation, control can be achieved in a small area. Setting up light traps can minimize the adult moths (Singh and Sharma 2021. Using neem cake @ 250 kg/ha during land preparation hinders larval survival. Application of 3% neem oil or 5% NSKE at the seedling stage prevents larval feeding. Entomopathogenic fungi like Metarhizium anisopliae and Beauveria bassiana can control soil-dwelling larvae (Kumar et al., 2021). Soil drenches with Chlorpyriphos 20 EC (2.5 L/ha or Phorate 10 G (10 kg/ha) at sowing give adequate control over larvae. The foliar spray with Lambda-cyhalothrin 2.5 EC (1ml/L) during the initial stages of infestation offers faster control (Rathod et al., 2020). IPM methods promote early detection, cultural control methods, biological control agents, and judicious chemical control as a means of addressing climbing cutworm in the thenai into the future. Refraining from the overuse of pesticides prevents the destruction of natural control agents.

**Conclusion**

The Climbing cutworm, *Agrotis ipsilon*, is one of the devastating pests of Foxtail Millet during the early growth stages, resulting in heavy damage at the seedling stages and consequent yield losses. To have an effective pest management strategy, a combined approach involving prevention, culture, bio, and chemical controls is employed when the pest reaches the larval stages.

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**GHUJHIA WEEVIL IN THENAI**

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**Abstract**

Foxtail millet (*Setaria italica*) also known as thenai is an important small millet grown in dryland and semi-arid regions of India because of its short duration, climate resilience, and nutritional value. However, insect pests during the early part of the season seriously threaten the establishment and productivity of the crop. Among them the Ghujhia weevil, *Tanymecus indicus,* Marshall (Coleoptera: Curculionidae), has emerged as an occasional but economically important pest in thenai, especially at the seedling stage. The adult weevils inflict damage by cutting or scraping the seedlings near the collar region, leading to wilting, deadheart symptoms, and patchy crop stand. The immature stages are soil-dwelling and thus help the pest persist across seasons. This article gives a complete description of the identification, distribution, biology, damage symptoms, field detection, and economic threshold level of the pest and integrated pest management strategies, including preventive**,** cultural, biological, and chemical control for sustainable management of the ghujhia weevil in foxtail millet.

**Keywords**: Ghujhia weevil, Tanymecus indicus, foxtail millet, thenai, seedling pest, IPM

**Introduction**

Foxtail millet, *Setaria italica*, is one of the oldest domesticated millets in India. This crop plays an important role in food and nutritional security, especially in rainfed and marginal farming systems. It has high dietary fiber content and is rich in minerals and low-glycemic carbohydrates, hence befitting climate-resilient agriculture and health-conscious diets (Reddy et al., 2018). Thenai cultivation is majorly done under low input conditions, where early crop establishment is critical in order to achieve optimum yield.

Despite its hardiness, foxtail millet is susceptible to several insect pests in its early growth stages. The more injurious ones are soil-dwelling insects, as their attack on seedlings is very soon after emergence, mostly leading to stand loss. In recent times, changes in cropping patterns such as continuous cultivation of cereals, minimum tillage, and residue retention have changed the pest dynamics, which favoured the emergence of Ghujhia weevil as a sporadic but serious pest in millet ecosystems during recent years (Singh & Sharma, 2021).

The Ghujhia weevil, *Tanymecus indicus*, though conventionally recognized as a wheat, barley, and mustard pest, of late has been commonly reported on millets, especially foxtail millet, at the seedling stage. Adults feed at or near the soil surface**,** cutting the seedlings at the collar region, leading to the formation of dead heart and uneven crop stand (Rathod et al., 2020). Because the immature stages are hidden in the soil, the pest is difficult to control after establishment in the field. Hence, a detail on its biology and management is very much essential for sustainable thenai production.

**Taxonomic classification**

**Common name**: Ghujhia weevil

**Scientific name**: *Tanymecus indicus*

**Order**: Coleoptera

**Family**: Curculionidae

**Subfamily**: Brachyderinae

**Host Range**

*Tanymecus indicus* is essentially a pest of rabi cereals, especially wheat and barley, but under favourable conditions, it has also been reported to infest mustard, maize, sorghum, and millet**s**. In foxtail millet, this pest acts mainly as a seedling pest, causing damage shortly after germination. Patel et al. (2020) estimated that damage by T. indicus is severe when sowing coincides with adult emergence in fields with continuous cereal cropping. There are two main methods by which these modem protocols provide much better performance than earlier methods, but both require that the phones support this.

**Origin and Distribution**

*Tanymecus indicus* is native to the Indian subcontinent and is one of the weevils with wide distribution in different agro-climatic zones of India. It is prevalent in northern, central, and southern regions and is known especially from the cereal-based cropping systems in those areas (Singh & Sharma, 2021). Soil-dwelling immature stages are key factors associated with its persistence and agronomic practices, including minimum tillage and repeated cultivation of host crops.

**Morphology and Diagnostic Characters**

Adult ghujhia weevil is a small to medium-sized beetle, about 5–8 mm in length, with an oval body robust and a rather short, broad rostrum typical of weevils. The body is greyish-brown to dark brown with earthy mottling, which substantially camouflages this insect against the soil background. The elytra have distinct longitudinal striations.

The larva is a creamy white, C-shaped, legless grub with a brown head capsule, adapted for subterranean feeding on plant roots. Pupation takes place in the soil within an earthen chamber and forms an exarate pupa, with developing appendages visible. The combination of seedling cutting by adults and immatures being soil dwellers is an important diagnostic feature in this pest.

**Life Cycle and Phenology**

*Tanymecus indicus* undergoes complete metamorphosis and generally completes one generation per year. Adults emerge from the soil with the onset of monsoon rains and feed on young plants. Females lay eggs in soil crevices near the base of the host plants. The egg stage lasts about 6-7 weeks, followed by larval development in the soil, where the grubs feed on the roots for several weeks to months.

Pupation occurs in earthen cells at a depth of 15–60 cm in the soil and continues for approximately 7 to 9 weeks. Newly emerged adults remain in the soil until favourable conditions appear. In thenai, adult activity usually coincides with the early stages of crop growth, which leads to the damage of seedlings.

**Symptoms and Damage**

The ghujhia weevil causes maximum damage in the seedling and early vegetative stages of foxtail millet. The adult weevils cut or scrape the stem near the collar region, resulting in wilting, deadheart symptoms, and drying of young plants.

The infested fields present a patchy crop stand with reduced plant population. In severe cases, re-sowing is done. Larval feeding roots occur beneath the ground, causing stunt growth and reduced vigor, though less conspicuous than the damage caused by the adults (Singh & Sharma, 2021).

**Field Detection and Key Indicators**

Field detection works best early in the morning and late in the evening when the adults are active. Other key evidences included defoliated seedlings cut at the collar region, patchy gaps within the field; and adults hiding under soil cracks or clods.

The economic threshold level consideration was generally 1–2 adult weevils per square meter or 5–10% seedling damage, beyond which the control measures should be recommended.

**Motion and Multiplication**

Adult ghujhia weevils are relatively poor fliers, but most of the dispersal occurs along the soil surface. During the daytime, they take refuge in soil cracks and under plant residues and are active during cooler hours (Singh & Sharma 2021).

Continuous cereal cultivation favours population build-up of this pest, though a lack of soil disturbance and favourable soil moisture further support its survival. The pest can survive between seasons in the soil since all the immature stages remain in the soil, thus reappearing when conditions are suitable (Reddy et al., 2023).

**Damaging Stage of Pest**

Among the different stages of its life cycle, the adult stage is most economically injurious to the foxtail millet. Adults cut the seedlings at the collar region due to which the mortality of plants occurs along with a loss of stand. Larvae cause root damage but generally contribute less to direct yield loss. Pupae do not cause any damage (Patel et al., 2020).

**Methods of Prevention**

Rotation with non-host crops, especially legumes and oilseeds, breaks the life cycle of the pest. In addition, timely sowing and adequate land preparation ensure a good establishment of seedlings rapidly; this reduces the vulnerability of plants to the feeding of adults. Lastly, field sanitation and removal of volunteer cereals and weeds prevent carry-over of the pest.

**Control Methods**

Deep summer ploughing exposes larvae and pupae to heat and natural enemies, reducing population for the next season. Hand collection and destruction of adults during early infestation is effective in small fields. Installation of bird perches encourages predatory birds to feed on surface-active adults (Rathod et al., 2020). Application of neem cake @ 250 kg $ha^{-1}$ during land preparation deters egg laying and larval development. Neem oil (3%) or NSKE (5%) sprays at seedling stage reduce adult feeding. Soil application of entomopathogenic fungi such as Beauveria bassiana and Metarhizium anisopliae effectively control the soil-dwelling stages of the insect (Kumar et al., 2021).

Application of Phorate 10G at the rate of @10 kg $ha^{-1}$ or hydrochloride 4G @ 10 kg acre at the time of sowing effectively controls the stages in the soil. Foliar spraying of Chlorpyriphos 20 EC @ 2.5 ml $L^{-1}$ or Lambda-cyhalothrin 2.5 EC @ 1 ml $L^{-1}$ during early infestation reduces the population of adults.

Management of ghujhia weevil in thenai, therefore, involves the integration of preventive, cultural, biological, and need-based chemical methods. Emphasis on early detection and management during the seedling phase at the adult stage ensures sustainable control with minimum ecological harm.

**Conclusion**

The important early-season pest of foxtail millet is Ghujhia weevil, *Tanymecus indicus*, which has the capability of causing significant seedling mortality and stand loss. Adoption of integrated pest management practices focusing on preventive and cultural measures with support for biological and judicious chemical control is essential in thenai production for sustainability.

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# GRAM POD BORER IN THENAI

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**Abstract**

The gram pod borer, Helicoverpa armigera, is a real killer for thenai (foxtail millet), *Setaria italica).* The larva causes severe damage by attacking on panicles, florets, and developing grains, resulting in poor grain filling and heavy yield losses. The pest survives till 25-35 days , allowing multiple generations in a season under favorable warm and dryconditions. Characteristic damage includes bored spikelets, excreta on panicles, and partially eaten grains. Effective management relies on integrated pest management (IPM) practices involving timely sowing, cultural sanitation, conservation of natural enemies, use of biological control agents, pheromone traps, and need-based chemical control at the ETL.

**Keywords:** Gram pod borer, *Helicoverpa armigera,* Thenai, Foxtail millet, Panicle damage, IPM, Larval feeding

**Introduction:**

Thenai (*Setaria italica*) is an important small millet cultivated in dryland and rainfed ecosystems, valuedforitsnutritionalqualityanddroughttolerance. Even though it's strong, foxtail millet gets hit by bugs. The gram pod borer is a big problem that hurts how much you can grow. This bug eats a lot of different plants, over 180 kinds., and causes severe damage during the flowering and grain-forming stages. Understanding its biology, damage symptoms, and management strategies is essential for sustainable millet production.

**PestIdentityand Taxonomy:**

**Commonname**: Gram pod borer / Cottonbollworm

**Scientific name** : *Helicoverpa armigera*

**Order:** Lepidoptera

**Family:** Noctuidae

**Host Range**

The gram pod borer, *Helicoverpa armigera*, is one insect that eats a lot of different things. It attacks over 180 kinds of plants fromvarious families. You can find it munchingon field crops, veggies, oilseeds, beans, and even grains, so it pretty much has food all year round, helping it survive and grow. It really likes to eat beans such as chickpeas, pigeon peas, cowpeas, green grams, and black grams, plus oilseed crops like sunflowers and groundnuts. It also goes for cotton and vegetables like tomatoes, okra, chillies, and cabbage.

When it comes to grains, it goes after foxtail millet, sorghum, maize, pearl millet, and finger millet, with the larvae eating the flowers and grains. This pest even lives on weeds, which helps it stick around when its favorite crops aren't available. Because it can adapt to so many plants, lays so many eggs, and moves around quite a bit, H. armigera is a constant and big problem for farmers, making it tough to manage in areas where they grow foxtail millet.

**Originand Distribution**

The gram pod borer, *Helicoverpa armigera* (Hubner), is believed have originated in Old World tropics, particularly in Africa, where it evolved alongside a wide range of host plants. From its center of origin, the pest spread gradually to Asia, Europe, and Australia, adapting successfully to diverse climatic conditions and cropping systems. Today, *H.armigera* is instead of widely distributed and economically important insect pest in the world. In Asia,it is extensively spread throughout Southeast Asia, and the Middle East, where it causes severe damage to pulses, millets, oilseeds, vegetables, and cotton. In Africa, it occurs in almost all sorghum- and millet-growing regions. The pest is also well established in Southern Europe, especially in Mediterranean countries, and is a major pest in Australia. Reports of its occurrence extend to parts of South and Central America due to accidental introduction through international trade.Its wide distribution is attributed to its polyphagous feeding habit, strong migratory ability, high reproductive potential, and adaptability to different agro-climatic conditions, enabling it to survive year-round wherever suitable host crops are available.

**Morphology**

Adult moths are a light, pale brownish-yellow color. They have a thick body and their wings spread about 3–4 cm. The front wings are grey to light brown with a clear V-shaped mark. The back wings are a pale, smoky white with a wide blackish edge. Some adults might have a dark spot in the middle of the front wing and a light area near the dark part of the back wing. Figuring out if thenai has a gram pod borer issue usually depends on seeing the damage it causes, not spotting the adult moths. Signs to look for are holes in the panicles, grains that are partly eaten or hollow, greenish-black droppings on the ear heads, and larvae eating with their heads inside the grain while the rest of their body sticks out

**Life Cycle**

The gram pod borer, also called Helicoverpa armigera, goes through a full change in its life, with four steps: egg, larva, pupa, and adult. If the weather is good in tropical places, it can finish its whole life cycle in about 25–35 days. This means that many generations can grow one after another during a single growing season**.** Eggs hatch within 3–5 days, lasts for 14–21 days, passing through 5–6 instars, pupate in earthen cells at a depth of about 5–10 cm. The pupalperiod ranges from 7– 15 days**.** Emerges, lives onlyabout a day, mates, and lays eggs.

**Symptoms and Damage:**

Damage in thenai caused by Gram pod borer, *Helicoverpa armigera,* occurs mainly during the flowering and grain development stages. The larval stage is responsible for all economic damage. Young larvae initially feed on floral parts, while older larvae bore into spikelets anddevelopinggrains.Themostprominent symptom is thepresenceofbore holes on panicles and spikelets, leading to partial or complete destruction of developing grains. Larvae often feed with theirheadinserted intothe grainandtheposteriorpart of the body remaining outside, a characteristic feeding behavior that helps in field diagnosis. Affected grains become hollow, shriveled, or partially eaten, resulting in poor grain filling.Infested panicles show irregular feeding marks, broken spikelets, and a blasted or withered appearance. The presence of greenish-black fecal pellets (excreta) on the panicles and around damaged spikelets is a reliable diagnostic sign of infestation. Severe attack can lead to extensive panicle damage, reduced grain weight, and significant yield loss

**Field detection**

Early detection of gram pod borer infestation in thenai is essential for effective management. Field scouting should begin from the flowering stage and continue through grain development, as this is the most vulnerable period of the crop. Regular monitoring helps in identifying the pest at an early larval stage, when control measures are most effective. Visual inspection of panicles and leaves is the primary method of detection. Presence of eggs laid singly on leaves or panicles indicates the onset of infestation. Small, early instar larvae may be observed feeding on floral parts, while larger larvae are often seen partially hidden inside spikelets. A key indicator of infestation is thepresence of bore holes on panicles and Look for tiny holes and greenish-black bug poop on the grain heads. If the grains look empty, wrinkly, or like something's been eating them, that's another sign. A key sign of gram pod borer damage is seeing bugs with their heads inside the grain and their bodies sticking out. Pheromone traps can help you keep tabs on the adult moths – about 5 traps per 2.5 acres is good.

**Movement and Multiplication**

The gram pod borer *Helicoverpa armigera*, is a highly mobile and rapidly multiplying pest, which contributes to its widespread occurrence and severe damage in thenai. The adult moths are strong fliers and possess the ability to migrate over long distances, enabling them to move from one field to another and from one crop to successive host plantsthroughouttheseason. Population buildup often begins on early-season host crops such as pulses, vegetables, or weeds, from where adults migrate to flowering thenai fields that provide favorable conditions for egg laying.

Multiplication of *H. armigera* is veryrapid due to its high reproductive potential and short life cycle. Afemalemothcan lay upto 500–1000 eggs duringherlifetime. Under favorable conditions of warm temperature (25–35°C) and dry weather, the pest finishes its life cycle within 25–35 days, resulting in multiple overlapping generations in a single cropping season. This continuous reproduction, combined with migration and availability of diverse host plants, leads to sudden population outbreaks and severe infestation in thenai crops.

**Damaging Stageof Pest:**

The *Helicoverpa armigera* caterpillar only causes damage to thenai crops. Once they hatch, the caterpillars eat the flowers, spikelets, and grains that are growing. The young caterpillars will scrape at the flower parts for food, but the older ones will bore into the spikelets and grains, which causes a lot of damage. management efforts usually target the young caterpillars because they are easier to control and cause the most damage if you don't deal with them.

**Preventive methods**

Preventive measures plays a important role in reduction of the gram pod borer in thenai by avoiding favorable conditions for pest buildup. Timely and uniform sowing of thenai helps the crop escape peak pest populations, as staggered planting encourages continuous availability of host plants and promotes infestation. Selection of healthy, certified seeds and maintenance of optimum plant population contribute to uniform crop growth and reduced vulnerability. Field sanitation is an important preventive practice. Removal and destruction of crop residues, volunteer thenai plants, and alternate host weeds in and around the field eliminate breeding and carry-over sources of the pest.Deep summer ploughing exposes and destroys pupae present in the soil, thereby reducing the initial pest population in the following season.

**Cultural and Mechanical method**

Cultural methods are the most effective and eco-friendly practices for managing gram pod borer in thenai, as they reduce pest buildup by modifying the crop environment and disrupting the pest life cycle. Timely and synchronized sowing of thenai helps the crop escape peak infestation by preventing prolonged availability of flowering panicles. Avoiding staggered planting reduces migration of the pest from older to younger crops. Crop rotation with non-host crops such as root crops, oilseeds, or vegetables breaks the continuity of the pest's life cycle. Removal of alternate host plants and weeds from field bunds and nearby areas eliminates breeding and survival sites.

**Mechanical methods**

Involve the physical removal or trapping of the pest. Hand picking and destruction of larvae and egg masses during early stages is effective in small and medium-scale fields. Installation of pheromone traps (5 traps per hectare) helps in monitoring adult moth populations and reducing mating success. Light traps operated during night hours attract and kill adult moths, aiding in population suppression. Bird perches installed in the field encourage insectivorous birds such as mynas and drongos to feed on larvae, contributing to natural pest reduction.

**Biological methods**

This means using natural predators and tiny organisms to keep the pest population down without messing up the environment. Parasites are a big help in keeping H. armigera populations in check. For example, Trichogramma chilonis, which attacks the pest's eggs, stops them from hatching into larvae. Regularly releasing Trichogramma during the flowering period can lower how many pests you see. Other parasites, such as Campoletis chlorideae and Chelonus blackburni, target the larva and mess with how they grow.

**Chemical method**

Chemicalcontrol of grampodborer in thenai should be adoptedonlywhenthepestpopulation exceeds the Economic Threshold Level(ETL) and when preventive, cultural, and biological methods are insufficient. Since the larval stage causes damage, insecticides must be targeted against early instar larvaeformaximum effectiveness.Thecriticalstage for spraying is duringtheflowering to early grain formation stage, when eggs hatch and young larvae begin feeding on panicles. Spraying at this stage prevents severe damage to developing grains. Applications should preferably be carried out during the early morning or late evening hours, when larval activity is higher and spray drift is minimal.Emmacetin benzoate 5 SG @ 0.4 g/L of water Spinosad 45 SC @ 0.3 ml/L of water Chlorantraniliprole 18.5 SC @ 0.3 ml/L ofwater indocarb 14.5 SC @ 1.0 ml/L of water.

Lambda-cyhalothrin 5 EC @ 1.0 ml/L of water . Spraying should be done early in the morning (before 9 AM) when adult borer are most active. Proper spray coverage of the panicles is essential for good results.

**IPM**

IPMbeginswith preventivemeasures, such as timelyand uniform sowing ofthenai to avoid peak pest activity and reduce continuous host availability. Field sanitation, including removal of crop residues, volunteerplants, andalternatehostweeds, helps in reducing initial pest populations. Deep summer ploughing destroys pupae present in the soil.Regular monitoring and surveillance are essential components of IPM. Fields should be scouted from the flowering stage onwards to detect eggs and early instar larvae.Installation of pheromone traps (5 traps per hectare) helps monitor adult moth activity and provides early warning of infestation.Biological control plays a central role in IPM. Conservation and release of natural enemies such as Trichogramma chilonis, larval parasitoids (Campoletis chlorideae), predators, and application of microbial agents like HaNPV and Bt help suppress pest populations without harming the ecosystem. Mechanical methods, including hand picking of larvae, use of light traps, and installation of bird perches, further reduce pest pressure.Chemical control is used only as a last resort, when pest levels exceed ETL. Selective insecticides targeting early larval stages should be applied at the flowering to early grain formation stage, ensuring rotation of chemicals to avoid resistance and minimal impact on beneficial organisms.By integrating these compatible methods, IPM provides long-term control of gram pod borer in thenai, reduces dependence on chemical pesticides, preserves natural enemies, and ensures stable yield and environmental sustainability.

**Conclusion:**

The gram pod borer, *Helicoverpa armigera*, is a huge problem for Thenai farmers because it ruins crops, mainly when the plants are flowering and making grains. It eats many different plants, reproduces quickly, and can travel far, so it's hard to control if you only use one method. To best handle this pest in the long run, it's best to combine different ways: plant on time, keep the fields clean, check for pests regularly, protect the bugs that eat the pests, and use biological controls. Using certain bug killers carefully and only when needed, targeting the young bugs, can increase control and keep the environment safe. By using these combined methods, farmers can be sure of getting good harvests of high-quality Thenai while protecting the environment.

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# TERMITES IN THENAI

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**Abstract**

Thenai (Foxtail millet, Setaria italica) is one of the important minor millets grown in semi-arid and dryland regions of India. It is valued for its short duration, drought tolerance, nutritional richness, and suitability for marginal soils. However, the productivity of thenai is constrained by several insect pests, among which termites are one of the most destructive soil pests. Termites attack the crop from sowing to maturity by feeding on seeds, roots, and basal portions of plants, leading to poor germination, drying, and lodging of plants. Termite infestation is more severe under dry conditions, light soils, and fields with high organic matter. This document provides a detailed account of termite pests in thenai, covering pest identity, host range, distribution, morphology, life cycle, nature of damage, symptoms, economic threshold, and integrated pest management strategies for sustainable control.

**Key words:** Termites, Thenai, Foxtail millet, Odontotermes, soil pest, IPM.

**Introduction**

Thenai (Setaria italica L.) is an ancient millet crop cultivated widely in India, especially in Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, and parts of central India. It is primarily grown under rainfed conditions and plays a crucial role in food and nutritional security for rural populations. Despite its hardiness, thenai is susceptible to a range of insect pests that reduce plant stand and yield. Among the soil-dwelling pests, termites are particularly important because they remain unnoticed until severe damage becomes visible. Termites attack the crop at early stages by feeding on seeds and roots, resulting in gaps in the field and uneven crop establishment. Under prolonged dry spells, termite damage can lead to complete crop failure in patches. A proper understanding of termite biology, damage symptoms, and management practices is essential for minimizing losses in thenai cultivation. Hence, this paper reviews various aspects of termites infesting thenai with special emphasis on integrated pest management.

**Pest Identity and Taxonomy**

**Common name:** Termites

**Scientific name:** Odontotermes spp., Microtermes spp.

**Order:** Isoptera (Blattodea: Termitoidae)

**Family:** Termitidae

**Host Range**

Termites are polyphagous pests and attack a wide range of crops. In addition to thenai, they feed on many cereals, millets, pulses, and plantation crops. Thenai (Foxtail millet) – principal host, other millets (sorghum, pearl millet, finger millet), rice (upland), maize, pulses and oilseeds, sugarcane and vegetables, dry grasses and crop residues.

**Origin and Distribution**

Termites are widely distributed throughout the tropical and subtropical regions of the world. In India, they are present in almost all agro-climatic zones. Severe termite incidence in thenai is commonly reported from dryland areas of Tamil Nadu, Karnataka, Telangana, Andhra Pradesh, Madhya Pradesh, Rajasthan, and Maharashtra. Their population builds up rapidly in sandy to loamy soils under dry weather conditions and in fields with continuous monocropping and poor soil moisture.

Workers are soft-bodied, creamy white, wingless insects. They are responsible for feeding, foraging, and damaging the crop roots and basal stems. Soldiers have a larger head with strong mandibles. They protect the colony and do not feed on crops. Reproductive forms are dark-colored with two pairs of equal-sized wings. After mating flights, they shed their wings and establish new colonies.

**Life Cycle**

Termites exhibit social behavior and live in well-organized colonies. The life cycle consists of egg, nymph, and adult stages. Eggs are laid by the queen inside the nest and hatch in 1–3 weeks. Nymphs develop into workers, soldiers, or reproductives depending on colony needs. Adults perform specific roles in the colony; workers cause crop damage. Termite activity is highest during dry periods, especially after sowing when soil moisture is low.

**Symptoms and Nature of Damage**

Termites feed on germinating seeds, roots, and basal portions of plants. Plants dry suddenly and can be easily pulled out. Circular patches of dried plants appear in the field. Earthen galleries are seen on plant bases and soil surface. Severe infestation results in poor plant stand and yield loss.

**Field Detection**

Presence of earthen runways on soil surface, drying of plants in patches, and hollowed stems are key indicators of termite infestation. There is no fixed ETL for termites. Any visible infestation at early crop stages warrants immediate control. The worker caste is the damaging stage. Workers feed continuously on plant roots, seeds, and stems.

**Control Methods**

Deep summer ploughing to destroy termite colonies, removal of crop residues and stubbles, maintaining adequate soil moisture, avoiding continuous monocropping, seed treatment before sowing**,** crop rotation with non-host crops, timely irrigation during early crop stages, application of well-decomposed fym instead of undecomposed organic matter, destruction of termitaria in and around fields**,** use of entomopathogenic fungi like metarhizium anisopliae, conservation of natural enemies such as ants and birds, neem cake application @ 250 kg/ha reduces termite incidence. Chemical control should be adopted when infestation is severe. seed treatment with chlorpyriphos 20 ec @ 4 ml/kg seed, soil application of chlorpyriphos 10 g @ 10 kg/ha, fipronil 0.3 g @ 25 kg/ha. Integrated management involving cultural practices, biological agents, and need-based chemical control is the most effective and eco-friendly approach to manage termites in thenai.

**Conclusion**

Termites are serious soil pests of thenai, particularly under dryland conditions. Early detection and adoption of integrated pest management practices can significantly reduce crop losses. Emphasis on preventive and cultural measures along with judicious chemical use ensures sustainable management of termites in foxtail millet cultivation.

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## SORGHUM SHOOT FLY

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**Abstract**

Sorghum (Sorghum bicolor L. Moench) is a major food cereal grown on a large scale in semi-arid and rainfed areas of India. This crop remains less productive due to attack by several insect pests, of which the most serious insect is the shoot fly, Atherigona soccata Rondani (Diptera: Muscidae), attacking young sorghum during the initial phase of its life cycle. The larval phase of the shoot fly affects the main stalk of young seedlings and causes the dead heart symptom. The dead heart symptom results in sparse plants, followed by an increased tillering habit and non-productive stalks. The population often thrives when sorghum is grown continously and when alternate gramineous food sources are provided. In addition, when sorghum is grown in hot and wet environments and at a late sowing time, the impact of the pest becomes pronounced. The present study is a structured presentation of the details of pest type, geographic distribution, host, morphology, life cycle, injury symptoms, crop inspection, and levels of economic threshold of the pest. The different methods such as preventive, cultural, mechanical, biological, chemical control, and others in relation to IPM can be employed for effective management of sorghum shoot fly.

**Keywords:** Sorghum shoot fly, Atherigona soccata, deadheart, seedling pest, integrated pest management.

**Introduction**

Sorghum (Sorghum bicolor L. Moench) is an essential food crop and quality feed for many people in the Indian subcontinent, and it is mainly grown in rainfed and upland ecosystems. It is of prime importance in securing food supplies, animal feed, and for the production of bioethanol. Among the main producers of sorghum, the Indian subcontinent ranks prominent, and it is grown in substantial quantities in the Indian states of Maharashtra, Karnataka, Telangana, Andhra Pradesh, and Madhya Pradesh. Despite its hardiness, sorghum is vulnerable to various insect pests at various stages of development. Of these, one of the most important insects that cause damage to sorghum at the seedling level is the shoot fly, Atherigona soccata. The damage that is caused by shoot fly is one of the most severe factors responsible for yield loss in sorghum. This normally takes place within the first 30 days from sowing. The adult shoot fly lays its eggs on the lower surface of juvenile sorghum leaves. On emerging, the larva migrates to the central whorl, where it renders the growing point defunct by cutting it, causing the middle shoots to dry up, known as deadheart. This results in a reduction in the Plant Density as the affected plant is compelled to grow Tillers that are stunted and unproductive

The shoot fly infestation is affected by sowing time, temperature, humidity, and crop patterns. The late-sown crop is very vulnerable to shoot fly attack, especially when it synchronizes with the adult population activities. Knowledge on shoot fly biology and management is very critical in dealing with the challenge in order to improve the productivity of sorghum. The review will offer a detailed insight into the aspects of sorghum shoot fly and its management practices.

**Pest Identity and Taxonomy**

**Common name:** Sorghum shoot fly

**Scientific name**: *Atherigona soccata*

**Order:** Diptera

**Family**: Muscidae

**Host Range**

*Atherigona soccata* is basically a sorghum eater, but it can also attack other cereals like grasses. Sorghum (Sorghum bicolor) – major pearl millet (pennisetum glaucum), maize (zea mays), natural grasses and fodder grasses, alternate hosts for grasses support the pest's survival during the off-season.

**Origin and Distribution**

The sorghum shoot fly is quite widely distributed in tropical as well as in subtropical parts of the world. In India, it is found in all major sorghum-growing states, namely: Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, Madhya Pradesh. The pest is more serious under warm and humid conditions, especially in late-sown kharif and rabi sorghums.

**Morphology**

Eggs are cigar-shaped, white, and found singularly on the underside of young leaves. A feature that distinguishes them is the presence of two prominent ridges on the eggshell. The larva is a legless, cream-colored maggot that is tapered at the anterior end. The larva lives on the growing point within the central whorl, resulting in deadheart. Pupation typically occurs within the stem or in the soil around where the plant grows. The larva ends up in a brown barrel-shaped pupa. Adults are greyish-colored flies that resemble houseflies but are smaller. They are most active at early morning and evening time.

**Life Cycle**

Egg: 1-2 days, Larval: 7-10, Pupal: 7 days. Living up to seven to fourteen days in several overlapping generations may occur within the cropping season. The peak intensity of infestation occurs in the first 30 days following sowing.

**Symptoms**

Drying up of central shoot (deadheart), very easy pulling out of dead central leaf with foul smell, tillering accompanied by thin, unproductive shoots, plant density and yield reduction the damage is most serious at 10-30 days. Field detection and key indicators eggs laid on the underside of juvenile leaves deadheart symptoms in seedlings adult flies flying around juvenile vegetation

ETL is 10% deadhearts OR 1 egg per seedling.

**Movement and Multiplication**

The adult fly is a weak flyer, but it can spread within a field. The crop is continuously grown, and late planting, along with the presence of grassy weeds, are ideal conditions for their buildup in large numbers. Damaging Stage "The most damaging stage is the larval stage, or maggot stage. Eggs, pupae, and adult mosquitoes do not actually cause harm.

**Control Methods**

Timely sowing at the onset of monsoons**,** use of shoot fly-resistant sorghum varieties shoot flies, "seed treatment with recommended insecticides", avoidance of late sowing this refers to the various techniques used to high seed rate followed by thinning, elimination and destruction of dead heart seedlings, crop rotation: use of non-host crops, field sanitation and weed control. Conservation of natural enemies like parasitoids (Neotrichoporoides nyemitaw**)** applying neem seed kernel extract (5%)**,** neem oil spray (3%) at the seedling stage. Chemical control works well for application at the early seedling stage. Imidacloprid 70 WS @ 5 g/kg**,** thiamethoxam 30 fs @ 10ml/kg seed**,** soil or foliar application, chlorpyriphos 20 ec @ 2, carbofuran 3G @ 10 kg/ha. Measures for managing the shoot fly include proper sowing time, use of resistant varieties, seed treatment, and protection of natural enemies. Insecticide control should be the final approach and should be combined with crop management practices.

## Conclusion

Sorghum shoot fly, Atherigona soccata, is considered to be one of the important early-stage pests, leading to potential yield losses if not controlled in a proper manner. It is important to control such a pest through early detection and integrated pest control measures to avoid potential losses. Raising awareness regarding control along with sound biological control practices would ensure safe control of such a pest.

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## SORGHUM STEM BORER

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**Abstract**

Sorghum stem borer (*Chilo partellus*) is one of the most destructive insect pests affecting sorghum cultivation in tropical and subtropical regions. The pest causes damage primarily during the early vegetative stages by boring into the stem and feeding on internal tissues. This feeding results in characteristic symptoms such as shot holes, dead heart formation, stunted growth, and lodging. Severe infestation can significantly reduce grain yield and fodder quality. The pest has a high reproductive capacity and can complete multiple generations in a single cropping season, making it difficult to manage if not controlled early. Understanding the biology, damage pattern, and management strategies of sorghum stem borer is essential for effective control. Integrated Pest Management (IPM), combining cultural, mechanical, biological, and chemical methods, offers a sustainable approach to minimize crop losses while protecting the environment.

**Keywords:** Sorghum, stem borer, Chilo partellus, dead heart, shot holes, integrated pest management, larval pest, crop yield loss.

**Introduction**

Sorghum (*Sorghum bicolor*) is an important cereal crop grown extensively for food, fodder, and industrial purposes, particularly in dry and semi-arid regions. It is valued for its drought tolerance and ability to grow in marginal soils. However, sorghum productivity is limited by several insect pests, diseases, and weeds. Among insect pests, the sorghum stem borer is considered one of the most serious constraints to sorghum production. The pest damages the crop internally by boring into the stem, which disrupts the transport of water and nutrients. Infestation is most severe during the seedling and early vegetative stages, when plants are highly vulnerable. Losses caused by stem borer not only reduce grain yield but also affect fodder quality, making it a serious concern for farmers. Therefore, effective management strategies are necessary to ensure sustainable sorghum production.

**Pest Identity and Taxonomy**

**Common Name:** Sorghum Stem Borer

**Scientific Name:** *Chilo partellus*

**Order:** Lepidoptera

**Family:** Crambidae

**Host Range**

The sorghum stem borer is a polyphagous pest that attacks a wide range of cultivated and wild grass species. Sorghum is the primary host, but the pest also infests other cereal crops such as maize, pearl millet, and finger millet. In addition to cultivated crops, the stem borer can survive on various grasses, including sugarcane, napier grass, and wild grasses found around agricultural fields. These alternate hosts play an important role in the survival and carryover of the pest during off-seasons. The wide host range of Chilo partellus makes management difficult, as the pest can persist even in the absence of the main crop. Therefore, removal of alternate host plants and proper field sanitation are important components of effective pest management.

**Origin & Distribution**

The sorghum stem borer complex is primarily represented by the spotted stem borer (*Chilo partellus),* which is indigenous to Asia and the Indian subcontinent but has become highly invasive in sub-Saharan Africa since its accidental introduction in the early 1930s. It is now widespread across East and Southern Africa, including countries like Ethiopia, Kenya, and South Africa, and has recently expanded into the Mediterranean Basin in Turkey and Israel. Other significant species include the African maize stem borer (*Busseola fusca*), which is strictly native to mainland Africa south of the Sahara, and the pink stem borer (*Sesamia inferens*), indigenous to monsoonal tropical Asia and Oceania, where it occurs from Pakistan to Japan. While these pests vary in origin, they are now widely distributed throughout the tropical and sub-tropical regions of Asia and Africa, often co-occurring and competing for host plants like sorghum, maize, and pearl millet.

**Morphology and Diagnostic Characters**

The sorghum stem borer belongs to the order Lepidoptera and family Crambidae. The adult insect is a medium-sized moth with pale brown or straw-colored forewings bearing small dark spots. The hind wings are whitish and semi-transparent with fringed margins. Eggs are creamy white, flattened, and scale-like, laid in overlapping masses on the underside of leaves, usually near the midrib. The larva is the most distinctive stage; it is pale yellow to dirty white with a dark brown head capsule and a smooth cylindrical body. Fully grown larvae measure about 20–25 mm in length. Pupae are brown in color and are found inside the stem, within tunnels, or in plant debris. Diagnostic characters include shot holes on leaves, dead heart formation, and larval tunneling inside the stem filled with frass.

**Life Cycle**

The life cycle of the sorghum stem borer consists of four distinct stages: egg, larva, pupa, and adult. The female moth lays eggs in masses on the underside of sorghum leaves, usually near the midrib. Each egg mass contains several overlapping, scale-like eggs that are creamy white in color. The eggs hatch within a few days depending on temperature and humidity. The newly hatched larvae are very active and initially feed on leaf surfaces and in the whorl region, producing small shot holes on the leaves. After a short period of external feeding, the larvae bore into the stem and begin feeding on internal tissues, where they remain concealed for most of their larval life. The larval stage is the longest and most damaging phase of the life cycle. Fully grown larvae pupate inside the stem or in plant debris near the base of the plant. The pupal stage lasts for several days, after which adult moths emerge. Adults are nocturnal, mate soon after emergence, and females begin laying eggs, thus completing the life cycle. Several overlapping generations may occur within a single cropping season, leading to continuous infestation.

**Symptoms & Damage**

Damage by sorghum stem borer varies with the stage of crop growth. In the early seedling stage, larvae feed on the leaf whorl, resulting in small pinholes or shot holes on the emerging leaves. As larvae grow, they bore into the stem and feed on internal tissues. This causes drying of the central shoot, known as dead heart, which can be easily pulled out. Infested plants show stunted growth and reduced tillering. In later stages, larval tunneling weakens the stem, leading to lodging and poor grain filling. Internally damaged plants appear healthy initially but later collapse, causing heavy yield loss. Presence of frass inside tunnels is a clear sign of infestation.

**Field Detection**

Early detection of sorghum stem borer infestation is critical for effective management. One of the earliest indicators is the appearance of shot holes on young leaves. Dead heart formation in seedlings is a prominent and easily recognizable symptom. On splitting affected stems, tunnels filled with frass and larvae can be observed. In older crops, lodging and reduced ear head development indicate stem borer damage. Monitoring adult moth activity using light traps can also help detect pest presence. Regular field scouting, especially during early crop stages, is essential for timely intervention.

**Movement and Multiplication**

The sorghum stem borer has a high reproductive potential and multiplies rapidly under warm and humid climatic conditions. Female moths lay egg masses on sorghum leaves, and eggs hatch within a few days. Young larvae move actively towards the whorl region and begin feeding. As they mature, larvae bore into the stem, where they remain protected from predators and pesticides. Adults are strong fliers and can travel long distances, allowing the pest to spread rapidly across fields and regions. Overlapping generations occur during the cropping season, leading to continuous infestation if not managed properly.

**Damaging Stage of the Pest**

The larval stage is the only damaging stage of the sorghum stem borer. Newly hatched larvae initially feed on leaf surfaces and whorl tissues, while older larvae bore into the stem and feed internally. This internal feeding causes the most severe damage as it destroys vascular tissues. Eggs, pupae, and adults do not cause direct damage to the crop but play an important role in the continuation of the pest population.

**Preventive Methods**

Preventive measures help reduce initial infestation and pest buildup. Timely sowing of sorghum helps the crop escape peak stem borer activity. Use of healthy seeds and resistant or tolerant varieties reduces damage levels. Proper field sanitation, including removal and destruction of crop residues and stubbles, eliminates overwintering stages of the pest. Balanced fertilizer application, especially avoiding excessive nitrogen, prevents lush growth that attracts stem borers. Crop rotation with non-host crops also helps break the pest life cycle.

**Mechanical Methods**

Mechanical control methods are simple, cost-effective, and environmentally friendly. Removal and destruction of egg masses during early crop stages reduce larval population. Uprooting and destruction of dead heart plants help prevent further spread. Deep summer ploughing exposes pupae to sunlight, predators, and desiccation. Use of light traps helps in monitoring and partially reducing adult moth population. These methods are particularly useful for small and marginal farmers.

**Chemical Methods**

Chemical control is recommended when stem borer infestation exceeds the economic threshold level. Seed treatment with recommended insecticides provides early protection to seedlings. Application of granular insecticides into the whorl region is effective against early instar larvae before they bore into the stem. Foliar sprays may be applied to control adult moths and newly hatched larvae. Chemical control should be used judiciously to avoid pesticide resistance, resurgence of pests, and negative effects on beneficial insects and the environment.

**Biological Methods**

Sorghum stem borer (*Chilo partellus*) can be effectively managed through biological methods by conserving and releasing natural enemies. Important parasitoids such as *Trichogramma chilonis* (egg parasitoid) and *Cotesia flavipes* (larval parasitoid) reduce borer populations by attacking their eggs and larvae. Predators like ladybird beetles, spiders, and ants also help by feeding on eggs and young larvae. Application of bio-pesticides such as *Bacillus thuringiensis* (Bt) or *Beauveria bassiana* targets larvae without harming beneficial insects. Growing tolerant varieties and maintaining field biodiversity further support natural biological control and reduce stem borer damage in sorghum.

**Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) is the most sustainable approach for managing sorghum stem borer. IPM combines cultural practices such as timely sowing, crop rotation, and resistant varieties with mechanical methods like removal of infested plants. Biological control through conservation of natural enemies such as parasitoids and predators plays an important role in reducing pest population. Chemical control is used only as a last resort and based on economic threshold levels. IPM minimizes pesticide use, reduces production costs, and protects ecological balance while effectively managing the pest.

**Conclusion**

The sorghum stem borer is a major insect pest that poses a serious threat to sorghum production. Damage caused by larval feeding inside the stem leads to dead heart formation, lodging, and severe yield loss. Due to its high reproductive capacity and concealed feeding habit, early detection and timely management are crucial. Adoption of integrated pest management strategies offers an effective and environmentally safe solution for controlling stem borer infestation. Proper management of this pest ensures healthy crop growth, improved yield, and increased profitability for farmers.

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## PINK STEM BORER IN SORGHUM

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**Abstract:**

Sorghum (Sorghum bicolor L. Moench) is a major cereal species widely grown in semi-arid and rainfed areas of India. Though sorghum is quite versatile and resilient to abiotic and biotic stresses, its yield is severely limited by a range of insects, especially those that infest sorghum in their early life cycle stages. Amongst these, a key internal sorghum feeder is pink stem borer, Sesamia inferens Walker (Lepidoptera: Noctuidae). The last life stage of the pink stem borer is the one that affects the plant through its ability to make the heart dead as a result of its feeding. The effect is mainly because the plant develops white earheads. The pink stem borer is more devastating in conditions associated with late sown crops and in regions where cereal crops can be grown all year round. In this paper, the information related to the identity of the pest, host range, distribution, morphology, life cycle, nature of damage, detection of the pest in the field, and the economic thresholds of the pink stem borer can be found. Management techniques, both preventive, cultural, mechanical, biological, as well as chemical, are highlighted in the concept of integrated pest control of the pink stem borer of sorghum.

**Keywords:** Pink stem borer, Sesamia inferens, sorghum, deadheart, stem borer, integrated pest

**Introduction:**

Sorghum (Sorghum bicolor (L.) Moench) is an important coarse cereal crop raised in India as well as other parts of the world. It is preferred for the drought conditions under which it grows. This crop serves as an important source of food, forage, as well as industry. Sorghum is commonly raised in various states of India, including Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, and Madhya Pradesh. Although it is a resilient crop, sorghum has various types of insect pests that target it at various stages of its life cycle. Among the important groups of pests are the stem borers, which are usually difficult to control since they consume plant material from inside the plant. Of all the stem borers, the pink stem borer, Sesamia inferens, poses a tremendous threat to growing sorghum. The larvae tunnel into the stalk near the plant base and indulge in the consumption of the growing points of the plant, leading to drying of the central shoot, which is termed deadheart. In the later stages of plant life, the damage caused by the insect results in white earheads, chaffy grains, and lodging. The insect has a strong ability to survive in residues.

It is necessary to learn the biology, symptoms, and control methods of the pink stem borer to reduce yield losses. This review gives a clear description of the pest and highlights the use of IPM strategies for the proper control of the pest in sorghum.

**Pest Identity and Taxonomy:**

**Common name:** Pink stem borer

**Scientific name:** *Sesamia inferens*

**Order:** Lepidoptera

**Class:** Insecta

**Family:** Noctuidae

**Host Range**

Sesamia inferens, the polyphagous caterpillar, is reported to damage various cereal and grass species. Sorghum (*Sorghum bicolor*) - major, rice (Oryza sativa) maize (*Zea mays*) , sugarcane (*Saccharum officinarum*), pearl millet (*Pennisetum glaucum*) , wild grasses .The fact that alternate hosts are available helps the pest to thrive all year round.

**Origin and Distribution**

The genus P. *distinguenda*, or the pink stem borer, is found throughout Asia, especially in India, China, Japan, and Southeast Asian nations. In India, this insect is found throughout major sorghum-growing areas, especially in regions that produce cereal crops continuously.

It is more prevalent in warmer and more humid environments, as well as in late-sown crops. The bug population increases fast in regions with poor sanitation around fields and crop residues remaining in the fields.

**Morphology**

Eggs are creamy white, flattened, and occur in large quantities on the lower side of the leaves or within the leaf sheaths. Each egg mass is usually covered with scales of a brownish color from the abdomen of the female. These larvae are stout, smooth, pale pink in color, hence the popular name for this pest. The fully developed larva has a total length of 25-30 mm, along with a brown head capsule. Pupation takes place in the stem or in crop residues. The pupa has a reddish-brown color and a cylindrical appearance. Adult moths are of moderate size, with pale straw-colored forewings and whitish hind wings. There is a tuff of hair at the tip of the abdomen in the female.

**Life Cycle**

Its type of metamorphosis is complete. Stage of eggs: 5–7, Larval stage: 20-30, Four stages, with a adult lifespan of 5-10 days. There are a few generations in a year that overlap. The pest is most harmful in the early vegetative phase of sorghum.

**Symptoms and Nature of Damage**

Drilling into the stem close to the base of the plant, drying of central shoot leading to dead heart, evidence of frass present at the entry hole, white earheads in more mature crop stages, chaffy grains and poor grain filling, heavy infestation leads to considerable yield losses.

**Movement and Multiplication**

Moths are able to fly and migrate in short distances. The young ones hide inside the plant stems; hence, they are protected from their natural enemies and pesticides. Cereal continuous cultivation increases their buildup. Later Instars and Pupae Stages of Larvae are the most damaging. There are no direct damaging stages for eggs, pupae, or adults.

**Control measures**

Planting sorghum on time, uprooting and destruction of crop residues, avoidance of late sowing, use of tolerant or resistant varieties, deep summer plowing - to destroy larvae and pupae, harvesting and destruction of deadheart plants, crop rotation using non-host crops, crop rotation, field sanitation and weed control, protection of natural enemies such as parasitoids (trichogramma spp.), application of trichogramma spp, application of neem seed kernel extract (5%). Chemical control should be employed as soon as infestation exceeds ETL. Carbofuran 3G @ 10 kg/ha (soil dressing). The recommended preparation and dosage of all pesticides are given here with Lambda-cyhalothrin 5 EC @ 1mL/L. Sprays should be timed when the larvae are in their early instars. In managing the pink stem borer, farmers can use integrated approaches that entail proper sowing, cultural practices, biological control, and the use of pesticides. The use of pesticides alone is dangerous since it results in the development of pest resistance.

**Conclusion:**

Pink Stem Borer: The pink stem borer, is a significant pest of sorghum as it causes damage both at the vegetative and reproductive phases. Prompt attention and the adoption of integrated pest management techniques are critical in order to reduce losses of yields. Raising awareness on preventive and cultural controls coupled with biological as well as need-based chemical controls of the pest can effectively provide long-term sustainable and environment-friendly methods of pest control.

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# SORGHUM SHOOT BUG

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**Abstract**

Sorghum is one of the most important cereal crops cultivated in tropical and subtropical regions due to its adaptability to drought and poor soils. However, its productivity is severely affected by various insect pests, among which the sorghum shoot bug (*Peregrinus maidis*) is a major sucking pest. The pest causes damage by suckiNg sap from young plants, leading to yellowing, stunted growth, drying of the central shoot, and in severe cases, plant death. Infestation is more serious during early crop stages and under warm, humid conditions. Proper understanding of the pest's biology, morphology, damage symptoms, and management strategies is essential for minimising crop losses. Integrated Pest Management (IPM) approaches offer effective and environmentally safe control by combining cultural, mechanical, biological, and chemical methods.

**Keywords:** Sorghum, shoot bug, *Peregrinus maidis*, sucking insect pest, crop damage, integrated pest management, early-stage infestation.

**Introduction**

Sorghum (*Sorghum bicolor*) is a staple cereal crop grown extensively for food, fodder, and industrial purposes in many parts of the world, particularly in Asia and Africa. It plays a crucial role in food security due to its tolerance to drought and low-input farming systems. Despite its hardy nature, sorghum is attacked bEconomicallyange of insect pests that reduce both yield and quality. Among these pests, the sorghum shoot bug is considered economically important because it attacks the crop at the most vulnerable seedling and vegetative stages. Continuous sap sucking by the pest weakens the plant and interferes with normal growth. If the infestation is not managed in time, it can lead to significant yield loss. Therefore, understanding the nature of the pest and its management is essential for sustainable sorghum production.

**Pest Identity and Taxonomy**

**Common Name:** Sorghum Shoot Bug

**Scientific Name:** *Peregrinus maidis*

**Order:** Hemiptera

**Family:** Delphacidae

**Host Range**

The sorghum shoot bug has a wide host range and primarily attacks crops belonging to the family Poaceae. Sorghum is the principal host, but the pest also infests maize, pearl millet, finger millet, and other cereal crops. In addition to cultivated crops, the pest can survive on several wild grasses, which act as alternate hosts and help maintain the pest population during the off-season. The availability of multiple host plants enables the sorghum shoot bug to persist throughout the year and spread easily between crops. This wide host range makes management difficult and highlights the importance of field sanitation and crop rotation in controlling the pest.

**Origin & Distribution**

The shoot fly's origin is generally associated with the ancient history of sorghum cultivation, which was first domesticated around 8000 BCE in Ethiopia and Sudan. The fly is widely distributed across the areas where sorghum has traditionally been a staple crop. It is widely distributed across tropical and subtropical regions of Asia, Africa, and Mediterranean Europe. It has not been recorded in Australia or the Americas. Within affected areas like India, it is found in almost all sorghum-growing states, including Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu.

**Morphology and Diagnostic Characters**

The sorghum shoot bug belongs to the order Hemiptera and family Delphacidae. The adult insect is small, delicate, and wedge-shaped with a straw-colored to pale brown body. It has well-developed piercing and sucking mouthparts adapted for extracting plant sap. The wings are transparent and extend beyond the body, enabling short-distance flight. Nymphs resemble adults in shape but are smaller, wingless, and light yellow to pale brown in color. A distinguishing diagnostic character of this pest is the presence of waxy filaments on the body, particularly in nymphs. Adults are highly active and show quick jumping behavior when disturbed, which helps in easy identification during field inspection.

**Life Cycle**

The life cycle of the sorghum shoot bug consists of egg, nymph, and adult stages and is completed in a relatively short period under favorable climatic conditions. The female insect lays eggs singly or in small groups inside the leaf tissues or leaf sheaths, which protects the eggs from external damage. The eggs hatch within a few days into nymphs, which resemble adults but lack wings. Nymphs undergo several molts while continuously feeding on plant sap. The nymphal period lasts for about two to three weeks, depending on temperature and humidity. After completing development, nymphs transform into adults, which are capable of reproduction and dispersal. Both nymphs and adults remain active feeders throughout their life span, and overlapping generations often occur, leading to rapid population buildup during warm and humid seasons.

**Symptoms and Damage**

Damage caused by the sorghum shoot bug occurs mainly due to continuous sap sucking from leaves, leaf sheaths, and the basal portions of young plants. Initial symptoms include pale yellow discoloration of leaves, which later turns into drying and curling. The central shoot may dry up, giving a scorched appearance. Infested plants show poor growth, reduced tillering, and weak stems. In severe cases, seedlings may die, resulting in gaps in the field. The pest also secretes honeydew, which promotes the growth of sooty mold, further reducing photosynthesis. These symptoms collectively lead to reduced plant vigor and lower yield.

**Field Detection and Key Indicators**

Early detection of sorghum shoot bug infestation is essential for effective management. Infested fields often show uneven crop growth with patches of yellow and weak plants. Drying of the central shoot in young plants is a prominent indicator. On close observation, small, palecolored insects can be seen jumping at the base of the plants. Presence of sticky honeydew on leaves and increased activity of ants are also important signs of infestation. Regular field scouting during early crop stages helps in timely identification of the pest.

**Movement and Multiplication**

The sorghum shoot bug has a high reproductive potential, especially under favorable climatic conditions such as warm temperature and high humidity. Females lay eggs inside the leaf tissues or leaf sheaths, which provides protection to the eggs. After hatching, nymphs feed on the same plant and gradually move to nearby plants as population increases. Adults can move by hopping and short-distance flying, enabling rapid spread within and between fields.

Continuous multiplication without natural control measures can lead to sudden population outbreaks.

**Damaging Stage of the Pest**

Both the nymphal and adult stages of the sorghum shoot bug are damaging. Nymphs start feeding immediately after hatching and continue to suck sap throughout their development. Adults also feed actively and contribute significantly to crop damage. Since all active stages feed on the plant, the pest causes continuous stress to the crop, especially during early growth stages when plants are more susceptible.

**Preventive Methods**

Preventive measures are the first line of defense against sorghum shoot bug infestation. Use of healthy and certified seeds reduces the risk of early pest attack. Timely sowing helps the crop escape peak pest activity. Proper field sanitation, including removal of weeds and crop residues, minimizes pest breeding sites. Avoiding excessive application of nitrogen fertilizers prevents lush growth that attracts sucking pests. Crop rotation and cultivation of tolerant or resistant sorghum varieties also play a significant role in reducing pest incidence.

**Mechanical Methods**

Mechanical control methods are useful, especially in small-scale farming systems. Removal and destruction of heavily infested plants help prevent the spread of the pest to healthy plants. Hand collection of insects during early morning hours can reduce pest population in small plots. Light traps may be installed to monitor adult activity and partially reduce their numbers. These methods are environmentally safe and reduce reliance on chemical pesticides.

**Chemical Methods**

Chemical control is adopted when the pest population exceeds the economic threshold level. Seed treatment with recommended systemic insecticides provides protection to seedlings during early growth stages. Foliar sprays of suitable insecticides may be applied when infestation becomes severe. However, chemical control should be used judiciously to avoid development of resistance, pest resurgence, and harm to beneficial insects. Proper dosage and timing of application are crucial for effective control.

**Biological Methods**

A biological method for controlling shoot bugs in sorghum involves the use of natural predators, parasitoids, and microbial agents that suppress the pest population without harming the environment. Predatory insects such as ladybird beetles, predatory bugs (*Orius* species), spiders, and ants feed on the eggs, nymphs, and adults of shoot bugs, effectively reducing their numbers. Additionally, egg and nymph parasitoids, like species of Anagrus, lay their eggs inside shoot bug eggs or nymphs, killing them during development. Fungal pathogens such as Beauveria bassiana and Metarhizium anisopliae can also infect and kill shoot bugs, serving as effective microbial control agents. Supporting these biological methods with cultural practices—such as removing crop residues, maintaining field hygiene, and intercropping with legumes to attract predators—enhances their effectiveness and helps manage shoot bug populations sustainably.

**Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) is the most effective and sustainable approach for controlling sorghum shoot bug. IPM involves the combined use of cultural practices such as timely sowing and crop rotation, mechanical methods like removal of infested plants, conservation of natural enemies, and need-based chemical application. Regular monitoring and decision-making based on economic threshold levels reduce unnecessary pesticide use. IPM not only controls the pest effectively but also protects the environment and maintains ecological balance.

**Conclusion**

The sorghum shoot bug is a major sucking pest that causes serious damage to sorghum, particularly during early stages of crop growth. Continuous sap sucking by both nymphs and adults leads to poor plant vigor, stunted growth, and yield reduction. Early detection and proper identification are essential for effective management. Adoption of integrated pest management strategies provides sustainable and eco-friendly control of the pest. Effective management of sorghum shoot bug ultimately contributes to improved crop productivity and farmer profitability.

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**EARHEAD BUG IN SORGHUM**

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**Abstract**

Sorghum is an important cereal crop grown in large areas of semi-arid and arid regions of India as it possesses a unique combination of drought tolerance and multi-use value for food, fodder, and as an industrial raw material. Despite this adaptability, sorghum productivity is severely limited by insect pests, specifically the ones that attack the crop during the reproductive stage of the plant. Among these, one of the most destructive pests that affects grain yield and quality is the earhead bug, Calocoris angustatus Leth. (Hemiptera: Miridae). Both nymphs and adults of the earhead bug feed on developing grains through piercing and sucking sap from the milky endosperm. These bugs cause shriveled and discolored grains, which are of poor germination potential. Infestation at the milky stage causes severe yield loss in addition to reduced grain weight and deterioration in market value. The pest is highly active during warm and humid weather conditions of the rainy season and proliferates rapidly in monocropped sorghum ecosystems. The present paper provides a detailed account of the pest's identity, host range, distribution, morphology, life cycle, nature of damage, field symptoms, and economic threshold level. More emphasis is given to integrated pest management strategies, including prevention, cultural, mechanical, biological, and chemical control measures for sustainable and environmentally safe management of earhead bug in sorghum.

**Key words:** Earhead bug, Calocoris angustatus, sorghum, sucking pest, grain quality, integrated pest management

**Introduction**

Sorghum (Sorghum bicolor L. Moench) is one of the major coarse cereals of India and the fifth most important cereal crop globally. It is dominantly grown under rainfed conditions and serves as an important crop for food security, livestock feeding, and rural livelihoods. India is among the largest producers of sorghum; its cultivation is mainly concentrated in Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, and Madhya Pradesh. Although sorghum is considered a hardy crop, it is attacked by a wide range of insect pests from seedling to maturity. Among those, pests attacking the earhead during the reproductive phase are particularly important because they directly affect grain yield and quality.

The earhead bug, *Calocoris angustatus*, has emerged as an important pest of sorghum, especially during the milky to dough stage of grain development. The insect pest belongs to the family Miridae and is generally known as the sorghum earhead bug/sorghum head bug.

The nymphs and adults cluster on earheads and suck the developing grains, causing shriveling, discoloration, and foul smell because of enzymatic breakdown of the grain contents. A heavy infestation leads to chaffy grains and considerable economic loss. High-yielding sorghum hybrids, flowering of sorghum crop around the same time, and congenial climatic conditions are the factors that have led to the frequent outbreaks of earhead bug. A deeper understanding of its biology, damage pattern, and management strategies goes a long way in devising effective control measures. The earhead bug in sorghum will be reviewed in-depth, giving emphasis to integrated pest management.

**Pest Identity and Taxonomy**

**Common Name:** Earhead bug / Sorghum head bug

**Scientific Name:** Calocoris angustatus Leth.

**Order:** Hemiptera

**Family:** Miridae

**Host Range**

Calocoris angustatus is mainly a sorghum pest. Under field conditions, however, it might survive on other graminaceous crops and grasses. Sorghum (Sorghum bicolor) - principal host Pearl millet (Pennisetum glaucum) - occasional host Maize - rare and incidental Wild grasses - act as alternate hosts during off-season Compact and succulent earheads are preferred by the pest, hence improved sorghum hybrids are more susceptible than traditional ones.

**Morphology and diagnostic character**

The adult earhead bug is a very small and slender insect about 6–8 mm long. It has a pale green to light brown color with long legs and antennae. The body is elongated, the wings transparent, and extend beyond the abdomen. Adults are highly mobile and actively feed on earheads. Nymphs are similar in appearance to adults but are smaller and wingless. They are greenish in color and pass through five nymphal instars. Nymphs are extremely gregarious and remain confined to earheads during their development. An earhead bug infestation can be diagnosed by the presence of both nymphs and adults on earheads together with shriveled grains.

**Life Cycle**

The species develops through incomplete metamorphosis: egg-nymph-adult. Egg stage: Eggs are laid singly inside the glumes or soft tissues of the earhead; the incubation lasts 4–7 days. Nymphal period: The nymphal period lasts about 10 to 15 days, passing through five instars. Adult stage: The adults live for 2–3 weeks in which they further feed and reproduce on earheads. This pest completes several overlapping generations during the cropping season. The population peaks during the milky stage of grain development.

**Symptoms and Nature of Damage**

Nymphs and adults cause injury by piercing and sucking sap from developing grains. Feeding causes grains to shrivel, flatten and discolor Grains give off a characteristic foul odour. Grain weight and test weight reduction Poor seed germination and quality Severe infestation leads to chaffy earheads. The milky stage is when the damage is heaviest, while late-stage infestation impacts more upon grain quality rather than quantity.

**Field Detection and Key Indicators**

Presence of greenish bugs on earheads during early morning or evening. thriveling and browning of grains, sticky exudates and foul smell from earheads, reduced grain filling, economic threshold level (etl): 1–2 bugs per earhead at the milky stage.

**Movement and Multiplication**

Earhead bugs fly actively and easily migrate from one field to another. Adults migrate from early-sown to late-sown crops. High humidity, dense earheads, and continuous cultivation of sorghum favor rapid multiplication.

**Control Methods**

Timely sowing to escape peak pest population, selection of less compact earhead varieties, removal of the alternate host grasses, avoidance of staggered sowing, crop rotation with non-host crops, synchronized sowing in a region, shaking earheads in the early morning to dislodge bugs, use of perches for birds to encourage predation. Conservation of natural enemies such as spiders and predatory bugs, neem seed kernel extract 5% spray at milky stage, neem oil at 3% reduces bug population, chemical control should be adopted only when etl is crossed, malathion 50 ec@ 2 ml/l chlorpyriphos 20 ec @ 2.5 ml/l, lambda-cyhalothrin 2.5 EC@ 1 ml/L. It is better to spray during early morning or evening hours. A judicious integration of timely sowing, resistant varieties, biological control, and need-based chemical application is the best strategy for managing the earhead bug. Overuse of insecticides should be avoided to protect natural enemies and prevent the buildup of resistance.

## Conclusion

The earhead bug, Calocoris angustatus, is one of the most important sorghum production constraints due to its direct effect on grain yield and quality. Proper management necessitates early detection and application of integrated management practices against the insect pest. Emphasis on preventive and cultural methods supported by biological and judicious chemical control ensures sustainable management of the pest while minimizing hazards to the environment.

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# SORGHUM MIDGE

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**Abstract**

Sorghum midge (*Stenodiplosis sorghicola*), a key biotic constraint in semi-arid sorghum production, infests flowering **spikelets**, with larvae feeding on developing grains to cause chaffy heads and yield losses. Native to northeastern Africa, it has spread globally, targeting sorghum and wild relatives like **johnsongrass**. Adults are tiny orange flies; the 14-18 day life cycle enables multiple generations, synchronized with host flowering. Damage signs include pupal cases, emergence holes, and red ooze. Effective management integrates resistant varieties, synchronized planting, sanitation, biological agents (parasitoids, predators), and targeted insecticides at 50% flowering, emphasizing IPM for sustainable control.

**Keywords:** Sorghum midge, sorghum, chaffy heads, red ooze, management.

**Introduction**

Sorghum (Sorghum bicolor L. Moench) is an important cereal crop cultivated widely in semi-arid regions for food, fodder, and industrial uses. Among the major biotic constraints affecting sorghum production, the sorghum midge (Stenodiplosis sorghicola Coquillett) is one of the most destructive insect pests, particularly during the flowering stage. The larvae feed on developing grains, resulting in chaffy spikelets and significant yield losses. Infestation severity is influenced by crop phenology, climatic factors, and management practices. Understanding the biology, damage symptoms, and management strategies of sorghum midge is essential for developing effective integrated pest management approaches to minimize yield losses and ensure sustainable sorghum production

**Pest Identity and Taxonomy**

**Common name:** sorghum midge

**Scientific name:** *Stenodiplosis sorghicola*

**Order:** Diptera

**Family:** Cecidomyiidae

### Host Range

The sorghum midge (*Stenodiplosis sorghicola)* primarily attacks cultivated sorghum (grain and forage), but also infests closely related wild grasses like Johnson grass (*Sorghum halepense),* Columbus grass, and Sudan grass, preventing seed development by feeding on ovaries within the flower spikelets. While other grasses (like maize, rice, sugarcane) suffer from different midges, S. sorghicola is generally restricted to Sorghum species, with different Contarinia species targeting native Australian Sorghum relatives.

### Origin and Distribution

The sorghum midge (*Stenodiplosis sorghicola)*, an orange, mosquito-like fly, is believed to have originated in northeastern Africa, the primary center of origin and early domestication of its host plant, sorghum. From Africa, the midge has spread globally and is now a widely distributed and major pest in nearly all regions where sorghum and its primary wild host, johnsongrass (S. halepense), are grown. Its current global distribution includes idespread, including Sudan, Nigeria, Senegal, Ethiopia, and others. widely present in India, Pakistan, Bangladesh, West Iran, Sri Lanka, South East Asia, and South China. Found across the United States (from Virginia to Texas, and north to Kansas), the Caribbean, and South America. Recorded in Italy. Present in Australia (except Western Australia due to strict quarantine measures), Fiji, New Caledonia, and Papua New Guinea.

### Morphology

The adult sorghum midge is a tiny, fragile, mosquito-like fly. The adults are small, typically about 1.5 to 2 mm (around 1/16 to 1/8 inch) long. The body has a distinctive bright orange or reddish-orange abdomen. The head, antennae, and legs are dark brown or black. They possess a single pair of transparent or clear wings. The adults have very long, prominent antennae. Females are slightly larger than males and possess a long, slender, needle-like ovipositor (egg-laying organ) at the rear of their abdomen, which they use to insert eggs into the flowering spikelets. Males are slightly smaller and have an abdomen that is rounded at the tip. Identifying the minute adult midge can be challenging in the field, so visual damage symptoms and behavioral patterns are often used for diagnosis. Adult midges are most active during mid-morning (9 to 11 a.m.) when temperatures and humidity are favorable. They can be seen flying around and into flowering sorghum heads to lay eggs. A common scouting method is to place a clear plastic bag over a flowering head and gently shake it; the dislodged orange flies can then be counted inside the bag. The most reliable sign of a past infestation is the presence of small, white, or transparent pupal cases (exuviae) protruding from the tips of damaged spikelets after the adults have emerged. Crushing infested spikelets firmly between the fingers may produce bright orange-red droplets from the body fluids of the internal larvae.

**Life Cycle**

The sorghum midge life cycle (egg, larva, pupa, adult) takes about 14-18 days, overwintering as larvae in cocoons within old spikelets, emerging in spring with Johnson grass blooms, then migrating to sorghum for multiple generations, damaging developing seeds with larvae feeding inside, causing shriveled grain; phenology centers on timing with host plant flowering (Johnson grass first, then sorghum) from spring through summer/fall, with diapausing larvae surviving cold for years.

**Life Cycle**

Female lays tiny eggs inside flowering sorghum spikelets (florets). Hatches in 2-3 days, feeds on developing seed fluid for 9-11 days, then pupates. Lasts 2-3 days, often at the spikelet tip, pupal skin left behind after emergence. Emerges, lives only about a day, mates, and lays eggs.

**Symptoms and Damage**

Sorghum midge damage causes shriveled, empty, or chaffy grains, giving the head a blighted look, with tell-tale signs being white pupal cases sticking out from spikelets and tiny emergence holes; the larvae feed inside the developing kernel, preventing seed formation, leading to significant yield loss, with crushed damaged kernels often showing a red ooze. Grains fail to fill, becoming small, flattened, or completely empty (chaffy). Infested heads look blasted, withered, or blighted, with a mix of normal and underdeveloped spikelets. Small, clear, or whitish pupal skins are often seen protruding from the tip of damaged spikelets.

**Field detection and key indicators**

The best time for detection is during the bloom stage, preferably mid-morning (9-11 am) on a calm day when the female midges are most active. Kneel beside a plant and observe the flowering head against the sky, looking for the small, orange, mosquito-like adult midges. Lightly tapping the stalk can encourage them to move. Place a clear plastic bag or a white bucket over the blooming head and gently shake it. The dislodged midges (which are weak fliers) can then be counted inside the bag or bucket for a more accurate population estimate. Check fields every day or every two days during head emergence and the entire flowering period, as the midge life cycle is short and populations can build up rapidly. Begin scouting at field edges, especially those downwind of other midge hosts like Johnsongrass or earlier-planted sorghum crops, where infestations typically start. The primary indicator is seeing the adult flies themselves. They are tiny (1.5-2 mm long), reddish-orange, and have a mosquito-like appearance with a long, thin egg-laying organ (ovipositor) on females. A later, post-damage indicator is the presence of small, transparent or white pupal cases (skins) sticking out from the tips of the affected glumes (the leaf-like structures enclosing the grain).

Damaged spikelets will not develop a normal seed kernel. The resulting grains are empty, shrivelled, or flat, leading to a "blasted" or blighted appearance of the panicle. During the grain-filling or milk stage, squeezing a damaged spikelet between the fingers may produce a red or orange ooze, which is the body fluid of the feeding midge larva. Midge adults caught in spider webs in the field are an early sign of activity.

**Movement and Multiplication**

Adult midges are small (1.5-2 mm long) and relatively weak fliers, usually moving around within and between nearby plants, especially around mid-morning when they are most active. They can be seen as small red flies flying against still panicles. Midge populations build up on early-flowering wild grasses, such as Johnson grass, and then migrate to early-planted sorghum. As the season progresses, they move to later-planted sorghum crops, which often experience higher pressure as a result. The primary method of long-distance spread is through the transport of grain containing the diapausing (overwintering) larvae in their protective cocoons within damaged florets. These larvae can remain in a resting stage for up to five years.

**Multiplication**

The sorghum midge has a rapid life cycle, which allows its population to multiply quickly under favorable conditions. Females (orange abdomen, long ovipositor) live for only about one day, while males live for just a few hours. They mate, and the female lays eggs shortly after emergence. The female typically lays eggs singly into developing flower spikelets during the bloom stage. A female can lay up to 120 eggs in her short lifetime. Eggs hatch in 2-3 days into small, white larvae that feed on the developing ovary, preventing normal seed development. The larval period lasts about 9-11 days, during which they grow and turn orange. The larvae pupate inside a cocoon within the spikelet. The pupal stage is about 3 days. Before adult emergence, the pupa wriggles its way to the tip of the glume, leaving the white pupal case sticking out after the adult flies away. A complete life cycle can take as little as 14-16 days. This short cycle allows for multiple (up to 9-12) generations per season, leading to a rapid population buildup, particularly where sorghum flowering is staggered.

**Damaging Stage of Pest**

The damaging stage of the Sorghum Midge (Stenodiplosis sorghicola) is the larval stage, where tiny, maggot-like larvae feed inside developing florets, consuming the immature seeds, leading to chaffy, shriveled, or missing grains, often with empty pupal cases left behind on the head. Damage appears as “blasted” heads with no or poorly filled kernels, significant yield loss, and visible white pupal skins emerging from the glumes.

**Preventive methods:**

Plant Resistant Varieties: Select hybrids with high midge resistance (MR) ratings (7-8+) to significantly reduce damage. Early & Uniform Planting: Sow sorghum as early as possible after the monsoon, ensuring uniform planting for synchronized flowering, which avoids attractive late-season midge peaks. Deep plow or burn crop residues after harvest to destroy overwintering larvae, and eliminate Johnsongrass and volunteer sorghum plants in and around fields. Rotate with non-host crops like cotton, soybeans, or sugarcane; intercropping with legumes can also help. Timely irrigation helps maintain crop uniformity, preventing delayed flowering.

**Cultural and Mechanical methods**

Cultural controls are the most effective approach for managing sorghum midge, as the pest spends most of its life cycle protected inside the plant’s spikelets. Plant early in the season to avoid peak midge populations, and ensure the entire crop is planted as uniformly as possible to promote even flowering and maturity across the field. This shortens the vulnerable period and prevents midge migration from older to younger heads. Eliminate wild grasses, especially Johnsongrass, from within and around the field, as these serve as early-season hosts for midge development before the sorghum crop flowers. Rotate sorghum with non-host crops like sugarcane, peanuts, or legumes to break the pest’s life cycle in the field. After harvest, destroy or bury crop residues and stubbles (e.g., via deep tillage) to reduce the number of overwintering larvae and prevent carry-over to the next season. Maintain a high plant density to reduce the number of insects per plant and minimize damage.

**Mechanical Measure**

Mechanical measures involve physically trapping, removing, or destroying the pests. Set up light traps to monitor, attract, and kill adult midge and other pests, operating from dusk until midnight. A pan of kerosene water can be placed below the light source to trap them. During the bloom stage, use a clear plastic bag or white bucket to physically check for midge presence. Place the bag over the flowering head, gently shake it, and count the dislodged midges to monitor population levels and determine if the economic threshold is reached. Remove and destroy any heavily infested plant parts or chaffy spikelets that show signs of midge damage to prevent the pest from spreading. while primarily for monitoring, pheromone traps can be used to attract male moths, helping to assess pest pressure.

**Biological methods**

Sorghum midge (Stenodiplosis sorghicola) is a major insect pest of sorghum that damages grains during the flowering stage. Biological control involves the use of living organisms and natural plant resistance to reduce pest populations in an eco-friendly manner.

**Natural enemies** play a key role in controlling sorghum midge. Important parasitoids include *Aprostocetus diplosidis* and *Tetrastichus* species, which parasitize the larvae and pupae of the midge and prevent their development. Predators such as spiders, ants, ladybird beetles, and lacewings feed on adult midges and help reduce their population in the field. Conservation of these beneficial insects by avoiding unnecessary pesticide sprays improves natural control.

**Host plant resistance i**s another effective biological measure. Certain sorghum varieties possess resistant traits such as compact panicles, short flowering duration, and biochemical factors that reduce egg laying and larval survival of the midge. Growing resistant or tolerant varieties helps in minimizing yield losses without harming the environment.

**Microbial control agents,** including *entomopathogenic* fungi and bacteria, can infect and kill sorghum midge under favorable conditions. Although their use is limited, they have potential in integrated pest management programs.

**Chemical method**

Sorghum midge (*Stenodiplosis sorghicola*) is a destructive pest that attacks sorghum during . the flowering stage. Chemical control is effective when applied at the correct time to protect the crop from grain damage. The critical period for insecticide application is during 50% flowering, as adult midges lay eggs in freshly opened florets. Spraying before or after this stage is less effective.

Recommended insecticides for controlling sorghum midge include: Carbaryl 50 WP @ 2 g/L of water, malathion 50 ec @ 1 ml/l of water, quinalphos 25 ec @ 2 ml/l of water, chlorpyriphos 20 ec @ 2.5 ml/l of water, dimethoate 30 EC @ 1.7 ml/L of water. If flowering continues for a longer period, two sprays at 5–7 day intervals may be necessary to provide effective control. Spraying should be done early in the morning (before 9 AM) when adult midges are most active. Proper spray coverage of the panicles is essential for good results.

**IPM**

Sorghum midge damages grains during flowering, sow the crop at the right time to avoid peak midge population, ensure uniform and early flowering of the crop, remove volunteer sorghum plants and weeds, grow midge-resistant sorghum varieties, conserve natural enemies like parasitoids and predators, monitor the crop during flowering stage, spray insecticides only when needed and at 50% flowering, apply spray early in the morning, avoid unnecessary chemical sprays to protect beneficial insects.

**Conclusion**

Integrated pest management stands out as the cornerstone for sorghum midge control, prioritizing cultural practices like early uniform planting, resistant hybrids, and host removal to disrupt the pest's rapid life cycle and migration. Biological agents and field monitoring enhance efficacy while minimizing chemical reliance, preserving natural enemies. Timely scouting during bloom and precise insecticide use at peak activity further safeguard yields. Adopting these strategies ensures resilient sorghum production amid climatic and phenological challenges, reducing losses and promoting eco-friendly farming in midge-prone regions.

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**APHIDS ON SORGHUM**

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**Abstract**

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops grown in arid and semi-arid parts of the world. This crop, though drought tolerant and adaptable, suffers seriously from several insect pests. Aphids, in particular, have emerged as one of the most economically injurious sorghum pests. Aphids feed by sucking phloem sap from leaves, stems, and panicles, leading to reduced plant vigor, chlorosis, drying of leaves, and sometimes, death. Honeydew secretion due to their feeding promotes the growth of sooty mold, interfering with photosynthesis. In addition, the aphid is a vector of viral diseases that further reduces yield and grain quality. Their parthenogenetic mode of reproduction allows the aphid population to increase rapidly under favorable environmental conditions, especially under warm and dry conditions. The paper is an overview of the aphids affecting sorghum with respect to the taxonomy, distribution, morphology, life cycle, damage symptoms, and dynamics of the population and control measures. Particular emphasis is given to methods of sustainable control and the approaches of integrated pest management for the condition of minimal crop loss with maximal protection of the environment.

**Keywords:** Sorghum aphid, Melanaphis sacchari, sorghum, sap-sucking insects, honeydew, virus transmission, integrated pest management

**Introduction**

Sorghum is the most important cereal crop worldwide, utilized as a staple food, fodder crop, or raw material for biofuel production. It is widely grown in Asia, Africa, and the Americas, with a high tendency towards dryland and marginal farming because of its drought and poor soil tolerance. Despite being hardy, sorghum is weakened in its production by a number of insect pests that reduce yield and grain quality. Aphids have gained increasing importance among these pests due to their rapid multiplication and severe potential for causing damage. Aphids are small insects with a sucking mouthpart that feeds on the vascular tissues of plants, weakening the crop and impairing nutrient transport. The sugarcane aphid, Melanaphis sacchari, is currently one of the most economically injurious aphid species to sorghum. Aphid damage includes both direct injury from feeding and honeydew deposition, which promotes development of sooty mold that reduces photosynthesis. In addition, aphids are vectors of various plant viruses. Because development of effective management usually involves the need for a deep knowledge of the biology, ecology, and management of aphids, this review appraises the current state of knowledge with emphasis on IPM-based management of sorghum-infesting aphids.

**Pest Identity and Taxonomy**

The aphids attacking sorghum belong to the order Hemiptera and the family Aphididae. These insects possess piercing-sucking mouthparts adapted for extracting phloem sap. The most important species of the aphid affecting sorghum is the sugarcane aphid, Melanaphis sacchari (Zehntner). Originally associated with sugarcane and other grasses, this aphid has now been reported as a major pest of sorghum in many parts of the world.

The species is mainly parthenogenetic, with females producing live young without mating. This form of reproduction allows the aphid populations to build up rapidly. Winged forms are induced when the colonies become crowded or when there is deterioration in the host plant quality, thereby enabling the aphids to disperse to other plants and fields. Correct identification of M. sacchari is important, as it differs from other cereal aphids such as Rhopalosiphum maidis in host-plant preference, damage pattern, and response to management practices.

**Origin and Distribution**

The sugarcane aphid is a cosmopolitan pest that is widely distributed across the sorghum-growing regions of Asia, Africa, Australia, and the Americas. In North America, it gained major attention after being reported as a serious pest of grain sorghum in Texas in 2013, from where it spread rapidly to other states. Its wide distribution is mainly due to the high reproductive capacity, adaptability to different environments, and availability of suitable host plants. Under conditions of generally warm, dry weather, M. sacchari has been an intermittent minor pest in certain parts of south Asia and Africa. Continuous cropping of sorghum and related grasses favors its buildup and spread; it is thus a periodic persistent threat to worldwide production of sorghum.

**Morphology and Diagnostic Characters**

Adult sugarcane aphids are small, soft-bodied insects about 1.5–2.5 mm in length. Their body color ranges from pale yellow to light brown, with long antennae and slender legs. Aphids commonly form dense colonies on the underside of leaves, stems, and panicles. A key diagnostic feature of the aphid infestation is the sticky honeydew on plant surfaces. This honeydew supports the growth of sooty mold, appearing as a black coating on leaves that reduces photosynthetic activity. Winged adults possess transparent wings and are responsible for long-distance dispersal. Such characteristics will help in differentiating aphids from other insect pests in the sorghum field.

**Life Cycle and Phenology**

The life cycle is short and highly efficient. Females reproduce without mating and give birth to live nymphs. The life cycle can be completed in 5–8 days when conditions are favorable, leading to several overlapping generations within one cropping season.

Nymphs go through several instars before adulthood, and adult females reproduce throughout their lives. Population growth is closely tied to abiotic conditions, mainly temperature and moisture, and to the availability of suitable hosts. Hot, dry conditions are generally conducive to a rapid increase in aphid populations. A basic understanding of aphid phenology is essential for any monitoring activity linked to management interventions.

**Symptoms and Damage**

The insects inflict both direct and indirect damage to the plants. Continuous sap feeding directly causes reduction in vigor, yellowing, curling, and drying of leaves in severe cases, ultimately causing death to the plant. The honeydew that they secrete promotes the development of sooty mold, interfering with photosynthesis and reducing grain filling. Indirect damage is caused by the transmission of viral diseases that further weaken the plant and reduce yields. Severe infestations of young seedlings may result in wilting and poor establishment. In mature plants, aphids cause a reduction in panicle size, shriveled grains, and a heavy loss in yield. Crop damage varies with stage of crop, aphid density, and environmental conditions.

**Cultural and Mechanical Methods**

Aphid management has an important role in cultural practices. Deep summer plowing helps expose both the aphid and the plant residues to natural enemies and adverse environmental conditions. Intercropping sorghum with non-host crops such as soybean, mustard, or millet decreases aphid colonization. Hand-picking of aphid-infested parts is effective in the early stages of the infestation in limited areas. Field sanitation, such as removal of crop residues, helps reduce carryover populations. Reflective mulches deter the aphids from settling, while conservation of natural enemies improves biological suppression.

**Biological Methods**

Biological control is one of the key components of sustainable management of aphids. The major natural enemies of aphids include ladybird beetles (Coccinella spp.), green lacewings (Chrysoperla spp.), and syrphid flies, which are actively engaged in predation on aphids. Parasitic wasps such as Aphidius colemani reduce the populations of aphids through parasitism. Other entomopathogenic fungi that can be applied as foliar sprays include Beauveria bassiana and Metarhizium anisopliae. The botanical products from neem, garlic, and chili serve as repellents and feeding deterrents. Combining biological agents with cultural practices strengthens long-term pest suppression while reducing chemical dependence.

**Chemical Methods**

It is advisable to adopt the chemical control method only when the population of aphids goes beyond the economic threshold level. Foliar sprays are preferred since aphids are essentially leaf feeders. Some of the commonly used insecticides include chlorpyriphos, dimethoate, carbaryl, and lambda-cyhalothrin.

Sprays must be given to the ventral part of leaves where the population of the infesting insects is concentrated. Re-peated use of the same chemical must be avoided to prevent resistance development. Chemical sprays integrated with neem oil extracts and other botanical sources increase their efficacy and lower non-target effects. Proper dosage and timing; Safety measures are essential.

**Integrated Pest Management (IPM)**

Integrated Pest Management offers an efficient and environmentally safe method for managing aphids in sorghum. The regular field scouting thus enables early detection. Cultural control by crop rotation, intercropping, and balanced fertilization reduces pest incidence.

While biological control agents naturally suppress the population of aphids, chemical intervention is only used when absolutely necessary. The avoidance of excessive nitrogen fertilization and the maintenance of field hygiene further support IPM success. Integration of multiple control methods ensures sustainable management of aphids and long-term crop productivity.

**Conclusion**

Aphids are among the most injurious insect pests of sorghum, causing significant yield losses through sap feeding, honeydew production, sooty mold formation, and virus transmission. Effective management depends on early detection, regular monitoring, and a thorough understanding of aphid biology. Sustainable control is based on cultural, mechanical, and biological means, while chemical measures should be used very judiciously. Integrated Pest Management ensures a judicious and environmentally friendly approach to minimizing aphid injury and maintaining stable sorghum production. Awareness and utilization by farmers of IPM practices are crucial for long-term success.

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## SHOOT FLY IN PEARL MILLET

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**Abstract**

Pearl millet (*Pennisetum glaucum L.*) is an important cereal crop cultivated widely in arid and semi-arid regions of India due to its drought tolerance and nutritional value. Despite its hardiness, pearl millet is highly susceptible to insect pests during the early stages of crop growth. Among them, the shoot fly, Atherigona approximata Malloch (Diptera: Muscidae), is one of the most destructive pests causing significant yield losses. The larval stage of the shoot fly damages young seedlings by feeding on the growing point, resulting in characteristic deadheart symptoms. Severe infestation leads to poor plant stand, increased tillering with weak and unproductive shoots, and ultimately reduced grain yield. The pest is particularly severe in late-sown crops and under warm, humid climatic conditions. This paper presents a comprehensive account of the pest's identity, host range, distribution, morphology, life cycle, nature of damage, field detection, and economic threshold levels. Integrated pest management (IPM) strategies, including preventive, cultural, mechanical, biological, and chemical control measures, are discussed to achieve sustainable management of shoot fly in pearl millet.

**Keywords:** Shoot fly, Atherigona approximata, pearl millet, deadheart, seedling pest, integrated pest management

### Introduction

Pearl millet (Pennisetum glaucum L.) is a major coarse cereal crop grown extensively in India, especially in regions characterized by low rainfall and poor soil fertility. It serves as a staple food, fodder crop, and source of livelihood for millions of small and marginal farmers. Pearl millet is valued for its resilience to drought, high nutritional content, and adaptability to marginal environments. Despite its adaptability, pearl millet is attacked by several insect pests from seedling to maturity. Among early-stage pests, shoot fly is considered one of the most serious constraints affecting crop establishment and yield. Shoot fly infestation is particularly severe during the first 30 days after sowing and can cause heavy yield losses if not managed timely.

Adult shoot flies lay eggs on the undersurface of young leaves. After hatching, the maggots bore into the central whorl and feed on the growing point, resulting in the drying of the central shoot known as deadheart. Such damage reduces plant population and induces excessive tillering, which often does not compensate for the loss in yield.

Shoot fly incidence is influenced by sowing time, climatic conditions, and cropping pattern. Late sowing, warm weather, and continuous cultivation of pearl millet favor pest multiplication. Understanding the biology and management of shoot fly is essential for minimizing crop losses. This review provides a detailed account of shoot fly infestation in pearl millet and its integrated management.

**Pest Identity and Taxonomy**

**Common name:** Shoot fly

**Scientific name:** *Atherigona approximata Malloch*

**Order:** Diptera

**Family:** Muscidae

**Host Range**

*Atherigona approximata* primarily attacks pearl millet but may also infest other cereal crops and grasses. Pearl millet (*Pennisetum glaucum*) – major host, Sorghum (*Sorghum bicolor*), Foxtail millet (*Setaria italica*), Wild grasses. Alternate hosts help the pest survive during off-season periods

**Origin and Distribution**

The shoot fly is widely distributed in tropical and subtropical regions. In India, it occurs in all major pearl millet-growing states, including Rajasthan, Gujarat, Maharashtra, Haryana, Uttar Pradesh, and parts of southern India. The pest is most severe during warm and humid conditions, particularly in late-sown kharif crops. Continuous millet cultivation and presence of grassy weeds favor its persistence.

**Morphology and Diagnostic Characters**

Eggs are elongated, cigar-shaped, creamy white, and laid singly on the underside of young leaves. Distinct longitudinal ridges are present on the egg surface. The larva is a legless, creamy-white maggot that feeds on the growing point inside the central whorl. This stage is responsible for deadheart formation. Pupation occurs either inside the stem or in the soil near the plant base. The pupa is brown and barrel-shaped. Adults are small, greyish flies resembling houseflies but smaller in size. They are active during early morning and evening hours.

**Life Cycle and Phenology**

*Atherigona approximata* undergoes complete metamorphosis.Egg stage: 1–2 days, Larval stage: 7–10 days, Pupal stage: 7–10 days, Adult longevity: 7–14 days. Several overlapping generations occur during the cropping season. Infestation is most severe during the first 20–30 days after sowing.

**Symptoms**

Drying of central shoot (deadheart), easy pulling of dead central leaf, foul smell from damaged whorl, increased tillering with weak, non-productive shoots, reduced plant stand and yield

**Field Detection**

Eggs visible on underside of young leaves, Deadheart symptoms in seedlings, Adult flies hovering near young plants, 10% deadhearts or 1 egg per plant

**Movement and Multiplication:**

Adult flies disperse short distances within fields. Continuous cropping, late sowing, and warm weather favor rapid multiplication. The pest survives on alternate grass hosts during the off-season.

**Damaging Stage of the Pest**

The larval (maggot) stage is the most destructive stage. Eggs, pupae, and adults do not cause direct damage to the crop.

**Preventive Methods**

Timely sowing at the onset of monsoon, Use of shoot fly-tolerant pearl millet varieties, Seed treatment with recommended insecticides, Avoidance of late sowing

**Cultural and Mechanical Methods**

Higher seed rate followed by thinning, Removal and destruction of deadheart seedlings, Crop rotation with non-host crops, Clean cultivation and weed management

**Biological Methods**

Conservation of natural enemies such as parasitoids and predators, Application of neem seed kernel extract (5%), Neem oil spray (3%) during early seedling stage

**Chemical Methods**

Seed treatment with Imidacloprid 70 WS @ 5 g/kg seed, Thiamethoxam 30 FS @ 10 ml/kg seed, Soil or foliar application: Chlorpyriphos 20 EC @ 2.5 ml/L\, Carbofuran 3G @ 10 kg/ha (at sowing)

**Integrated Pest Management (IPM)**

Integrated management of shoot fly in pearl millet involves timely sowing, use of tolerant varieties, seed treatment, cultural practices, and conservation of natural enemies. Chemical control should be used judiciously and only when economic threshold levels are exceeded.

**Conclusion**

Shoot fly, Atherigona approximimata, is a major early-stage pest of pearl millet causing significant yield losses through deadheart formation. Early detection and adoption of integrated pest management practices are essential for minimizing damage. Emphasis on preventive and cultural measures, supported by biological and need-based chemical control, ensures sustainable and environmentally safe management of shoot fly in pearl millet.

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**STEM BORER IN PEARL MILLET**

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**Abstract**

Stem borers are among the most destructive insect pests of pearl millet (*Pennisetum glaucum*), causing significant yield losses in India and other tropical regions. The predominant species affecting pearl millet is *Chilo partellus* Swinhoe (Lepidoptera: Crambidae), although *Sesamia inferens* Walker is also reported as a minor pest in some regions (Singh & Kumari, 2025; MDPI, 2025). Larvae of stem borers initially feed on leaves, producing "windowing" symptoms, and later bore into the central stem, causing "dead heart" in young plants and stem tunnelling in older plants (TNAU Agritech Portal, 2025). Severe infestations reduce photosynthetic efficiency, impede nutrient transport, and increase susceptibility to lodging, ultimately decreasing grain yield (ICRISAT, 1989; Millets Res., 2025). Factors influencing infestation include climatic conditions, cropping patterns, and agronomic practices. Management strategies for stem borers include cultural, mechanical, biological, chemical, and integrated approaches. Biological methods involve natural enemies like parasitoids and entomopathogenic agents, while chemical control is employed judiciously when economic thresholds are exceeded (AgriBot, 2025; Agritech TNAU, 2025). Integrated Pest Management (IPM) combines preventive measures, host resistance, biological control, and selective chemical usage to achieve sustainable suppression of stem borer populations (Academic OUP, 2025). This review synthesizes the pest's taxonomy, morphology, life cycle, damage symptoms, detection, and management practices to provide comprehensive guidelines for effective stem borer control in pearl millet.

**Keywords:** Stem borer, *Chilo partellus*, *Sesamia inferens*, pearl millet, dead heart, larval tunnelling, pest management, IPM

**Introduction**

Pearl millet (*Pennisetum glaucum*), commonly called bajra, is a staple cereal in arid and semi-arid regions due to its drought tolerance and high nutritional value (Singh & Kumari, 2025). Despite its resilience, pearl millet is susceptible to several insect pests, with stem borers being among the most damaging (MDPI, 2025). The major stem borer species in India is *Chilo partellus* Swinhoe (Crambidae), which attacks the crop from early vegetative stages to panicle initiation (TNAU Agritech Portal, 2025). Early larval feeding produces “windowing” or shot-hole symptoms on leaves, while older larvae tunnel into the central stem, causing “dead heart” in young plants and stem breakage in older plants (ICRISAT, 1989). Stem borer incidence is influenced by climatic conditions, cropping patterns, and agronomic practices, including crop rotation, sowing dates, and residue management (Millets Res., 2025). Severe infestations reduce grain yield by 20–60% depending on pest density and crop stage at attack (Singh & Kumari, 2025). Understanding the pest’s biology, host range, life cycle, and seasonal dynamics is essential for designing effective management strategies. This assignment focuses on the identification, taxonomy, morphology, life cycle, damage symptoms, detection methods, and integrated management of stem borers in pearl millet, drawing upon research articles, agri-tech portals, and extension publications (AgriBot, 2025; Academic OUP, 2025).

**Pest Identity and Taxonomy**

**Common name:** Stem borer

**Scientific name:** *Chilo partellus*

**Order:** Lepidoptera

**Family:** Crambidae

**Subfamily:** Crambinae

**Host Range**

*Chilo partellus* is a polyphagous pest primarily affecting graminaceous crops. Major hosts include pearl millet, sorghum (*Sorghum bicolor*), maize (*Zea mays*), and finger millet (*Eleusine coracana*), as well as sugarcane and several wild grass species that serve as alternate hosts (Singh & Kumari, 2025; Biotech Articles, 2025). Alternate hosts play a key role in maintaining stem borer populations between cropping seasons, especially in rainfed areas (TNAU Agritech Portal, 2025). Some other secondary hosts include rice (*Oryza sativa*), little millet (*Panicum sumatrense*), and fonio (*Digitaria exilis*), depending on regional cropping patterns (MDPI, 2025). Knowledge of host range is important for predicting infestation levels and planning crop rotations to minimize pest pressure. Wild grasses and volunteer crops are often overlooked but serve as reservoirs, highlighting the need for field sanitation and removal of alternate hosts (Millets Res., 2025). Host preference is influenced by plant age, vigor, and environmental conditions, with younger, succulent plants being more susceptible (ICRISAT, 1989).

**Origin and Distribution**

*Chilo partellus* is native to South and Southeast Asia and has spread widely to India, Pakistan, and parts of Africa, including Kenya, Tanzania, and Zimbabwe (Singh & Kumari, 2025; MDPI, 2025). Its distribution is closely linked to climatic conditions, cropping patterns, and availability of host plants. In India, it is prevalent in all major millet-growing regions, particularly in Rajasthan, Maharashtra, Karnataka, Telangana, and Andhra Pradesh (Biotech Articles, 2025; TNAU Agritech Portal, 2025). The pest is most active during warm, humid periods and can complete multiple generations per year under favorable conditions. Seasonal migration and dispersal of adults via flight facilitate rapid spread across regions, making early detection and timely management critical (AgriBot, 2025). Infestation levels are higher in areas with continuous cereal cultivation and poor crop residue management, as overwintering larvae and pupae survive in crop stubbles and wild hosts (Millets Res., 2025; ICRISAT, 1989). Understanding the geographic distribution is essential for planning monitoring, preventive measures, and IPM strategies across different agro-ecological zones (Academic OUP, 2025).

**Morphology and Diagnostic Characters**

The morphology of *Chilo partellus* varies across developmental stages—egg, larva, pupa, and adult moth. Eggs are flat, oval, translucent to pale yellow, and laid in clusters along the midrib of leaves, often covered with scales for protection (TNAU Agritech Portal, 2025; Biotech Articles, 2025). Early instar larvae are cream-colored with brown head capsules, while older instars develop brownish to yellowish body coloration with longitudinal stripes and conspicuous prothoracic shields (Singh & Kumari, 2025). Larval diagnostic features include three pairs of thoracic legs and five pairs of abdominal prolegs with a characteristic crochets arrangement, which differentiates *C. partellus* from other stem borer species (niphm.gov.in, 2025). Pupae are cylindrical, yellow-brown, and usually located within the stem tunnels, partially visible through bore holes. Adult moths are medium-sized (20–30 mm wingspan), straw-colored with narrow forewings bearing brownish lines, while hindwings are whitish (MDPI, 2025). Sexual dimorphism is minimal, though females are slightly larger and have more robust abdomens for egg-laying (Singh & Kumari, 2025). The combination of larval head capsule, proleg crochets, and adult wing patterns forms the primary diagnostic basis for field and laboratory identification (AgriBot, 2025). Accurate identification is essential for targeted pest management, especially in fields where multiple borer species co-occur.

**Life Cycle and Phenology**

*Chilo partellus* exhibits a complete metamorphosis (holometabolous) life cycle with four stages: egg, larva, pupa, and adult. Eggs hatch in 5–10 days, depending on temperature and humidity (TNAU Agritech Portal, 2025). Newly hatched larvae feed on tender leaves, causing “windowing” damage, then bore into the central stem, where they complete the larval stage in 28–35 days (Singh & Kumari, 2025). Larvae undergo 5–6 instars; later instars cause significant stem damage, producing frass-filled tunnels. Pupation occurs within the stem or at the base of the plant for 7–10 days, after which adult moths emerge and mate (MDPI, 2025). The life cycle duration is influenced by environmental factors, allowing 3–5 generations per year in warm, humid regions (ICRISAT, 1989). Adult moths are nocturnal, flying primarily at dusk and night to lay eggs on young plants (Millets Res., 2025). The phenology of stem borer activity typically coincides with early vegetative growth and tillering stages of pearl millet, though late-season infestations on panicles may occur under prolonged favorable conditions (Biotech Articles, 2025). Understanding life cycle and phenology is critical for timing control interventions such as insecticide applications or release of biological agents.

**Symptoms and Damage**

Initial stem borer infestation manifests as leaf feeding, creating “windowing” or shot-hole symptoms on young leaves (TNAU Agritech Portal, 2025). As larvae bore into stems, they sever the central growing point, causing “dead heart” in seedlings or young plants (Singh & Kumari, 2025). Older plants show stem tunnelling, which weakens vascular tissue, reduces nutrient and water transport, and may lead to lodging or breakage during high winds (MDPI, 2025). The intensity of damage depends on pest density, plant age, and environmental conditions. Severe infestations can result in 20–60% yield loss depending on timing and number of generations (ICRISAT, 1989). Secondary symptoms include frass accumulation at bore holes and delayed panicle emergence. Dead hearts can be manually counted to assess infestation levels in the field, which serves as a basis for economic threshold determination (Millets Res., 2025). The damage also indirectly facilitates entry of pathogens, compounding yield loss. Early detection and identification of symptoms are essential for timely interventions (AgriBot, 2025). Environmental factors such as high humidity and moderate temperatures favor rapid larval development and exacerbate crop losses (Biotech Articles, 2025).

**Field Detection**

Field detection of *Chilo partellus* begins with regular scouting during early vegetative stages. Key indicators include **windowing of leaves**, shot-hole feeding, and presence of eggs along the midrib of young leaves (TNAU Agritech Portal, 2025; Singh & Kumari, 2025). Progressive infestation is indicated by **"dead hearts"**, where the central shoot of the plant withers and can be easily pulled out, revealing bored stems filled with frass (Millets Res., 2025). Examination of stems shows **larval tunnels and frass pellets**, which are characteristic of stem borer attack. Light traps can be employed to monitor adult moth populations, as adults are nocturnal and peak in activity during dusk and early night (AgriBot, 2025). Sampling involves inspecting 10–20 plants per field randomly to estimate infestation percentage, which helps determine whether economic thresholds have been reached (ICRISAT, 1989). Early detection is critical because interventions applied during the larval stage are more effective than treatments applied after tunnelling is complete. Additional indicators include **yellowing or stunted growth** in severely affected areas, often correlating with higher larval densities (MDPI, 2025). Understanding field signs aids timely decision-making for cultural, biological, or chemical control measures.

**Movement and Multiplication**

Adult stem borer moths are capable of **flight dispersal**, facilitating migration across fields and neighboring farms (Biotech Articles, 2025). Nocturnal adults typically move short distances initially but can be carried by wind to new host crops, contributing to rapid colonization. Larvae do not actively move far but can **crawl along stems or soil surfaces** to locate feeding sites when food becomes scarce (TNAU Agritech Portal, 2025). Stem borers reproduce continuously under favorable conditions, producing multiple overlapping generations per year (ICRISAT, 1989). Eggs are laid in clusters on host plants, and a single female can lay hundreds of eggs during her lifespan, ensuring rapid multiplication of populations (Singh & Kumari, 2025). Overwintering or off-season survival occurs in crop residues, stubble, and alternate hosts, allowing the pest to persist between cropping seasons (Millets Res., 2025). Infestation intensity is higher in monoculture systems and areas with poor field sanitation due to the availability of continuous host material. Knowledge of movement patterns and reproductive potential is essential for timing control interventions and breaking pest cycles through crop rotation or residue management (AgriBot, 2025).

**Damaging Stage of Pest**

The **larval stage** is the primary damaging stage of *Chilo partellus* in pearl millet (TNAU Agritech Portal, 2025). Young larvae cause **leaf damage**, reducing photosynthetic efficiency and weakening seedlings. Older larvae bore into the central stem, destroying the **apical meristem**, resulting in "dead hearts" in young plants and severe stem tunnelling in older plants (Singh & Kumari, 2025). This tunnelling disrupts nutrient and water flow, weakens the structural integrity of the plant, and makes it prone to lodging during adverse weather conditions (MDPI, 2025). The larval stage lasts 28–35 days depending on environmental conditions, allowing sufficient time to cause extensive damage before pupation (ICRISAT, 1989). Pupae and adults do not directly feed on the crop but play a crucial role in population continuation and dispersal. Damage is often compounded by secondary pathogens entering through bore holes. Economic losses are significant when larval attack coincides with vegetative or reproductive stages, potentially reducing grain yield by up to 60% in heavily infested fields (Millets Res., 2025). Effective management targets this larval stage through monitoring, cultural, biological, or chemical interventions (AgriBot, 2025).

**Preventive Methods**

Preventive measures are crucial in reducing stem borer infestation before it becomes economically damaging. **Field sanitation** is a primary preventive strategy, involving removal and destruction of crop residues, stubbles, and alternate host grasses where larvae and pupae may overwinter (TNAU Agritech Portal, 2025; Millets Res., 2025). **Timely sowing** of pearl millet can help avoid peak moth activity, as synchronizing planting with periods of lower adult population reduces larval establishment (Singh & Kumari, 2025). Use of **healthy and certified seeds** ensures vigorous crop growth capable of tolerating minor pest damage. **Light traps** can be deployed before and during the early vegetative stage to capture adult moths, thus reducing egg-laying potential (AgriBot, 2025). Crop rotation with non-host crops such as legumes interrupts the pest's life cycle and reduces pest carryover between seasons (ICRISAT, 1989). Preventive irrigation and nutrient management, by promoting robust plant growth, can enhance plant resilience against larval feeding. Additionally, **monitoring and scouting** fields regularly for early signs of infestation such as leaf windowing or egg clusters allows timely interventions, preventing escalation to economically significant levels (MDPI, 2025). Overall, preventive methods form the foundation of Integrated Pest Management (IPM) for stem borers, reducing reliance on chemical control.

**Cultural and Mechanical Methods**

Cultural and mechanical methods aim to create unfavorable conditions for stem borers while enhancing crop resilience. **Deep ploughing** during field preparation exposes overwintering larvae and pupae to predators and desiccation, reducing initial pest populations (TNAU Agritech Portal, 2025). **Intercropping** pearl millet with legumes such as cowpea, pigeon pea, or lablab disrupts pest movement and increases natural enemy abundance, thereby lowering infestation rates (Biotech Articles, 2025). **Crop residue management**, including removal or incorporation of stubbles, prevents larval survival between seasons (Millets Res., 2025). **Manual destruction of egg clusters and larval bore holes** in small plots can be effective under low infestation conditions. **Staggered sowing** can avoid synchronization of pest generations with crop stages most susceptible to damage (Singh & Kumari, 2025). Light traps and pheromone traps also serve as mechanical control methods to monitor and reduce adult moth populations in the field (AgriBot, 2025). Combining cultural and mechanical approaches with preventive practices enhances overall pest suppression and supports sustainable pearl millet production (ICRISAT, 1989). These methods are eco-friendly and cost-effective, forming an essential component of IPM strategies against stem borers.

**Biological Methods**

Biological control focuses on exploiting **natural enemies** of stem borers to suppress pest populations. **Egg parasitoids** like *Trichogramma chilonis* are effective in reducing egg hatch and subsequent larval infestation (TNAU Agritech Portal, 2025). **Larval parasitoids** such as *Bracon chinensis*, *Apanteles flavipes*, and *Xanthopimpla* spp. attack and kill developing larvae within stems (Singh & Kumari, 2025; Biotech Articles, 2025). Predators including spiders, ants, and beetles consume both larvae and pupae, contributing to natural regulation of stem borer populations (AgriBot, 2025). Entomopathogenic fungi, such as *Beauveria bassiana* and *Metarhizium anisopliae*, can infect larvae and reduce survival rates under field conditions (MDPI, 2025). Encouraging **natural enemy habitats** by planting flowering strips or maintaining field borders enhances parasitism and predation (Millets Res., 2025). Conservation of beneficial organisms requires minimizing the use of broad-spectrum insecticides and adopting selective, need-based chemical control when necessary. Biological control is cost-effective, environmentally sustainable, and forms a core component of IPM strategies against *Chilo partellus* in pearl millet (ICRISAT, 1989). Integrating biological methods with cultural and mechanical practices enhances long-term pest suppression while preserving agro-ecosystem health (TNAU Agritech Portal, 2025).

**Chemical Methods**

Chemical control is primarily aimed at the larval stage of stem borers, which causes the maximum damage to pearl millet by boring into stems and forming dead hearts (TNAU Agritech Portal, 2025; Singh & Kumari, 2025). The timing of application is critical—early intervention when larvae are feeding on leaves or before tunnelling begins ensures effective control (Millets Res., 2025). Seed treatment with systemic insecticides like carbofuran (3 g/kg seed) or thiamethoxam (2–3 g/kg seed) protects seedlings from early larval attack, preventing dead heart formation (AgriBot, 2025). Systemic action of the chemical provides long-lasting protection during the vulnerable early growth stage. Soil application of insecticides such as phorate (10–15 kg/ha) or carbofuran granules near the base of seedlings creates a toxic barrier that kills larvae when they attempt to bore into stems (TNAU Agritech Portal, 2025). This method is effective in controlling soil-dwelling early instar larvae. Foliar application of insecticides like chlorpyrifos (0.05%), quinalphos (0.05%), or carbaryl (0.1%) targets young larvae feeding on leaves before they bore into the stem (MDPI, 2025). Sprays should cover the whorls and tender leaves thoroughly for maximum efficiency. Although less common in field crops, baiting systems with slow-acting insecticides can suppress larval populations by being carried back to stem tunnels (Biotech Articles, 2025). Targeted applications are preferred to reduce chemical load and protect natural enemies. Apply insecticides only when economic thresholds are exceeded to prevent unnecessary environmental contamination (ICRISAT, 1989). Follow recommended dosage, method, and safety guidelines to minimize impact on beneficial organisms and avoid residue accumulation. Chemical methods are most effective when integrated with cultural, mechanical, and biological practices as part of an IPM strategy (AgriBot, 2025; TNAU Agritech Portal, 2025).

**Integrated Pest Management (IPM)**

Integrated Pest Management (IPM) for stem borers in pearl millet combines **preventive, cultural, biological, and chemical strategies** to maintain pest populations below economic thresholds in an environmentally sustainable manner (Singh & Kumari, 2025). Key IPM components include **timely sowing**, **resistant varieties**, and **field sanitation** to reduce pest carryover. Cultural practices such as intercropping with legumes, deep ploughing, and crop rotation disrupt the pest's life cycle and promote natural enemy populations (Millets Res., 2025; TNAU Agritech Portal, 2025). **Biological control agents**—including egg parasitoids (*Trichogramma chilonis*), larval parasitoids (*Bracon chinensis*, *Apanteles flavipes*), and entomopathogenic fungi (*Beauveria bassiana*, *Metarhizium anisopliae*)—are integrated to reduce reliance on chemicals (AgriBot, 2025; MDPI, 2025). Chemical control is applied **judiciously**, only when economic thresholds are exceeded, using selective insecticides at recommended doses (ICRISAT, 1989). **Monitoring and field scouting** inform intervention timing, while **light or pheromone traps** can reduce adult populations. Combining these strategies ensures long-term suppression of stem borers, minimizes environmental hazards, preserves beneficial organisms, and enhances pearl millet productivity (Biotech Articles, 2025). IPM thus represents a sustainable, science-based approach to pest management that balances economic, ecological, and social considerations (Academic OUP, 2025).

**Conclusion**

Stem borer (*Chilo partellus*) is a major pest of pearl millet, causing severe yield losses through dead hearts, stem tunnelling, and lodging. Understanding its biology, life cycle, and host range is essential for effective management. Early detection through field scouting and monitoring of adults allows timely interventions. Preventive measures, cultural and mechanical practices, and biological control reduce pest pressure sustainably. Chemical control, applied judiciously, complements other methods when economic thresholds are exceeded. Integration of all strategies within an **IPM framework** ensures long-term suppression of stem borers, minimizes environmental impact, and enhances crop productivity. Sustainable management relies on combining scientific knowledge with eco-friendly practices for optimal pearl millet yield.

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## Plume Moth on Pulses (*Exelastis atomosa*)

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**Abstract**

Pulses constitute a critical source of dietary protein in India and are vulnerable to insect pest complexes throughout their growing season. Among these, the plume moth, *Exelastis atomosa* (Lepidoptera: Pterophoridae), has emerged as an economically significant pest of pigeonpea and occasionally affects other leguminous crops. The larval stage penetrates flower buds, flowers, and developing pods, interfering with reproductive development and causing substantial yield reduction. Crop losses can be severe, particularly in rainfed systems where multiple pest pressures converge. This paper provides a comprehensive account of the plume moth, covering its identity, host range, distribution, morphology, life cycle, damage symptoms, field detection methods, and economic threshold levels. Various management strategies, including cultural, mechanical, biological, and chemical approaches, are discussed within an integrated pest management (IPM) framework. Em- phasis is placed on early detection, habitat diversification, and conservation of natural enemies to achieve effective and environmentally sustainable control of plume moth in pulse-based cropping systems.

**Keywords:** Plume moth, *Exelastis atomosa*, pulses, pod borer, pigeonpea, integrated pest management

## Introduction

Pulses, including pigeonpea (*Cajanus cajan*), chickpea, lentil, and mung bean, serve as primary sources of plant-based protein for millions of people across South Asia and play a vital role in food and nutritional security. However, pulse crops are highly susceptible to insect pest damage, particularly during the flowering and pod formation stages, which are critical for yield determination. In recent years, the plume moth (*Exelastis atomosa* Walsingham) has gained prominence as a major pest in pigeonpea-growing regions of India, including Maharashtra and other states. Although historically considered a mi- nor pest, its economic importance has increased due to changes in agronomic practices, reduced use of broad-spectrum insecticides, and altered climatic patterns.

Unlike other well-documented pod borers such as *Helicoverpa armigera*, the plume moth is a small, delicate moth characterized by deeply divided wings that give it a distinctive T-shaped resting posture. The larvae exhibit cryptic feeding behavior, tunneling into flower buds and young pods, which often goes unnoticed until significant damage has occurred. This pest is particularly problematic in short-duration pigeonpea cultivars and in fields with inadequate canopy cover. Given the increasing demand for pulse production and the economic vulnerability of smallholder farmers, effective management of plume moth is essential for sustaining productivity and ensuring livelihood security.

**Pest Identity and Taxonomy**

**Common name**: Plume moth

**Scientific name:** *Exelastis atomosa*

**Order:** Lepidoptera

**Family:** Pterophoridae

**Subfamily:**

Pterophorinae

## Host Range

*Exelastis atomosa* is primarily a monophagous pest, with pigeonpea (*Cajanus cajan*) serving as its principal host. Occasional infestations have been reported on lablab bean (*Lablab purpureus*), and rarely on chickpea under conditions of high pest population density. However, pigeonpea remains the most economically significant host, particularly during the flowering and pod development stages.

## Origin and Distribution

*Exelastis atomosa* Walsingham is an indigenous species of the Indian subcontinent and is widely distributed across pigeonpea-growing regions. It is most prevalent in central and southern India, where pigeonpea cultivation is extensive. The pest thrives under hot and dry conditions during the flowering period, and its incidence is closely associated with rainfed cropping systems and regions with extended flowering duration.

## Morphology

The adult plume moth is a small insect with a wingspan of 14–18 mm, characterized by a slender body and deeply cleft wings that create a distinctive plumose or feather-like appearance. When at rest, the wings are held in a characteristic T-shaped posture. The body coloration is pale brown to grayish, often with faint dark markings on the wings. Eggs are minute, oval, and pale yellow, typically laid singly or in small clusters on flower buds. Larvae are pale green to pinkish, measuring up to 10 mm in length when fully grown, with a well-defined head capsule. Pupation occurs within damaged pods or rolled leaves inside a loosely woven silken cocoon. The combination of deeply divided wings in adults and the endophytic larval feeding habit serves as a key diagnostic feature distinguishing *E. atomosa* from other pulse pests.

## Life Cycle

*Exelastis atomosa* undergoes complete metamorphosis, passing through four distinct life stages: egg, larva, pupa, and adult. Female moths lay 30–60 eggs over their lifespan, preferentially on flower buds and occasionally on tender leaves. The egg stage is brief, lasting approximately 3–5 days under favorable conditions. Larvae emerge and immediately bore into flower buds, flowers, or young pods, where they feed for approximately 10–14 days, passing through multiple instars. Pupation occurs within damaged plant material or in leaf litter, and the pupal stage lasts 7–10 days. Under warm conditions, the pest completes multiple overlapping generations during the flowering and podding period, with population build-up occurring rapidly when host phenology and environmental conditions are favorable. The pest survives adverse periods as pupae in crop residues or soil.

## Symptoms and Damage

Damage caused by *Exelastis atomosa* is entirely attributable to the larval stage, which feeds within the reproductive structures of pigeonpea. Larvae bore into flower buds, causing them to wither and drop prematurely. Infested flowers exhibit wilting, discoloration, and failure to set pods. In young pods, larvae create entry holes and feed on developing seeds, leading to pod deformation, shriveling, and premature drying.

Characteristic symptoms include premature shedding of buds and flowers, presence of small circular entry holes on pods, accumulation of frass (insect excreta) near the pod tip, and presence of silken webbing on infested plant parts. Severe infestations can result in yield losses ranging from 15–30%, depending on the intensity of attack and the stage of crop development. The cryptic nature of larval feeding often delays detection until substantial damage has already occurred.

## Field Detection

Field detection of *Exelastis atomosa* is most effective during the flowering and early pod formation stages. Visual symptoms to monitor include premature dropping of flower buds, wilting of flowers, presence of small entry holes on pods, frass accumulation near pod tips, and silken webbing on plant structures. Adult moths can be observed resting on foliage during early morning hours or attracted to light traps during evening hours. Larval presence can be confirmed by carefully dissecting infested buds or pods. The economic threshold level (ETL) is generally considered to be 5–10% infestation of flowers or pods, or the presence of 1–2 active larvae per 20 randomly selected flowers or pods during the peak flowering stage. Detection of infestation at or above this threshold indicates the need for immediate IPM intervention to prevent economic loss

## Movement and Multiplication

Adult plume moths exhibit limited dispersal capacity and primarily spread within fields during evening hours, although they are weak fliers and do not typically migrate over long distances. Population multiplication is rapid under warm and dry conditions, particularly when host plants are in the reproductive phase.

The pest overwinters as pupae in crop residues, leaf litter, or soil, allowing it to persist between cropping seasons. Population build-up is closely associated with the availability of susceptible host stages, extended flowering duration, and favorable microclimatic con- ditions within the crop canopy. Continuous availability of flowering hosts in staggered plantings or in mixed cropping systems can support multiple overlapping generations and sustained pest pressure.

## Damaging Stage of Pest

In *Exelastis atomosa*, the larval stage is exclusively responsible for economic damage. Larvae feed on reproductive tissues, directly reducing yield potential by destroying flowers and developing seeds. Adult moths are non-feeding or feed minimally on nectar and serve only reproductive functions. Eggs and pupae do not cause damage to the crop. Therefore, management strategies are primarily targeted against the larval stage during the flowering and early pod formation period to prevent yield losses.

## Preventive Methods

Selection and cultivation of tolerant or moderately resistant pigeonpea cultivars, where available, can reduce pest incidence. Avoidance of staggered or delayed sowing is rec- ommended, as extended flowering periods provide continuous food sources for multiple pest generations. Post-harvest field sanitation, including removal and destruction of crop residues, volunteer plants, and alternate hosts along field margins, helps reduce overwin- tering populations. Judicious use of nitrogenous fertilizers is advise```P, as excessive vegetative growth can create favorable microclimatic conditions for pest development. Preventive practices are consistently emphasized in pulse IPM literature as the foundational component of sustainable pest management.

## Cultural and Mechanical Methods

Growing pigeonpea in combination with non-host cereals such as sorghum or maize can reduce pest incidence by disrupting host location and increasing natural en- emy populations. Planting highly attractive trap crops such as marigold or sunnhemp along field borders can concentrate pest populations for targeted management. Synchronizing sowing dates within a region helps avoid peak pest activity periods and reduces the window of crop vulnerability. Hand-picking and destruction of visibly infested buds, flowers, and pods during early infestation stages can be effective in small-scale farming systems. Plowing fields during hot summer months exposes overwin- tering pupae to desiccation and predation, significantly reducing the initial pest load for the subsequent season. Conserving natural enemies by avoiding broad-spectrum insec- ticides and establishing insectary plants (flowering borders) enhances biological control. Installation of bird perches encourages avian predation of adult moths. Cultural and mechanical methods are labor-intensive but highly effective when imple- mented as part of an integrated strategy, particularly during early crop stages.

**Biological Methods**

Application of neem oil at 3–5% concentration (30–50 ml per liter of water) as a foliar spray during early flowering can deter oviposition and disrupt larval development. Neem seed kernel extract (NSKE) at 5% concentration can also reduce larval feeding. Neem cake incorporation into soil at 250 kg per hectare during land preparation provides additional deterrent effects. Foliar application of garlic extract, chili extract, or other pungent plant-based formulations can discourage adult feeding and oviposition on tender plant tissues. Application of *Bacillus thuringiensis* var. *kurstaki* (Btk) at recommended doses provides effective control of lepidopteran larvae. Entomopathogenic fungi such as *Beauveria bassiana* and *Metarhizium anisopliae* can be applied as foliar sprays (5–10 g per liter of water) or soil drenches to target larval and pupal stages.Protecting predators such as spiders, coccinellid beetles, and parasitoid wasps through reduced use of broad- spectrum insecticides and establishment of flowering borders enhances natural biological control. Although field validation in pulse systems requires further research, biological control methods are strongly recommended as part of long-term sustainable IPM strategies. **Chemical Methods**

Chemical control should be employed judiciously and only when pest populations exceed economic threshold levels. Foliar application of insecticides is most effective when timed to coincide with peak larval activity during the flowering stage. Recommended insecticides include synthetic pyrethroids, organophosphates, and newer chemistries with selective modes of action. Applications should be made during early morning or late evening hours to maximize efficacy and minimize impact on pollinators. Indiscriminate use of broad-spectrum insecticides during flowering should be avoided to protect beneficial insects, including pollinators and natural enemies. Insecticide rotation is essential to delay the development of resistance. Integration of chemical control with cultural and biological methods enhances overall efficacy while reducing environmental impact and input costs.

**Integrated Pest Management (IPM)**

An effective IPM strategy for plume moth management in pulses integrates the following components: Cultivation of tolerant or resistant cultivars where available. Timely and synchronized sowing, intercropping, trap cropping, and post-harvest field sanitation. Regular field scouting during the flowering period to detect early infestation and determine pest population dynamics. Conservation of natural enemies through habitat manipulation and application of microbial and botanical biopesticides. Use of selective insecticides only when pest popula- tions exceed economic threshold levels, with attention to timing and rotation to prevent resistance development. Training programs on pest identification, monitoring techniques, and IPM principles enhance adoption and effectiveness of sustainable management practices. Successful IPM implementation requires coordination among farmers within a region to synchronize management practices and reduce pest carryover between seasons.

## Conclusion

The plume moth, *Exelastis atomosa*, represents a cryptic yet economically significant pest of pigeonpea in India, capable of causing substantial yield reductions during the critical reproductive phase. Effective management requires early detection, diversification of cropping systems, and judicious use of inputs within an integrated pest management framework. Given the nutritional and economic importance of pulse crops in the region, continued attention to emerging pests such as the plume moth is essential for sustaining pulse production and ensuring food security.

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