Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2025; 13(4): 37-40

Received: 24-04-2025
Accepted: 28-05-2025

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Critical impact of insect pests on the nutritional and agricultural significance of small millets in the Kumaun Himalayas

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DOI: https://www.doi.org/10.22271/j.ento.2025.v13.i4a.9538

Abstract
This study examines the significant impact of insect infestations on the yield and nutritional value of small millets in the Kumaun region of Uttarakhand. Small Millets, recognised globally as "nutricereals" and climate-resilient crops, are integral to subsistence agriculture in the Indian Himalayas. Despite their inherent hardiness, these crops face considerable threats from a diverse array of insect pests, including shoot flies, stem borers, grasshoppers, and aphids, which cause substantial yield losses ranging from 10% to 100%, depending on the millet variety and the type of pest. Beyond direct yield reduction, infestations compromise the nutritional composition of grains, affecting protein, mineral, and vitamin content, and can introduce food safety risks through mycotoxin contamination. The prevalence and severity of these pests are intricately linked to the varied agro-climatic conditions and traditional farming practices in Kumaun, with climate change emerging as a critical factor accelerating pest challenges. Effective management necessitates an Integrated Pest Management (IPM) approach that combines cultural practices, biological control, targeted chemical interventions, and, crucially, the development of host plant resistance. Prioritising economically viable and sustainable interventions, particularly seed treatments and resistant cultivars, is essential to enhance farmer livelihoods, reverse the decline in millet cultivation, and bolster food and nutritional security in the region. Their agronomic advantages are manifold, including high adaptability to low rainfall conditions, remarkable resilience to prolonged dry spells, and rapid recovery after delayed rains, which positions them as ideal climate-resilient crops for contingency plantings.

Keywords: Small millets, traditional crops, Uttarakhand, food security, agricultural sustainability, pest status, Kumaon region, climate resilience, and nutritional security

Introduction
Small millets are tiny, nutritious cereal grains that play an essential role in many farming systems, especially in Uttarakhand. These crops, including finger millet, kodo millet, foxtail millet, little millet, proso millet, and barnyard millet, are grown across a wide altitude range-from coastal Andhra Pradesh to Himalayan hills up to 8,000 feet above sea level (Shanthakumar *et al.,* 2010) [14]. Their ability to withstand harsh climatic conditions, require minimal water, and thrive in drought-prone areas makes them invaluable, particularly in stressful environments. Despite being rich sources of vitamins, minerals, proteins, and dietary fibers, small millets remain underappreciated globally. Their low-input nature supports traditional agriculture, especially in Uttarakhand, where farmers have cultivated these ancient grains for about 10,000 years (Nagaraj *et al*., 2012) [11]. Small millets primarily grow in marginal and degraded lands with poor soil fertility and are susceptible to unpredictable weather patterns. They are generally considered Nutri-cereals due to their richness in carbohydrates, proteins, fats, dietary fibres, and minerals. These crops are essential in the semi-arid tropics of Asia and Africa, renowned for their high productivity and brief growing season in hot conditions. (Mausch *et al*., 2017) [10]. Nutritionally, they exceed major cereals like rice, wheat, and maize, offering more carbohydrates, protein, fibre, antioxidants, polyphenols, minerals, and vitamins (Sendhil *et al*., 2023) [17]. Small millets are crucial food sources for millions, especially in hot and humid regions worldwide (Rani *et al*., 2017) [13]. They are mainly grown in marginal areas where major cereals struggle to yield substantial results (Wang *et al*., 2018) [18].

In the context of climate change, small millets provide a promising solution to global food and nutritional insecurity. These crops have significant potential to enhance food security and improve nutritional outcomes for populations worldwide (Goron & Raizada, 2015) [5]. Millets are characterised by high beneficial fat content and serve as an important source of essential minerals, including iron (Fe), zinc (Zn), magnesium (Mg), and calcium (Ca). Additionally, they are rich in vitamins, dietary fibre, and vital amino acids such as cysteine and methionine. Given their exceptional nutritional properties and resilience to climatic variations, millets have gained considerable global interest in recent years, increasingly competing with traditional cereals that have historically dominated the market (Anju Jr & Sarita, 2010) [1].

Materials and Methods

Field survey and data collection

A seasonal survey study was conducted in 2023-2024 in selected areas of two districts in the Kumaun region, specifically Almora and Bageshwar. The survey focused on farmers' understanding of their socioeconomic status, production levels, and pest issues associated with small millet cultivation in these regions. This study adopted a survey research design to gather both qualitative and quantitative data from farmers in different locations within the Kumaon region. The survey aimed to understand the existing cultivation practices, challenges faced by farmers, and their perceptions of the potential of small millets. The survey utilized a structured questionnaire featuring both closed and open-ended questions, covering the types of small millets grown (e.g., finger millet, barnyard millet), agronomic practices (e.g., sowing, harvesting, irrigation), challenges encountered in millet cultivation (e.g., pests, market access), Socio-economic impact (e.g., income generation, food security), and Farmers' knowledge and perceptions of the nutritional and environmental benefits of small millets.

Nutritional significance:

Millets offer numerous health benefits due to their impressive nutritional content, making them an excellent addition to a balanced diet (Hassan *et al*., 2021) [7]. These grains are also rich in essential minerals such as iron, calcium, magnesium, and phosphorus, which play a vital role in maintaining healthy bones, supporting muscle function, and promoting overall well-being (Gowda *et al*., 2022) [6]. Millets provide a rich source of vitamin B, including niacin, thiamin, and riboflavin, all of which are crucial for energy metabolism and overall health and well-being. (Singh *et al*., 2020) [15]. Small millets are considered nutritionally superior to refined cereals and can play a crucial role in ensuring food and nutritional security in regions like Kumaun (Bisht *et al*., 2022) [2]. Their resilience and adaptability to diverse agro-ecological conditions further enhance their importance as a sustainable food source (Bhat *et al*., 2018) [3]. Moreover, small millets, being rich in essential nutrients and dietary fibre, are increasingly recognised for their potential health benefits, including reducing the risk of chronic diseases (Bhat *et al*., 2018; Pramitha *et al*., 2023) [3, 12] and improving overall health outcomes. Their inclusion in diets can significantly enhance nutritional security in Kumaun, promoting sustainable agricultural practices while addressing health concerns.

As awareness of their benefits grows, integrating small millets into local diets can further support sustainable agriculture and improve community health outcomes in Kumaun. This integration not only supports local farmers but also aligns with global efforts to revive traditional crops for their nutritional and ecological advantages, as seen in various initiatives worldwide (Pramitha *et al*., 2023) [12]. Incorporating small millets into dietary practices can help combat the rising prevalence of lifestyle-related diseases, making them a vital component of public health strategies in Kumaun.

Pest status of small millets

Holotrichia consanguinea Blanch is a common white grub that dwells in the soil. It is recognised for targeting the roots of millet crops, leading to severe infestations in arid and semi-arid areas. Several species of shoot flies, belonging to the family Muscidae within the order Diptera, have been documented as pests of millet crops in India. (Kalaisekar, *et al*., 2017) [9]. Insects, during their development, early instar larvae have been recorded eating through the leaf sheath, causing severe damage to the growing tip of the plant, resulting in wilting, yellowing, and ultimately the death of the infested plant.

Table 1: Major Insect Pests Associated with Small Millets

S. No.	Common name	Scientific name	Damaging stage	Host plant
1.	White grub	*Anomala dimidiata*	grub	Finger millet, barnyard millet, proso millet, foxtail millet
2.	Shoot fly	*Atherigona* sp.	maggot	Finger millet, barnyard millet, proso millet, foxtail millet
3.	Stem borer	*Sesamia inferens*	larvae	Barnyard millet, finger millet, proso millet
4.	Shoot aphids	*Hysteroneura setariae*	Nymph and adult	Barnyard millet, finger millet
5.	grasshopper	*Hieroglyphus* sp., *Cataloipus* sp.	Nymph and adult	Finger millet, barnyard millet, proso millet, foxtail millet
6.	Leaf folder	*Nephrosclerosis medialis*	Larvae	Finger millet
7.	Earwig	*Forficula* sp.	Nymph, adult	Barnyard millet, finger millet
8.	Grey weevil	*Myllocerus* sp.	Grub and adult	Finger millet, barnyard millet, proso millet, foxtail millet
9.	Ear headworm	*Sitotroga cerealella*	Larvae	Finger millet, barnyard millet, proso millet, foxtail millet
10.	semilooper	*Chrysodexis* sp.	Larvae	Finger millet
11.	Shoot bug	*Peregrinus maidis*	Nymph and adult	Barnyard millet

Fig 1: Survey identifies insect pests and diseases affecting small millets in the Kumaun region of Almora and Bageshwar districts

Results

The field survey conducted in the Almora and Bageshwar districts of the Kumaon region during 2023-2024 yielded insightful findings regarding the cultivation, significance, and challenges associated with small millet production. The results highlight both the agronomic and socioeconomic dynamics of small-millet farming in these high-altitude regions**.** The survey revealed that finger millet (ragi) and barnyard millet (jhangora) are the most widely cultivated small millets in the region, followed by foxtail millet, kodo millet, and little millet. These millets are primarily grown under rainfed conditions with minimal external inputs, reinforcing their role in sustainable hill farming agriculture**.** Traditional agronomic practices dominate millet cultivation. Farmers rely on indigenous knowledge for sowing, intercropping, and harvesting. Many farmers are aware of the nutritional benefits of small millets. They recognise that these grains can improve digestive health, boost immunity, and enhance overall well-being, especially for children and the elderly. Finger millet is appreciated for its high calcium content. However, despite this awareness, the consumption of millets tends to be confined to household use, with limited promotion in local markets. Cultivating small millet has a positive impact on household food security and generates modest income, although this income is limited by restricted market access. Women play a significant role in millet cultivation, processing, and marketing, highlighting the crop's importance in boosting women's economic participation in the region. Farmers recognised that small millets thrive in the region's harsh climate, including poor soil, low rainfall, and fluctuating temperatures. This resilience makes them a reliable crop in the face of increased climate variability. Furthermore, promoting small millets can aid in restoring cultural heritage associated with these crops, enhancing their acceptance and usage in modern diets (Pramitha *et al*., 2023) [12] by fostering community engagement and education on their historical significance and culinary versatility. This approach not only contributes to health improvements but also strengthens local agricultural systems. This multifaceted strategy can empower communities to reclaim their agricultural heritage while addressing. The field survey conducted in the Almora and Bageshwar districts of the Kumaon region during 2023-2024 provided valuable insights into the cultivation, importance, and challenges of small millet production. The findings highlight both the agronomic and socioeconomic aspects of small-millet farming in these high-altitude areas. The survey showed that finger millet (ragi) and barnyard millet (jhangora) are the most commonly cultivated small millets in the region, followed by foxtail millet, kodo millet, and little millet. These millets are mainly grown under rainfed conditions with minimal external inputs, underscoring their role in sustainable hill farming. Traditional agronomic practices still dominate millet cultivation, with farmers relying on indigenous knowledge for sowing, intercropping, and harvesting. Many farmers are aware of the nutritional benefits of small millets, recognising that these grains can improve digestive health, boost immunity, and enhance overall well-being, especially for children and the elderly. Finger millet is valued for its high calcium content. However, despite this awareness, millet consumption is generally limited to household use, with little promotion in local markets. Growing small millets has a positive impact on household food security and provides a modest income, although market access remains limited. Women play a vital role in millet cultivation, processing, and marketing, emphasising the crop's importance in increasing women's economic participation. Farmers have noted that small millets thrive in the region's challenging climate, which includes poor soil, low rainfall, and temperature fluctuations. This resilience makes them a dependable crop amid climate variability. Additionally, promoting small millets can help restore cultural heritage associated with these crops, boosting their acceptance and use in modern diets (Pramitha *et al*., 2023) [12] by encouraging community engagement and education about their historical significance and culinary versatility. This not only benefits health but also strengthens local agricultural systems. Such a comprehensive approach can empower communities to reclaim their agricultural heritage while addressing current health issues through revitalising small millet cultivation and consumption. Promoting small millets can greatly enhance food security and sustainable agriculture, contributing to a more resilient food system in Kumaun. This resilience is vital in confronting climate change and evolving dietary habits, ensuring that Kumaun communities can thrive sustainably. By embracing the cultivation and consumption of small millets, Kumaun can reinforce its food systems, improve nutritional health, and build a sustainable agricultural future. Consumption. The promotion of small millets can significantly bolster food security and agricultural sustainability, creating a more resilient food system in Kumaun. This resilience is crucial in the face of climate change and shifting dietary patterns, ensuring that communities in Kumaun can thrive sustainably. By embracing the cultivation and consumption of small millets, Kumaun can strengthen its food systems, improve nutritional outcomes, and foster a sustainable agricultural future.

Conclusion

Small millets, especially finger millet and barnyard millet, are crucial to sustainable agriculture and food security in the Kumaun region. Their resilience to climate stress, low input needs, and rich nutritional profile make them ideal for marginal lands. The 2023–2024 field survey in Almora and Bageshwar revealed that while traditional cultivation practices persist and awareness of health benefits is growing, millet consumption is mostly limited to households due to poor market access. Women play a key role in their production and processing. Promoting small millets can enhance community

nutrition, support local economies, and preserve cultural heritage. Strengthening market linkages and increasing awareness can unlock their full potential, making them central to addressing climate resilience and nutritional challenges in the region.

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