



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(8): 442-448
Received: 19-05-2026
Accepted: 23-06-2026

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are provided below, following the
reference section

Incidence of insect, nematode and mite pests in fodder crops ecosystem: A comprehensive review

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i8Sf.6366>

Abstract

Fodder crops are the backbone of livestock and animal husbandry. These crops are essential in providing essential nutrients for sustaining animal productivity as well as maintaining their reproductive health. However, their productivity is heavily restricted due to the attack of several insect pests. These pests heavily damage fodder crops from both qualitative and quantitative aspects. These pests attack various crop stages, leading to significant yield reduction.

This review presents a comprehensive synthesis of major pests associated with fodder crops in different regions across the globe with a special reference to Indian conditions. It highlights pest biology, damage symptoms, and economic importance related to fodder crops, including cereals, legumes and perennial grasses. The relation of pests with prevalent temperature is given importance in some particular pests. Emphasis is given on how pests can change biochemical constituents of crops. This paper tries to highlight emerging challenges such as pest resistance, climate change and invasive species. This review will provide researchers and extension workers with valuable resources related to improving fodder crop production systems and pest management.

Keywords: Forage crops, Animal productivity, Livestock, Major pests, Pest biology, Damage symptoms, Invasive species, Economic importance, Pest resistance

Introduction

Fodder crops are integral to sustainable livestock production. Sustainable production is important to ensure a continuous supply of essential nutrients for the production of milk, meat, wool, etc., and high-value materials ^[86]. Fodder crops can maintain animal health and reproductive performance ^[19, 24].

Forage grasslands account for 26% of the land area and 70% of the agricultural area globally ^[16]. Worldwide, permanent meadows and pastures cover nearly 3.4 billion ha, while cultivated forage crops cover nearly 159 million ha ^[24]. In India, the production of forage crops covers around 8.4 mha, which has remained static for the last two decades ^[43]. India dominates the livestock sector with a major contribution of nearly 15% of the world's total livestock population within a range of 2-3% of the total area of the world ^[48].

Current estimates indicate a deficit of fodder production in India. This value is near 11- 12% in the case of green fodder, 23-25% in the case of dry fodder, and 28-30% in the case of concentrated feed, which limits the growth of livestock in India. This problem raised major concern about the livestock sector and its well-being ^[32].

Fodder crops include different types of crops, like cereals, legumes and perennial grasses ^[74]. Major cultivated fodder crops in India include Sorghum, Berseem, Lucerne, Cowpea, Clusterbean, Oats, Maize, Bajra and grasses like Napier grass, Bracharia grass, Marvel grass, Rye grass, Guinea grass ^[70]. Along with oats, berseem, lucerne and cowpea; range legumes like *Stylosanthes* spp. cultivated in India, and these crops contribute heavily to the economic benefits

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of the livestock sector in India ^[80].

All these crops are infested with numerous insect pests that damage yields, reduce biomass, and alter biochemical processes, ultimately leading to severe economic losses. Under favourable conditions, this pest damage can account for up to 50% crop damage ^[82].

Biotic stress factors such as insect pests, nematodes, and plant pathogens account for around 30% of qualitative and quantitative losses in the fodder production sector and restrict sustainable fodder production ^[2, 71]. Polyphagous sucking pests like different species of aphids impart heavy injury to the fodder crops ^[87].

Large range area of the Intermountain West of the U.S.A. is very important with respect to grass production, but production was severely damaged by the Black bugs, *Irbisia* spp. and *Labops* spp. (Hemiptera: Miridae) ^[14].

Pest control aspect should cover the whole crop field as a whole, not individual plants, so as to keep damage level below the threshold level ^[33]. Currently, the whole world is shifting towards implication of organic pest management strategies; this same applies for fodder cultivation ^[64]. Integrated pest management has been widely implemented worldwide to mitigate pests in forage crops effectively ^[65]. Modern-age IPM includes proper monitoring, non-chemical alternatives such as cultural and mechanical controls, habitat manipulation, biocontrol agents, and reduced, need-based chemical use ^[9, 41].

Pests affecting important forage crops

Fodder crops are damaged by several insect, nematode and mite pests, leading to serious damage. Pest dynamics change from crop to crop. Even perennial grasses are also infested by some pests ^[7]. Incidence of these pests depends on several factors, while climatic factors mostly regulate the severity and extent of damage caused by them.

Major pests of fodder Maize

Several insects have been reported to be associated with fodder maize in European countries ^[29]. Fodder grains of maize can be stored for future use, but there is always a risk of pest attack. Pests of stored products like lesser grain borer, rusty red flour beetle, and several moths have been considered detrimental to stored grains. These pests are considered a serious competitor for food resources ^[40].

Armyworms have become a serious threat to the world as they attack several important crops ^[66]. Larvae of the fall armyworm (*Spodoptera frugiperda*) are a major polyphagous pest of maize that vigorously feeds on leaves of maize and results in complete defoliation of leaves, mostly at the late whorl stage ^[39].

Several cetonid beetles such as *Chiloloba acuta* Wied, *Oxycetonia versicolor* (Fab), and *Protaetia alboguttata* are associated with fodder maize. These beetles cause severe defoliation of maize ^[72].

Shoot fly and fall armyworm incidence reached maximum during the summer months compared to other times of the year. A greater number of symptoms like pinholes and dead heart can be observed during the summer months ^[11].

Evaluation of diverse maize inbred lines showcased a strong relationship between biochemical constituents and fall armyworm infestation. Higher concentrations of total soluble sugars, reducing sugars, nitrogen, phosphorus and crude protein were positively associated with pest damage. In contrast, potassium, phenols, tannins, free amino acids and peroxidase activity exhibited negative associations with infestation, indicating their contribution to host plant resistance ^[84].

Major pests of fodder Cowpea

Cowpea has been infested by several insect pests that cause heavy damage to its production and productivity ^[61]. Aphids and whiteflies are major among those insect pests ^[6]. The Leaf miners, whiteflies (*Bemisia tabaci*), leafhoppers (*Empoasca* sp.), mites (*Tetranychus* spp.), thrips (*Megalurothrips sjostedti*), *Ootheca* sp., *Clavigralla* sp., *Maruca* sp. and aphids (*Aphis craccivora*) are associated with cowpea and significantly disturb its growth ^[60].

Leafhopper (*Empoasca kerri*) incidence was found in cowpea. Flea-beetle, *Pagria signata*; semilooper, *Plusia nigrisigna* and tobacco caterpillar, *Spodoptera litura* were reported as major defoliators infesting cowpea. These pests damage the cowpea crop and reduce its yield ^[69].

Maruca vitrata and *Cydia pythchora* populations attain peak during the beginning of the winter season, while the latter follows the former. Both these pod borers are considered major pests infesting cowpea ^[44]. *Maruca vitrata* follows a negative temperature correlation ^[1]. Another species of pod borer, *Maruca testulalis* Geyer infestation also recorded in cowpea in India ^[35].

Maruca vitrata poses a major threat to the production of cowpea across all the regions around the globe, but incidence is maximum in tropical climates ^[59]. Spotted pod borer (*Maruca vitrata*) has been reported as one of the major pests infesting cowpea under Indian conditions by making webs inside different plant parts. It can cause around 40 per cent crop loss under favourable conditions ^[26]. Not only in Indian conditions, but *Maruca vitrata* causes extensive crop loss in the African subcontinents where it is very hard to control these pests ^[81].

Major pests of Clusterbean (Guar)

Sucking pests like *Empoasca motti* Pruthi; whitefly, *Bemisia tabaci* and aphid, *Aphis craccivora* Koch cause severe damage to fodder guar in Indian conditions. These pests cause much damage to the production of ^[91].

Leafhopper, *Empoasca motti* Pruthi and thrips, *Megalurothrips dorsalis*, incidence reported on guar ^[57].

Yellow mite, *Polyphagotarsonemus latus* Banks has been reported to be a pest of clusterbean. It creates general mite infestation symptoms like downward curling of leaves ^[53, 55].

Gall midge *Asphondylia* spp. (Cecidomyiidae: Diptera), Guar midge *Contarinia texana* Felt. (Cecidomyiidae: Diptera), Leaf perforator *Dichomeris ianthus* Mayr. (Gelechiidae: Lepidoptera) reported as important pests infesting clusterbean ^[79].

Colonies of aphids on clusterbean cause stunting of the plants as well as a reduction in vigour. During the rainy season, leafhopper infestation in clusterbean has been reported to be at its maximum. Damaged flower buds and pods provide evidence of the presence of pod borer in clusterbean ^[89].

Major pests of fodder Sorghum

Several insect pests significantly reduce the yield of Sorghum, leading to severe loss in the livestock sector ^[49, 92]. Grain sorghum production is drastically reduced due to the effects of these insect pests ^[83]. These pests significantly reduce the growth of Sorghum through several mechanisms ^[51]. Stem borer damage causes heavy injury to fodder sorghum production ^[73].

The most important insect pests of fodder sorghum include the sorghum shoot fly, *Atherigona soccata* Rondani, spotted stem borer, *Chilo partellus* (Swinhoe), pink stem borer, *Sesamia inferens* Walker, sugarcane aphid, *Melanaphis sacchari* (Zehntner), corn leaf aphid, *Rhopalosiphum maidis* (Fitch), greenbug, *Schizaphis graminum* (Rondani), sorghum shoot bug, *Peregrinus maidis* (Ashmead), fall armyworm, *Spodoptera*

frugiperda (J.E. Smith), oriental armyworm, *Mythimna separata* Walker, sorghum earhead bug, *Calocoris angustatus* Lethierry, sorghum midge, *Contarinia sorghicola* (Coquillett) and black cutworm, *Agrotis ipsilon* (Hufnagel) [28, 31, 47]. These insect pests infest sorghum throughout different crop growth stages, causing damage to seedlings, foliage, stems, growing points, and panicles, thereby reducing forage yield, quality, and seed production [15, 78].

The sorghum shoot fly, *Atherigona soccata* Rondani, is one of the most destructive insect pests of sorghum, particularly at the seedling stage [36]. The maggots of the flies heavily infest the central shoot of crops, leading to dead heart symptoms in Sorghum. Infested plants show poor tillering, stunted growth, and reduced vigour, leading to significant reductions in green fodder yield and grain production under severe infestations [3, 18].

Pink stem borer (*Sesamia inferens* Walker): the caterpillar tunnels inside the stems of the crop, leading to dead hearts, weakening the stem, and reducing biomass production and forage quality [77].

Corn leaf aphid (*Rhopalosiphum maidis* Fitch) is a sucking pest that causes general symptoms and finally results in severe crop damage [12].

Fall armyworm (FAW), *Spodoptera frugiperda* Smith caterpillars are voracious leaf eaters, producing windowpane feeding, irregular holes, and severe defoliation, thereby reducing photosynthetic area and fodder yield [20, 27].

Sorghum midge (*Contarinia sorghicola* Coquillett), the maggots feed inside developing florets, causing empty spikelets, poor grain set, and considerable losses in seed production [18, 75].

Sugarcane aphid, *Melanaphis sacchari* (Zehntner) reported as a newly introduced pest attacking Sorghum in North American conditions in the year of 2013. It is a sucking pest causing general decline of the plant along with severe yield loss [13].

Major pests of Lucerne (Alfalfa)

Pests like alfalfa weevil, aphid, armyworm and potato leafhopper cause severe reduction in yield of lucerne mostly during the hot summer months [62]. These pests cause drastic reduction in yield and quality of productive lucerne and shorten the stand [45].

Lucerne weevil (*Hypera postica*) becomes active mostly during January to April and causes up to 25% crop loss. Aphid infestation in lucerne causes discolouration of the plant, stunting of plants, and reduction in vigour [79].

Major pests that infest lucerne include *Atractomorpha crenulata* (Fab.), *Tricentrus bicolor* (Dist.), *Leptocentrus obliquus* (Walk.), *Exitianus indicus* (Dist.), *Aphis craccivora* (Koch.), *Creontiades pallidifer* (Walker), *Cletus signatus* (Walker), *Dolycoris indicus* (Stall.), *Taenothrips distalis* (Karny), *Amsacta lineola* (Fab.), *Cretonotus gangis* (Linn.), *Agrotis spinifera* (Hubner), *Heliothis armigera* (Hubner), *Psalis pennatula* (Fab.), *Tephritis spilopecta* (Bezzi), *Eurytoma platyptera* (Wlk.), *Monolepta signata* (Mots.), *Hypera variabilis* (Hbst.) [56].

Foliar feeding by the alfalfa weevil (*Hypera postica* Gyll.) and the alfalfa snout beetle (*Otiorhynchus ligustici* L.) causes severe reductions in alfalfa stands [10]. Feeding by potato leafhopper (*Empoasca fabae* Harris) leads to reduced carbohydrate levels in lucerne roots and results in reduced growth [34].

Lucerne in New Zealand is infested by the lucerne weevil (*Sitona discoideus* Gyllenhal), three aphid species (*A. kondoi*, *A. pisum* and *T. trifolii*), the white fringed weevil (*Naupactus leucoloma* Boheman) and the little fringed weevil (*Atrichonotus taeniatulus* Berg.) [54]. The blue-green lucerne aphid

(*Acyrtosiphon kondoi* Shinji) and the pea aphid (*Acyrtosiphon pisum* Harris) act as highly efficient vectors of Alfalfa Mosaic Virus [23].

Stem nematode *Ditylenchus dipsaci* has been considered to cause severe damage to the crop in several agro-climatic conditions. Seed-borne infections are responsible for the travel of the nematode over a long distance [50].

Major pests of Egyptian Clover (Berseem)

Helicoverpa armigera (Hubner) has been considered a major problematic pest infesting Berseem in Indian conditions [90]. This pest can cause up to 80% reduction in yield of berseem [68]. Infestation of armyworm and aphids on Berseem was reported in Multan, Punjab. The Sandal berseem variety was most susceptible to aphid populations [30].

Polyphagous pests like whitefly, thrips and aphids are found to be associated with Berseem in the Sindh region of Pakistan. All of these are very important with respect to their damage, but aphids were found to be the most abundant in terms of species richness [52].

Coleopteran pest *Paederus fuscipes* was found to be highest in terms of relative abundance in the Sialkot region of Pakistan.

Other pests reported were: Orthoptera (*Acrida exaltata*, *Oxya hyla*, *Mermiria bivittata*), Hemiptera (*Rhopalosiphum maydis*, *Bemisia tabaci*, *Nezara viridula*), Lepidoptera (*Agrotis ipsilon*, *Spodoptera litura*, *Spodoptera exigua*) [85].

Stem nematode *Ditylenchus dipsaci* is considered a pest of Berseem in several regions of India [46].

Major pests of Pearl Millet

Pearl millet has been infested by the shootfly, *Atherigona approximata* and maximum infestation is reported during the seedling stage of the crop. In India, across several states, *Atherigona approximata* caused around 57% loss in fodder Pearl millet [57].

Except for the shoot fly, Other major pests causing damage in Indian conditions include: *Chilo partellus*, *Busseola fusca*, *Autoba silicula*, *Oedaleus senegalensis*, *Rhopalosiphum maydis*, *Sitobion miscanthi*, *Hyalopterous pruni*, *Blissus leucopterus*, *Pyrilla perpusilla*, *Thrips hawaiiensis*, *Chiloloba acuta*, etc. [38]

Pearl millet is heavily infested by several insect pests in the African subcontinent compared to India. In India, outbreaks of *Schistocerca gregaria*, *Holotrichia fissa*, and *Oedaleus senegalensis* have been reported [76]. Most important pests reported in Pearl Millet in India are: White grub *Holotrichia consanguinea*, Root bug *Stibaropus minor*, Root aphid *Tetraneura nigriabdominalis*, Shoot fly *Atherigona approximata*, Grey weevil *Mylocherus undecimpustulatus maculosus*, Corn leaf aphid *Rhopalosiphum maydis* and Green bug *Schizaphis graminum* [67].

Shoot fly, *Atherigona approximata*, has been considered a major pest of Pearl millet. Several species of stem borers such as *Chilo partellus*, *Coniesta ignefusalis* and *Sesamia inferens* damage caused severe loss of fodder Pearl Millet in Indian conditions. Except for these, fall armyworm and grey weevil incidence has been reported. All these pests are responsible for major crop loss across all the states of India [37].

Spike worm has been reported as an introduced pest of pearl millet in some particular regions of Africa. Discontinuous attacks of blister beetle, armyworm, chinch bug, and leaf beetle cause extensive damage to the crop in West Africa, while damage was seen to be maximum in the rainy season [25].

Armyworm *Pseudoletia separata* Walker (Noctuidae: Lepidoptera) was reported as a pest of Pearl Millet in Karnataka,

India^[8]. Spotted aleyrodid *Neomaskiella bergi* was reported to infest Pearl Millet in the Jodhpur region of Rajasthan^[88].

Major Pests of Hybrid Napier

Napier grass productivity has been restricted due to the incidence of a few insect pests^[58]. Napier grass has been infested by several species of planthoppers and stem borers^[63]. Leafhopper *Maiestas banda* (Kramer) has been acting as a vector of napier stunt disease. The causal organism of this disease is phytoplasma^[4, 5, 17]. Incidences of several other leafhopper and planthopper species were recorded to be associated with Napier plantations in Eastern Africa and surroundings. Among them, important species are: *Cicadulina mbila* (Naudé), *Cofana polaris* (Young), *Cofana unimaculata* (Signoret), *Leptodelphax dymas* (Fennah), *Thriambus strenuus* (Van Stalle), and *Maiestas* sp.^[42].

Larval stem borer incidence reported in hybrid Napier plantations in Kenya. General symptoms like notching of leaves and windowing of the leaf blade were proof of infestation by stem borer^[21, 22].

Key Findings

Fodder crops, mostly in India and the African subcontinents, are highly susceptible to insect, nematode and mite pests. Most of these pests are polyphagous in nature, such as *Helicoverpa armigera*, *Spodoptera* spp., and aphids. These pests account for severe economic damage in the livestock sector. Cereals like maize and sorghum are infested by shoot fly and stem borers, whereas leguminous fodders like cowpea and clusterbean are infested by pod borers, aphids and leaf miners. Perennial fodder like napier is infested by stunt disease and leafhoppers.

Research Gaps

- Very limited information is available on nematode and mite infestations in the fodder ecosystem.
- Very little information related to effect of climate change on major pests infesting fodder crops
- Invasive pest issues related to the fodder crops remain unexplored
- Insufficient quantification of yield loss due to some individual pests
- Lack of studies integrating major pest damage and integrated pest management

Future Perspectives

- Development of resistant varieties using advanced genetics tools should be prioritised for sustainable fodder crop production.
- Increased focus on conservation and augmentation of available natural enemies of the major pests of fodder crops to ensure eco-friendly pest management.
- Integration of AI-based pest monitoring tools specialised for the fodder ecosystem.
- Enhanced research on nematodes and mites associated with the major fodder crops.
- Deeper research on stage-specific pests of fodder crops and how they affect crop production.

Conclusion

Pests of fodder crops pose a significant threat to sustainable livestock production and the well-being of farm households. Effective management requires an integrated approach that mitigates these pests while maintaining productivity. IPM

strategies, coupled with biotechnology and digital agriculture, can offer a promising solution to the emerging pest challenges. Strengthening research and extension will be crucial for long-term suppression of pests and, at the same time, increasing the productivity of these pests. This review underscores the need for continuous innovation and holistic research to safeguard fodder resources and support the economy of the livestock sector, fulfilling the growing demand.

Declaration

Ethics approval and Consent to participate

Not applicable

Consent for publication

Not applicable

Competing Interest

The authors have no competing interests to declare that are relevant to the content of this article.

Funding

No specific grant for this article has been received from any funding agency in the public, commercial, or non-profit sectors.

Authors' Contributions

KN, VS, KP, TS and BI: Investigation and data collection; KHK, MA and MJK: Data curation and compilation; RK, KV and PA: Outline design and fact-checking; SC, KVK, SCS, MAK and SF: Writing the original draft and necessary editing; JAK: Validation and supervision.

Acknowledgements

The authors express gratitude towards the Department of Entomology, Professor Jayashankar Telangana Agriculture University, for academic support and guidance.

Availability of Data and Materials

Data sharing doesn't apply to this article as none of these datasets was generated or analysed during this current study.

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