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Review on Major Insect Pests of Mango in Nepal: Impact, Identification, and Integrated Management Strategies

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Abstract

Mango (*Mangifera indica)*, called as king of fruits is widely cultivated in Nepal, where huge scales of production and sales are projected to reach approximately 300 million in 2023. Although having strong output, Mango industry faces several challenges from insect and pest which affect the quality and quantity in fruits yield. This article examines the major pest affecting the mango crop in Nepal, including the mango hopper, mealybug, mango stem borer, mango fruit fly, and mango leaf webber. This paper discusses the nature of damage they cause, their biology and environmentally sustainable management practices. The promotion of integrated pest management practices is a crucial approach to mitigate the adverse effects of chemical pesticides, fostering environmental health and enhancing the economic benefits to Nepalese people. The reviews aim to provides insight into effective pest management solution, ensuring the sustainability of mango production in Nepal.

Keywords: Pest of mango, sustainable agriculture, IPM

Introduction

Mango (*Mangifera indica)* is also known as king of fruit is widely cultivated in tropical and sub-tropical region. In Nepal, production of mango in 2023 was in huge scale with sales expected to reach around Rs 300 million (Mishra S, 2023). About 35 percent of the nation's total fruit-producing land is used for mango growing, which is commercially practiced in 24

districts, including Jhapa, Morang, Siraha, Saptari, and Sarlahi (MOALD,2023) . The need for mangoes drives imports from India even with the strong domestic output, especially around the start and finish of the season (The Rising Nepal). The full yield potential of different mango types is greatly impeded by the presence of insect pests (Afreen et al., 2023). Climate change has also resulted in the emergence of pests that were previously unknown or inadvertently helped invading species spread (Reddy et al., 2018a). Mangos are infested with around 400 types of insect pests worldwide including sap feeder, borer, defoliators and fruit pulp feeder (Tandon & Verghese, 1985) .Insects that were once thought to be minor or secondary pests, such as mealybugs, thrips, mites, leaf webbers, stem borer, etc., have recently become a severe concern (Kamala Jayanthi et al., 2014). In Nepal, farmers only use pesticides, which results in insect resistance, degradation of the environment, and toxic residues in food, water, and soil. Despite the recent rise in popularity of organic farming, chemical pesticides are still the most widely accepted method of controlling pests (A. B. & Ibrahim S, 2024) . However, the use (and misuse) of chemical pesticides is frequently linked to significant dangers to human health and the environment (Brethour & Weersink, 2001) (Maina et al., 2024). In the horticulture sector, there is a clear overuse of chemical pesticides (Macharia et al., 2005) , which has resulted in many interceptions of horticultural products, particularly mango fruits, on the global market (Lux et al., 2003). Furthermore, the majority of farmers with limited resources find it difficult to afford the high cost of pesticides. Scholars promote the implementation of Integrated Pest Management (IPM) in underdeveloped nations as a more environmentally friendly substitute for the extensive use of broad range chemical insecticidal treatments (Norton et al., 1999). Integrated pest management (IPM), sometimes referred to as integrated pest control, is a comprehensive approach that combines

environmentally friendly and economically viable pest management techniques. IPM seeks to keep pest numbers below the point at which they become an economic concern. "The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment," according to the Food and Agricultural Organization of the United Nations. Research demonstrates that funding IPM initiatives results in increased agricultural profits. For instance, in several Asian nations, the IPM approach has been linked to high rates of return on cotton cultivation (Ekesi et al., 2011, Ooi, 2005). Other I/NGOs launched initiatives in tandem with the national and local governments as soon as the Nepali government launched the IPM-FFS. Similar to this, educational establishments began instructing graduate and undergraduate students in IPM-FFS (Kafle et al., 2014) . In this chapter we discuss the major insect pest of mango in Nepal and their biology, possible damage, environmentally acceptable management techniques and IPM technique to lessen the harmful effects of insecticides as well as to gain high economic benefits from it.

Some Major Pest of Mango

1. Mango hopper (Hemiptera: Cicadellidae)

Mango hopper (family: Cicadellidae) is a serious pest found across Nepal that affect mango crops. Around the world, more than 18 species have been recognized as pests.

Biology of mango hopper

There have been reports of 15 different species from Asia (A. B. & Ibrahim S, 2024) .Among them 3-4 species are serious pest of mango i.e *Idioscopus niverosparsus* (Leth), I. clypealis

(Leth), *I. nagpurensis* (Pruthi) and *Amritodus atkinsoni* (Leth) (Awan, 2022) .*Idioscopus niverosparsus* (Leth) is a brown in color with light marking on wings. Approximately 4-5mm in length. Females lay eggs on tender parts of the mango plant, mainly on buds and leaves. Nymphs are small and wingless, initially greenish-white but gradually develop brown color. Active nymphs hide under the flower edge. They are able to move forward, backward and sideways. They go through five instar stages. The adult emerges after molting, and the life span of adults is about 1-2 months. The adult's wings are light brown with a prominent white band running across them, and its scutellum has two dots (Thakur et al., 2022) .

Nature of damage

During the flowering season, these hoppers severely harm the mango crop, resulting in a 25–60% yield loss (Awan, 2022) . But only during the blossoming season did the hoppers reach their optimum activity (Babu et al., 2002) . They feed sap from the tender shoot, leaves and Inflorescence which leads to black sooty mold from honeydew secretion which affect photosynthesis activities of leaves and ultimately reduce the yield of mango (Verghese & Kamala Jayanthi, 2001) .During heavy infestation it can cause loss of mango yield up to 50% and also decrease its quality (Rajkumar et al., 2013). Sucking in cell sap from tender shoots can result in drying out, withering, and wilting of mango plant (Sajid et al., 2022).

Management

1. Pruning of mango tree and remove infested part which reduce hopper population and also provide adequate tree spacing which facilitates air circulation.
2. Use of yellow sticky traps around mango trees can help capture adult hoppers. This method reduces their population, especially in the early stages of infestation.

3. Instead of using synthetic insecticides,(Munj et al., 2020) recommends applying five sprays of either Metarrhizium anisopliae (oil formulation @ 0.5 ml/l) or Verticillium lecanii (commercial product @ 5 gm/l). This will help preserve the natural enemies of predators, such as coccinellids (e.g. Coccinella septempunctata, C. transversalis, and Menochilus sexmaculatus) and spiders.
4. Use of chemical pesticides when hopper population exceed the economic threshold level. Imidacloprid (17.8 % SL @ 1 ml/L of water) is most effective at controlling mango hoppers by targeting their feeding habits(Upadhyay et al., 2013).
5. Application of Nimex (@5 ml/L of water) for five times at 15 days interval from egg laying to time of pest also help in reducing hopper population (Upadhyay et al., 2013).

2. Mealybugs (Hemiptera: Pseudococcidae)

Mealybug, called *Drosicha mangiferae*, is a very damaging insect that causes significant loss in mango fruit (Karar et al., 2013). Mealybug is destructive pest in mango due to its larger range, rapid dissemination, and polyphagous nature (R. Gupta et al., 2021). It releases honeydew, which encourages the formation of sooty mold (Baradevanal et al., 2018). Mealybugs are challenging to control with insecticides due to their waxy covering as adults and their habit of gathering and settling in cracks and crevices as nymphal instars (Lo & Walker, 2011).

Biology of mealybugs

Mealybugs are tiny; their length ranges from 1/8 to 1/4 inch. Mealybugs are sexually dimorphic, which means that the male and female have somewhat different appearances (Vallie, n.d.) . The adult female mealybug is wingless, oval in shape, and covered with white,

powdery wax, giving it a cotton-like appearance. The waxy covering helps protect it from environmental factors and predators. The male mealybug is smaller, slenderer, and possesses a pair of wings. Males are short-lived and do not feed after they reach adulthood. Their primary role is to mate with females. The nymphs, also known as "crawlers," are smaller, pinkish to yellowish in color, and lack the waxy coating initially. They move to tender plant parts to feed. Warmer temperatures speed up the life cycle of mealybugs. In tropical climates, they can reproduce rapidly, leading to high population densities.

Nature of damage

Emerging nymphs climb up trees, perch on inflorescences, and consume sap by sucking, causing the collapse of flowers and disrupting photosynthetic processes (Pruthi & Batra, 1960). Extreme infection frequently results in fruit drops or renders the fruit unsuitable for sale (Karar et al., 2009a).Affected inflorescence get shriveled and dry which ultimately result the poor fruit set and premature fruit drop (Karar et al., 2009b).

Management

1. In November–December, plow the orchard.
2. According to Ishaq et al.(2004), who studied the integrated management of mango mealybugs, it is challenging to eradicate this pest with just pesticides. (Tandon & Verghese, 1985) discovered that the following methods were efficient in controlling Drosicha spp.: applying alkathane bands, removing weeds, preserving natural enemies, and spraying garlic oil or 4% neem seed extract on the trunk below the band
3. Remove weeds such as Clerodendrum infortunatum, which provides gigantic mealybugs with an alternate host (Afreen et al., 2023).

4. (Tandon, 1995) reported observations of a variety of natural enemies feeding on Drosicha mangiferae nymphs, including 11 species of ladybugs, 6 species of spiders, 2 species of mites, and 3 species of parasitoids.
5. (Khan, 2004) Suggested that, Sumnius renardi, the predator, gathers in crevices and tree bark. Burlap coverings deter the predator, increasing the number of surviving individuals. It reduces the number of mealy bug nymphs by 84.09% by feeding on them.
6. Applying systemic insecticides by trunk injections is the best course of action after the bug reaches the tree's foliage (Khan, 2004) .
7. Applying one sticky band per tree in December proved to be a considerable improvement over the controls in terms of limiting the upward migration of mealy bugs, as it provided 99.87% control over the control treatment (H. Singh et al., 2023).

3. Mango Stem Borers (Coleoptera: Cerambycidae)

One of the main pests in mango plantations is the mango stem borer. Mango fruit fly, mango hopper, and mango fruit borer were found to be the most common insect pests of mangos in surveys conducted in the districts of Siraha and Saptari (Upadhyay et al., 2013).

Biology of mango stem borer

The life cycle of the mango stem borer begins when females lay eggs in crevices or damaged areas of the tree bark. The eggs hatch in 1 to 3 weeks, and the larvae immediately begin boring into the tree's trunk or branches. The larval stage is the most destructive, as the larvae feed on the inner wood tissues, creating extensive tunnels that can last for 6 months to 2 years. Once fully grown, the larvae pupate inside the tree, with the pupal stage lasting about 3 to 4

weeks. After pupation, adult beetles emerge by boring exit holes in the bark, live for 2 to 3 months, and feed briefly on leaves before mating and starting the cycle again.

Nature of damage

The most destructive stage of the mango stem borer is the larval stage. After hatching, the larvae bore into the tree's trunk and larger branches, tunneling through the wood to feed on the inner tissues (xylem and phloem) (Magar et al., 2022). A key symptom of stem borer infestation is the presence of frass (insect excrement) and wood shavings or sawdust-like material near the base of the tree or around the boreholes. This is pushed out of the tunnels by the larvae as they feed. This damage causes yellowing and drying of branches, leading to the death of the entire tree (Afreen et al., 2023). Infested trees may display gum exudation from the entry holes made by the larvae, as a response to the injury caused by their feeding activity.

Management

1. Prune the branches affected by the stem borers.
2. During the months of May to August, it's crucial to wrap the stem with nylon mesh to effectively capture newly emerging adult beetles. This proactive measure will help protect mango plants and ensure a beetle-free environment for healthy growth (Reddy et al., 2018b) .
3. Using an iron wire or hook, remove the grubs from the diseased trunk holes and discard.
4. The active larvae inside the stem are killed by sealing the pores with cotton soaked in dichlorovos 76% EC or gasoline.
5. Cut off and eliminate any affected branches, then apply 50 grams of copper oxychloride per liter of water to the cut ends.

6. Three times in June, July, and August, the orchard should be tilled at a depth of 15 cm in the soil(A.I. Mohyuddin, n.d.).
7. Encourage natural predators such as woodpeckers and parasitic wasps that feed on larvae and adults.

4. Mango Fruit Flies (Family: Tephritidae)

In much of the world, fruit flies are a major pest of mangoes, resulting in losses to the economy (Verghese et al., 2011). The mango fruit fly (Bactrocera dorsalis) is a significant pest in Nepal, affecting mango production across the country. This pest infests the fruit, leading to reduced yield and quality. The larvae of the fruit fly feed inside the mango, causing internal decay and making the fruit unmarketable. Depending on their abundance, the types of commodities they eat, and the season, tephritid fruit flies can be deadly pests that can reduce productivity by 90–100% (Adhikari et al., 2020). Fruits and vegetables are considered horticulture crops and are part of Nepal's fundamental agricultural sector. Bactrocera dorsalis fruit fly problems were first documented in Nepal in 1970 (Pradhan RB., 1970)

Biology of mango fruit fly

The mature female fly has a needle-like ovipositor at the tip of her abdomen, and she uses it to lay 4–5 eggs in batches under the fruit's skin. As fruit deteriorates and creates a substrate for larval feeding, the fly pushes bacteria from the fruit's epidermis into the flesh (Fletcher et al., 1914). Within one to two days, the egg hatches into larvae that feed on the fruit flesh, causing additional deterioration, giving off an unpleasant odor, and in certain situations, causing the fruit to fall before its time. The larva grows in size by molting twice, progressing through three larval stages (instars). It develops in the fruit for about 6 to 9 days. Once fully developed, the larva emerges from the fruit, falls to the ground, burrows into the soil or

organic matter for a short distance, and its skin thickens and hardens to create a puparium. Inside the puparium, the larva transforms into an adult (Frias et al., 2009).

Nature of damage

The mango fruit fly (Bactrocera dorsalis) causes significant damage to mango crops by laying eggs just beneath the fruit's surface. Once the eggs hatch, the larvae burrow into the flesh and feed on the pulp, leading to internal decay. This feeding activity causes the fruit to become soft, discolored, and prone to secondary infections. Affected fruits often drop prematurely, significantly reducing yield and marketability. In severe infestations, damage can result in up to 70-80% fruit loss. Infested fruits are unsellable due to the presence of maggots, rendering them unfit for consumption.

Management

1. Gather fallen fruit that has been infected and burrow it into pits.
2. Pupae exposed to the intense sun and predators in November and December are caused by deep plowing.
3. Utilizing bottle traps with methyl eugenol at a height of five feet allows for the most efficient tracking and management of mango fruit fly populations (Niraula et al., 2024).
4. Mango fruits should be disinfested after harvest by immersing them in hot water at 48°C± 1°C for 60 minutes, no later than 24 hours after harvest. This method yields 100% egg mortality in the fruit without compromising its quality.
5. Use paper or cloth bags to cover developing fruits, preventing female fruit flies from laying eggs.

6. Use neem-based sprays and other eco-friendly biopesticides to disrupt egg-laying behavior of the female flies.

5. Mango leaf/shoot webber (Lepidoptera: Pyralidae)

The most common pest in the mango in tropics of mango-growing countries is mango leaf webber (Upadhyaya et al., 2022). In Northern India, the mango leaf webber (Orthaga euadrusalis Walker) has turned into a major pest (ICAR, 2014). It is currently widely present in mango orchards in Sri Lanka and Nepal. Temperature extremes have an impact on the dispersion of leaf webber, which is most active from August to December (Kasar et al., 2017).

Biology of leaf webber

Leaf tissue is the primary host throughout the pest's life cycle. In a year, it finishes five generations (Beria et al., 2008). According to (Haseeb et al., 2000), the female moth deposits dull green eggs on leaves, which hatch after a week. These eggs can be placed singly or in groups, close to the midrib or vein areas. The larvae have seven instars and undergo six moultings, according to study by (Kavitha et al., 2005). In around six weeks, the larvae become pupae (Haseeb et al., 2000). For 16–18 days, the pupal stage lasts. A fully developed moth resembles noctuid moths in that it is medium in size, grey in color, and has forewings that are somewhat dirty white and brownish black in color (Kavitha et al., 2005). Typically, the adult is greyish-brown in size, with dirty white hind wings and deep brown forewings. Typically, females are bigger than men.

Nature of damage

The pest lives gregariously on leaves as a larva. They sever the leaf surface, leaving the midribs and a network of veins that provide skeletal structure behind. These leaves are put

together, braided into a web, and created to resemble a nest (Kasar et al., 2017). These leaves ultimately dry out, but since they are intertwined in the web, they do not fall (Kavitha et al., 2005). The pest infestation may be identified by looking for obvious clusters of webbed dried leaves on trees, which occur when the affected leaf or section ultimately dries up. The webbing reduces the tree's ability to perform photosynthesis, weakening the tree and affecting its overall growth and fruit yield. Severe infestations can damage new shoots and buds, leading to stunted growth and reduced mango production.

Management

1. Caterpillars exposed to the light will die from desiccation and heat will burst out of clusters of webs. Burning the larvae and pupa as well as pruning the infected branches (ICAR, 2014)
2. Dwarf-resistant mango cultivars, which are simpler to control if the pest continues, should be used to rebuild the older orchards.
3. Beauveria bassiana sprayed twice or three times during the peak humidity period can also control the number of pests (Srivastava & Tandon, 1980) .
4. The web nest can be burned or scraped off, along with the pupa and maggots.
5. The use of fewer chemicals is cut down by protecting pests and pathogens such as Hormius, Pediobius bruchicida, Brachymeria lasus, Oecama sp., and others (Upadhyaya et al., 2022).
6. Spraying plants with nemactine 0.4% or nimbicidine 0.2% can help lower the number of cases (G. Singh, 2000).

6. Mango Shoot Gall Psylla (Homoptera: Psyllidae)

One of the most significant pests of mango in certain parts of Nepal, northern India, and Bangladesh is the mango shoot gall psylla, *Apsylla cistellata Buckton* (Psyllidae: Homoptera (G.Singh, 2000). Mango apical buds are transformed into hard, conical galls by *Apsylla cistellata*, where nymphs are fed and grow into adults. It has recently been noted that this pest is spreading geographically (Baradevanal, 2019). The yield loss caused by this insect has been estimated to be between 50 and 60 percent in cases of severe infestation (K. M. Gupta et al., 1958). It was noted that the occurrence of pests was highest in older orchards. Younger trees (less than five years old) showing the least signs of infestation (Kadam et al., 2017).

Biology of mango shoot gall psylla

The mango shoot gall psylla is a monophagous pest that takes a year to fully mature (Kadam et al., 2017). The mango shoot gall psylla (Apsylla cistellata) begins its life cycle when females lay small, oval-shaped yellow eggs on young mango shoots, particularly near the base of new leaves. These eggs hatch after 5-7 days, releasing pale, wingless nymphs. The nymphs are the most damaging stage, as they feed by sucking sap from tender shoots, which causes the plant to form protective galls around them. Galls, which are noticeable in September, are modified axillary and apical buds. Over a period of 2-3 weeks, the nymphs undergo five instar stages, growing larger with each molt. These galls serve as shelters for the nymphs as they continue to feed.

After completing the nymphal stage, they develop into adults, which are small, reddish-brown, winged insects, about 3-4 mm long. Adults are capable of flying and live for about 2-3 weeks. During this time, they reproduce, and the females lay new eggs, starting the cycle

again. The complete life cycle, from egg to adult, takes about 4-6 weeks, with variations depending on environmental conditions such as temperature and humidity.

Nature of damage

The mango shoot gall psylla (*Apsylla cistellata*) causes significant damage to mango trees, mainly during its nymph stage, by inducing the formation of galls. The nymphs feed on sap from tender shoots, injecting toxic saliva into the plant tissue. This disrupts normal growth, causing the cells to proliferate abnormally and form galls around the feeding site. These galls are swollen, abnormal growths that develop on shoots, leaf petioles, or buds, and they trap the nymphs inside, allowing them to continue feeding.

As a result, the affected shoots become stunted and deformed, with limited leaf and flower production. The galls also cause the shoots to become twisted or thickened, which hampers the plant's ability to grow properly. In severe cases, shoots may dry out and die. This stunted growth affects flowering, reducing the number of flowers and subsequently, the fruit yield. Additionally, the feeding activity weakens the overall health of the plant, making it less likely to produce healthy fruits.

Over time, repeated infestations can severely weaken the mango tree, reducing its vigor and making it more susceptible to other pests and diseases. The long-term impact includes significant yield losses, reduced tree productivity, and even dieback of heavily affected branches. When the green galls develop in the buds, the plant does not flower (Chowdhury, 2015).

Managements

1. In September, trim the branches of the tree that bear galls to a height of 15 cm (Samui & Jha, 2009).

2. Use nymphs to gather and kill the galls.
3. When leaves-bearing eggs were removed from the shoot, the percentage of reductions above control was 95.57% (Kumar et al., 2007).
4. Encourage and introduce natural predators such as lady beetles (e.g., *Coccinellidae*), lacewings (e.g., *Chrysopidae*), and parasitic wasps, which can feed on psylla eggs, nymphs, and adults. These beneficial insects help regulate psylla populations naturally.
5. Spraying trees with water under high pressure can help dislodge psylla nymphs and adults from the shoots, reducing their population.
6. Use insecticides as a last resort, and only when psylla populations exceed economic thresholds. Selective insecticides like neem oil**,** spinosad, or azadirachtin can be effective and less harmful to beneficial insects.

Conclusion

In conclusion, the production of mango in Nepal was significantly hampered by various insect, pest which affect both the quality and quantity of the mango. The major pests are mango hopper, mealybug, mango stem borer, mango fruit fly, and mango leaf webber possess various challenges to farmers requiring effective managements practices to mitigates their impacts. Integrated pest management is essential to reduce the reliance on chemical pesticides, thereby promoting the sustainable agriculture and protecting the environment. By employing a combination of biological, cultural, and mechanical control measures, farmers can enhance mango production while safeguarding their economic interests. Continued research and education on pest management are vital for empowering farmers and ensuring the long-term sustainability of the mango industry in Nepal.

Conflict Of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research paper. There are no financial, personal, or professional relationships that could be perceived as influencing the work presented in this study. All funding sources and affiliations are disclosed, and the integrity of the research has been maintained throughout the process.

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