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Indian Bay Leaf (*Cinnamomum tamala*) – How to Protect the Tree Spice from the Ravages of Insect Pests and Diseases

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ABSTRACT: Indian bay leaf (*Cinnamomum tamala*) is a valuable tree spice of India known for its beautiful aroma and fragrance. The main economic portion of this tree spice is its leaves, so that direct damage in leaves causes direct economic loss in its production. Due to the lacking of detailed information regarding its pest scenario and scientific management, a review work has been done. The study reveals that cinnamon butterfly, different species of leaf miner, chafer beetle, gall mite and cinnamon shoot and leaf webber are the important pests of bay leaf whereas major diseases include leaf spot and dieback, grey leaf spot and blight and bark canker. The insect pests can be managed by different cultural practices like hand picking and destruction of the larvae and adult beetles, trapping with different traps and using different bio-control agents and bio-pesticides besides chemical insecticides. The diseases too can be brought under control by taking different non-chemical approaches like pruning of infected branches and destruction of diseased plant parts, balanced fertilizer application, using bio-agents other than synthetic fungicides.

Keywords: Indian bay leaf, Insect pests, Diseases, Management.

INTRODUCTION

Spices are the most common and essential ingredient of every Indian kitchen. Hardly any recipe can be found that is made without spices. Among the several spices used for applying flavor in Indian cuisine, bay leaf or Indian bay leaf (*Tejpat*) is the most common one. This is a tree spice, botanically known as *Cinnamomum tamala* Nees and Eberm. having the characteristics of Lauracae family and they are evergreen in nature. It is known for originating in Southeast Asia and generally grows up to a height of 1-20 m with a stem girth of 20 cm (Pandit *et al*., 2010). There are more or less 270 species present under the genus *Cinnamomum* and they are most common in Asia and Australia. Most of them are known for their fragrance with economic importance and approximately 20 species are occurred in India (Anonymous, 1950). This tree spice is naturally found in the valleys, hills of Sub-Tropical Himalayas and foot hills of Himachal Pradesh within an elevation ranging between 750- 1800m and warm places like Kashi (Kumar and Duggal 2019). This tree spice has a wide distribution geographically from near Indus to Bhutan (Hooker, 1988). *Bhavaprakasa* mentioned that leaves of *Cinnamomum tamala* (*tamalapatra*) or Indian bay leaves were used for preparation of *'trijata'* which was prepared by using the bay leaves along with two other components including *Cinnamomum zeylanicum* (*tavak* or *dalchini*) and *Elettaria cardamom* (*elaichi*). *Trijata* is an ayurvedic ingredient used for making *asava* and *arista* which are mainly known for augmenting the fragrance as well as promoting the appetite and digestion. In different parts of India known for bay leaves, there is a product manufactured by the growers known as '*nagkesara*' which is a crude drug prepared from immature unripe fruit of *Cinnamomum tamala* tree (Vaidya, 1971). In '*Ayurveda*' it was described that different ailments like anorexia, bladder disorders, dryness of mouth, coryza, diarrhea, nausea and spermatorhea can be cured by using the bay leaves (Kapoor *et al.*, 2008). For the aromatic feature this spice is used in different food industries (Chang and Cheng 2002). Other than ayurvedic and medicinal properties *tejpat* is mainly used for spices. Leaves of this spice when crushed and added in different recipes produce aroma though the dried leaves are more aromatic. One mature tree can produce 10-20 kg dry leaves and the leaves contain 0.2-0.4% essential oil (Lamichhane and Karna 2010; Nabavi *et al.*, 2015). Dried seeds of tejpat with honey or sugar are a common

household medicine that is usually used for treating the children suffering from cough or dysentery (Sundriyal *et al*., 2004). Indian bay leaves contain essential oil (*tejpat* oil) which can be extracted by using different distillation processes that can be helpful for using as carminative, anti-flatulent, diuretic, and can be used against different cardiac disorders (Showkat *et al*., 2004). Major components of Indian bay leaves are *a*-pinene, camphene, myrcene, limonene, eugenol, p-cymene, methyl eugenol, eugenol acetate and methyl ether of eugenol (Smith *et al*., 2002; Saino *et al*., 2003). Among them eugenol (4-hydroxy-3-methoxy allylbenzene) is the main component which can be found in more proportion in the cinnamon oil (Fischer and Dengler 1990; Dighe *et al.*, 2005). In Northern India this three veined spice leaf is very popular for its fragrance and in Kashmir it is used as a substitute of betel leaves. Detailed information regarding the production and productivity of Indian bay leaves is lacking. During the year 2018 and 2019 the total production of Indian bay leaf was 5 thousand tons (Anonymous, 2019). Important *tejpat* producing states are Arunachal Pradesh, Uttaranchal, Himachal Pradesh, Assam, Meghalaya, Mizoram, Sikkim and West Bengal. There is no specific information regarding the production and area of *tejpat* in West Bengal. However, the main bay leaf growing pocket of this state is residing in the Uttar Dinajpur district. Hemtabad is the main growing as well as exporting place of the spice crop in this district. Foliage is the main economic portion of this spice tree hence feeding injury as well as discoloration causes direct loss of total marketable leaf yield. Insects and pathogens are responsible for menacing the quality production of bay leaves mainly. Sometimes the disease caused by different pathogens becomes the reason of losing the aroma and fragrance of the bay leaves. Several insects rely on this tree for their survival and reproduction and under those consequences they inflict considerable damage to the crop. Insects like leaf miner, chafer beetle, root grub and different gall forming organisms are the most common pests. The leaf galls are mainly induced by different species of mites, aphids, gall midges and gall wasps (Royer and Arnold 1914). Besides insects, several diseases have been reported from bay leaf plantations in South East Asia, among them one of the important one is *Colletotrichium gloeosporioides* induced leaf spot (Rov *et al*., 1976) and another one is leaf blight caused by *Glomerella cingulata* (Khan and Hossain 1985). The other diseases reported from cinnamon are rust caused by *Aecidium cinnamomi* (Goswami and Bhattacharjee 1973), grey leaf spot/ blight caused by *Pestalotia cinnamomi* (Anonymous, 1996), stripe canker caused by *Phytopthora cinnamomi* (Rands, 1922), pink disease caused by *Corticium saimonicolor* (Weiss, 2002) and brown root rot caused by *Phellinus iamaensis*. It was reported by some workers that leaf blight caused by *Pestalotia palmarum* caused 90 % leaf damage in India (Karunakaran *et al*., 1993). The major insect pests and diseases of this tree spice are described below in details.

Important insect pests of Indian bay leaf:

— Common mime/ Cinnamon butterfly (*Chilasa clytia* Lankeswara, Moore): This butterfly is a large swallowtail without any tail which is the common features of other swallowtail butterflies. Many of them have the potential to become a serious pest in the young plantation. Adult female lays spherical, waxy and orange yellow eggs singly on the both side of tender leaves. Velvety black or dark green larvae with white patches feed on reddish tender leaves and slightly mature light green leaves. Their feeding may results in complete defoliation leaving only the main veins only. Larval period varies from 15-18 days. Pupae are cylindrical in shape and camouflaged like dry twigs and attached themselves in the branches. Pupal period may extend up to 13-17 days (Revathy and Mathew 2014). They are mostly abundant during the monsoon months (Bell, 1912).

There are other papillionid caterpillars also reported for damaging the tender leaves *viz.*, common blue bottle (*Graphium sarpedon* Teredon), tailed jay (*Graphium agememnon*), common jay (*Graphium doson* Doson). Early instar caterpillars are smoky in color with spines (Fig. 1 & 2) and upon disturbance or threat they elicit their osmeteria like other papillionid caterpillars. They devour the tender foliage by remaining under side of the leaves but after maturity they move upper side and feed near the main veins.

Management:

- Hand picking and destruction of larvae are beneficial.
- Different botanicals and biopesticides like Azadirachtin 1 EC @ 1 ml/ l, Neem oil 2%, NSKE 5 %, *Beauveria bassiana* 1×10^8 CFU/ ml and *Metarhizium anisopliae* 1×10^8 CFU/ ml can be used.
- Different systemic insecticides like Imidacloprid 17.8 SL (0.005%), Acetamiprid 20 SP (0.04%) can be used during the tender leaf stage.
- The caterpillars are parasitized by different parasitoids like *Telenomus remus, Apanteles papilionis*, *Apanteles* sp. and *Bracon hebetor* (Krishnamurthy and Singh, 1988).
- In case of heavy infestation, when the plantation is with newly emerged leaf, any one of the following insecticides can be applied *viz*., Spinosad 45 SC @ 1.25 ml/ l, Chlorfenapyr 5 SG @ 1 g/ l (Haque *et al*., 2019), Novaluron 10 EC (0.01%), Emamectin benzoate 5 SG (Murthy *et al*., 2009), Quinalphos 25 EC 2 ml/ l or Chlorpyriphos 20 EC 2 ml/ l of water (Singh and Singh, 2020).

— Leaf miner (*Conopomorpha civica* Mayr., *Phyllocnistis chrysophthalma* Meyer, *Acrocercops* spp.): These lepidopteran pests reported by several authors (Butani, 1983; Devashayam and Koya 1993; Anandaraj *et al.*, 2001) and belong to the leaf miner family Gracillaridae. They are tiny moths with silvery scales. They lay their minute flat eggs on the lower

surface of tender bay leaves which are whitish green in color. The larva is also pale greenish in color and mines in between the lower and upper epidermis (Fig. 3). In case of heavy infestation 4-5 larvae with respective mines can be found in a single leaf. Mining damage caused by the larvae results in irregular blister like patches in the leaf (Fig. 4). Upon maturity the larva moves toward the leaf edges and folds the leaf corner and pupate inside it (Fig. 5). When the severely mined leaves mature then irregular brown patches develop on the upper surface of leaf and the mined area becomes dried up and the leaves are appeared as blighted. The leaf miners not only damage the leaf, injury caused by them also serve as an entry point of the fungal pathogen and the damaged leaves ultimately end up with leaf blight disease which results in losing of the aroma of the leaf.

Management:

- Pruning of heavily infested leaves is useful.
- When the new flashes of leaves arrive then protective spray should be given.
- Pest can be monitored by installing pheromone traps @ 4-5/ acre. The lure should be changed at 2-3 weeks interval.
- Natural enemies of leaf miners are parasitic *Ageniaspis citricola*, *Citrastichus phyllocnistoides*.
- Soil application of Imidacloprid in young plantations provides better control which may provide leaf miner control up to 8 weeks.
- Foliar spray of Monocrotophos @ 1.5 ml/ l or Quinalphos 2 ml/ l alternatively also provides better control.
- Due to the presence of the larvae inside the mine, contact insecticides can't control the larvae properly so that the insecticide like Dimethoate 30 EC, Profenofos 50 EC, Monocrotophos 36 WSC, Acephate 75 SP or Imidacloprid 200 SL can be applied at recommended doses (Jayaraj and Murali Baskaran 2012). Certain chemicals like cyantraniliprole 10.26 OD @ 60g a.i. ha^{-1} and thiamethoxam + lambda cyhalothrin 9.5 ZC @ 27.5 g a.i. ha^{-1} are very much effective for controlling the leaf miners (Prakash *et al*., 2021).

— Chafer beetle (*Popillia complanata* Newman): The adult Scarabid beetles are observed in the field during August-September. The chafer beetles are brownish in color and generally observed in the plantation during evening (Fig. 7 & 8). They generally prefer the mature leaves for feeding and their feeding results in large irregular holes (Fig. 6). Because of their feeding marketable leaf yield is severely reduced. Grub of these beetles feed on the cinnamon roots. They pupate inside the soil in an earthen cocoon. During daytime the beetles are not seen in the plantation, they appear during evening and continue feeding during the night. They continue feeding up to October.

Management:

- The grub can be killed by applying the insecticides like Chlorantraniliprole in the soil.
- Monocrotophos @ 1.5 ml or Quinalphos 2 ml/ l can be applied for managing the adult beetles. They spray should be given during evening hour because the beetles have nocturnal feeding habit.
- The adult beetles can be collected by trapping them with the help of light trap, lantern or petromax during night at 7.30 - 8.30 pm for 7-10 days. The collected beetles can be destroyed or killed by drowning them in kerosinized water (Pal, 1977).
- *Anthia sexguttata* is the naturally occurring predators of these beetles (Kalra and Kulshreshtha 1961).
- Different biopesticides containing the pathogen like *Bacillus cerus*, *B. thurigiensis*, *B. popilliae* etc. have been reported to cause the mortality of the grubs and *Metarrhizium anisopliae*, *Beauveria brassiana*, *Beauveria brongniartii* etc. have been observed to kill the adult beetles (Rao & Vijaylakshmi 1959; Shinde and Sharma 1971; Ranganathaiah, *et a1*., 1973).

— Gall mite (*Aceria doctersi*): These Eriophyid mites are phytophagous in nature which exclusively feed on the young leaves and their feeding induces gall formation. They form conical galls on the underside of the leaves, leaf stalks and tender stems. During sap sucking they produce several pouched galls on the leaves, inflorescence and tender stem of *C. tamala* which leads to severe distortion and subsequent drying of the infested leaves. As they inhabit inside the galls their control is very difficult.

Management:

- Regular monitoring of the plantation by checking the underside of the leaves for the presence of the mites is needed. In case of large trees damage is not so much severe so that chemical control is not needed rather than removing the infested twigs.
- Spraying of Abamectin 1.9% EC @ 0.5-0.75 ml/ l or Bifenthrin @ 1-1.5 ml/ l of water may prevent the initial mite infestation.
- Conservation of natural enemies like coccinelid beetles, *Brumoides suturalis*, *Jauravia soror*, *Scymnus gracilis*, satphylinid beetle *Liophaena gracilipes*, *Somatium oviformis*, thrips *Scolothrips indicus*, anthocorid bug *Orius tantillus*, lygaeid bug *Geocoris sp.* and other predatory mites like *Amblyseius largoensis*, *A. swirskii*, *Neoseiulus longispinosus*, *N. cucumeis*, *Euseius ovalis*, *Phytoseiulus persimilis* etc. is helpful.
- Fungal pathogen *Verticillium lecanii* @ 5 ml/ l, *Beauveria bassiana* @ 2-3 g/ l or *Hirsutella thompsoni* @ 3 g/ l of water may be applied.

— Cinnamon shoot and leaf webber (*Sorolopha archimedias* Meyrick): This Tortricid insect is a pest of minor importance. They infest the plantation with newly emerged leaves and fold the tender shoot and leaves by making web and feed inside the web. *Goniozus* sp. was found to parasitize the larvae. The pest can be managed by the application of Quinalphos 25 EC @ 2ml/ l of water.

Important diseases of Indian bay leaf

— Leaf spot and dieback: This disease is caused by *Colletotrichum gloesporioides* (Rov *et al*., 1976) and may occur in every stages of the tree. In case of seedlings, small irregular brownish specks are developed on the leaves. After that it enlarges and covers the leaf lamina which causes drying of the leaves. In further stage they also spread in the stem and cause drying of stem from tip and spread downward which initiates the typical dieback symptom. In mature plants and trees, small brown blackish spots generate and after some period the spots coalesces and form irregular brown blotches. Under favorable condition the necrotic lesions may cover more than half of the leaves. The spots mature and start covering the leaf lamina and become papery white with reddish brown borders (Fig. 14). Inside the spot dark brown concentric zone is formed during the alternating wet and dry spell. Dark brown demarcating band is developed at the junction of healthy tissue and diseased tissue which is the most common symptom of this disease. During the later stage the pathogen produces its fruiting body acervuli which can be seen at the central region of the necrotic spot as black raised dots.

Management:

- Use of disease free seedlings and planting materials is recommended.
- Upon detecting the disease the infested twigs, leaves and other parts should be collected and burned.
- After harvesting the leaves and pruning of the twigs, copper based fungicides can be pasted in the cut portion.
- Wider spacing prevents disease spread as well as more sunlight can reach inside the canopy so that quality and quantity of leaf is more.
- Different bacterial bio-agents like *Bacillus subtilis*, *Streptomyces* sp. etc. are known for controlling the leaf spot pathogen.
- Copper fungicides are the best for controlling the disease.
- Weather based fungicide application is more helpful for preventing severe disease incidence. The pathogen is more active when the prevailing temperature is 24-28 °C with high relative humidity (Silva and Michereff 2013). Based on the prevailing condition fungicide can be sprayed in the plantation.
- Fungicides like Bordeaux mixture (5:5:50), Copper oxychloride (0.3%), combination of Mancozeb (0.25%) and Carbendazim (0.1%), Chlorothalonil 75% WP or Thiophanate-methyl 70% WP can be applied at 14 days interval for managing this foliar disease . Some workers have been reported that Propiconazole 25EC and combination fungicides, Carbendazim 12 % + Mancozeb 63% WP and Trifloxystrobin 25 % + Tebuconazole 55 % WP can be used for 100 % suppression of the pathogen (Divya *et al*., 2022).

— Grey leaf spot or blight: This disease is initiated by fungal pathogens *viz.*, *Pestalotia palmarum* and *Pestalotia cinnamomi*. Symptom of this disease appears as a small yellowish brown spot on the leaf lamina later it enlarges and turns into grey patch with dark brown margin (Fig. 12 & 13). Size of the necrotic patches varies from 14 to 42 mm. As the disease progresses, the size of lesion increases and a huge portion of leaf dries up and blown away by the wind. Disease infestation results in loss of aroma of the leaves. This fungus also produces black dot like acervuli (Fig. 11) on the upper surface of the infested leaf by which the pathogen overwinters in the plant debris. The disease can cause severe damage and defoliation.

Management:

- Use of disease free planting material is advocated.
- Infected portion and all the fallen leaves and plant debris should be collected and destroyed and the orchard should be kept clean.
- Drainage system should be improved.
- It was found that application of Chlorine containing compounds like KCl or NaCl induces seeding growth and increases resistance against *Pestalotia spp.* (Abad and Blancaver 1975; Alonzo and Palomar, 1980).
- Top dressing with potassium fertilizer and systemic fungicides reduces the disease incidence.
- Different biocontrol agent like *Trichoderma viride*, *Gliocladium* spp. and *Pseudomonas* spp. can control the pathogen.
- The disease is severe where potassium is deficient and high application of nitrogenous fertilizer favors the disease so that balanced application of potassium and nitrogen fertilizer will be helpful.
- Regular application of potassium chloride will reduce the disease (Palomar and Betonio 1982).
- Optimum temperature for the growth of pathogen is 25 °C (Bhuiyan *et al*., 2021); continuous rain for 4-5 days along with strong wind is favorable for disease development (Athira, 2017). Based on this type of weather condition fungicidal application can be given.
- Different fungicides effective against this disease are Carbendazim + Mancozeb (0.2 % @ 2.0 g/ l), Kresoxim methyl (0.1 % @ 1.0 ml/ l), Copper oxychloride 50% WP (2.0 g/ l), 1% Bordeaux mixture, Propiconazole 0.3% etc.

— Bark canker: The disease is caused by the fungal pathogen *Phytophthora cinnamomi*. Disease symptoms initiate with the development of vertical necrotic stripes on the stems of the affected trees. The canker stripes are sunken and the canker zones are separated by the healthy portion by a black line. The stripes are 1-5 cm in length. The favorable temperature for the development of the pathogen is 24-28ºC. The disease can be managed by the application of Sulphur in soil.

Fig. 1. Larva of Tailed jay.

Fig. 2. Leaf damage caused by Tailed jay.

Fig. 3 (a & b). Leaf miner damage in newly emerged leaves.

Fig. 4. Heavy damage by leaf miner.

Fig. 5. Pupa and larvae of leaf miner.

Fig. 6 (a, b & c). Damage caused by chafer beetle in bay leaf plantation.

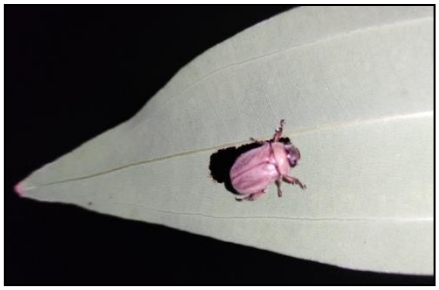

Fig. 7. Adult chafer beetle during night.

Fig. 8. Mating of adult chafer beetle.

Fig. 9. Whitefly infesting tender bay leaf.

Fig. 10. Leaf folder damaging bay leaf.

Fig. 11. Acervuli in Grey blight disease.

Fig. 12. Leaf infected by Grey blight disease.

Fig. 13 (a & b). Grey leaf blight symptom on bay leaf plant.

Fig. 14 (a & b). Upper and lower side of leaf infected by *Colletotrichum gloesporioides*.

CONCLUSION & FUTURE SCOPE

Studies on the seasonal incidence of the insect pests and diseases as well as their natural enemies present in bay leaf ecosystem in relation to the prevalent weather parameters can be done throughout the crop growing regions. Further investigation can be done to find out the best strategies for integrated pest management (IPM) and integrated disease management (IDM) for this tree spice.

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Conflict of Interest. None.

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