International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 9; Issue 04 (B); April 2020; Page No.21868-21872
DOI: http://dx.doi.org/10.24327/ijcar.2020.21872.4305

Research Article

MANGO RED BANDED CATERPILLAR, AUTOCHARIS ALBIZONALIS HAMPSON,A DESTRUCTIVE INSECT PEST OF MANGO ORCHARDS AT UPPER GANGETIC PLAINS OF WEST BENGAL: A COMPREHENSIVE ANALYSIS

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A R T I C L E I N F O

Article History:
Received 12th January, 2020
Received in revised form 23rd February, 2020
Accepted 7th March, 2020
Published online 28th April, 2020

Key words:

Red banded caterpillar, Mango ,Climatic parameter, Synthetic insecticides, Sticky bands

A B S T R A C T

Mango red banded caterpillar (MRBC), *Autocharis albizonalis* (Hampson) is one of the destructive pests of mango in orchards. This pest attacked mango fruit starting from marble shaped until to fruit maturity. Damage to mango fruits is insurmountable. Characteristic red and white alternative circular bands were found on the larval body. Larval stage of *A. albizonalis* was first found in March and then the highest number of population was observed in April and that was persistent up to June. MRBC fed on the mango pulp and made tunnel to reach seed. Climatic parameters such as temperature, relative humidity and rainfall variably influence the incidence of the caterpillar. *Himsagar, Arka Anmol, Prabha Sankhar* and *Amrapali* are respectively more susceptible varieties that were heavily affected by this insect pest. Synthetic insecticides, sticky bands, pheromone trap, and the application of egg parasitoids like *Trichogramma chilonis* and *T. chilotraeae* (Trichogrammatidae) are adopted to control the pest population.

INTRODUCTION

Mango, *Mangifera indica* Lin. (Family: Anacardiaceae) is the important orchard fruit of Asia and is widely distributed all over the world.Mango has been cultivated for more than 4000 year due to its nutritive value, taste and attractive fragrance. Mango growing states of India were primarily Andhra Pradesh, Karnataka, Telangana, Bihar, Tamil Nadu, Maharashtra, West Bengal, Gujarat, Madhya Pradesh, Orissa and Kerala. Andhra Pradesh positions top in the list on the basis of area, production and productivity (Anonymous, 2015). India is the largest mango producing country in the world (Bhattacharyya, 2014). A number of insect and non-insect pests are responsible to underscore mango production. Kapadia (2003) identified 30 destructive insect pests which was very much serious for mango orchards. Tandon and Lai, (1977) and subsequently by Tandon and Srivastava (1982) had enlisted about 260 insect species which encompassed both major and minor pests in Pakistan. A new mango fruit borer, Tirathabamundella was identified by Bhumannavar and Jacov (1989) from Andaman and Nicobar islands of India. MRBC was identified by Jha and Sarkar (1991) in the different orchards of Malda and Murshidabad Distict of West Bengal and now-a-days, this pest is regarded as alarming pest in some parts of India.

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Background: Mango red banded caterpillar (MRBC) infests mango fruit of different stages and renders damage to both pulp and seed. These caterpillars are mostly observed in South-East Asia including Vietnam, China, Papua New Guinea, Indonesia and north-east India, Philippines except in Burma (Mukherjee, 1997). Extent of infestation is about 40-55% (Golez,1991). MRBC also infests to *M. minor,* a wild fibrous mango that was recorded from Papua New Guinea and Boueaburmanica in Thailand (Tenakanai *et al*., 2006). In West Bengal, India the pest was prominently present in mango producing area. Infestation of fruit borer was also recorded from Puri District of Orissa, India (Sengupta and Behura,1955).

Life Cycle*:* Life cycle of MRBC comprises of four stages. However depending on the agro-climatic conditions the pattern of life cycle differs considerably.

Egg: Mating occurs within 1-3 days after emergence of females (Gibb *et al*.,2007). Mature female adults generally laid eggs on the fruits in order to protect it from sun light. However some eggs were laid during day time (Golez, 1991). Oviposition by female adult was generally found at the base of the peduncle covered with dried sepals (Krull and Basedow, 2006). Occasionally eggs were observed on other parts of the peduncle, non fruiting vegetative branches and base of the other fruits adjacent to mango orchards. The deposited eggs are sometimes covered by the sepals (Tenakanai *et al*., 2006).Sengupta and Behura (1955) had recorded that the eggs were white in colour and was generally observed near the

distal end of the fruit or fruit apex. Pheromone helped in mating process. Eggs are usually oval in shape measuring 0.3 - 0.5 mm and mostly covered by a waxy layer. Freshly laid eggs are white in colour but after 2-3 days the colour turn into pink (Krull, 2004). The period of oviposition covers the entire fruit maturation period (Golez, 1991). Golez (1991) from Philippines had further noted that oviposition mostly occured in masses at the fruit apex to give protection particularly from natural enemies and rain fall**.** Incubation and pre-oviposition period was in average 2-3 days and 1.5-2.5 days respectively. After hatching MRBC larva usually penetrated into the mango fruits preferably at marble size condition of mango fruit.

Larva: Eggs hatched into destructive larval stage. MRBC larva had characteristic white and red bands on the body **(Fig.1a).** Head is usually brown or black in colour. Golez (1991) had reported that MRBC had collectively five larval instars. First instar larva was recorded to feed on fruit pulp at the apex (Golez,1991; Waterhouse, 1998). Krull and Basedow (2006) had noted that MRBC fed on the fruit pulp and subsequently make a hole in the lower part of the fruit. Mango pulp was generally fed by first two larval stages but rest of the instars mostly feed on the seed (Waterhouse, 1998). Occasionally 11 larval instars were recorded. Further in some cases only one larval stage was also observed in one fruit (Waterhouse, 1998). The larvae were found to migrate from one fruit to another by making 'silk thread', if there was a inter-specific competition for food (Golez ,1991). Fenner (1997) had reported that full grown MRBC caterpillar was about 2cm in length. Sengupta and Behura (1955), on the other hand, had reported that MRBC was about 2.5cm in length. Prominent red and white inter-segmental streaks were found in fully grown caterpillars with hairy dorso-ventral demarcation. Characteristically, 1st instar larva was cylindrical in shape and brown coloured with about 2 days of developmental period. 2nd instar larva was brownish yellow in colour with about 2-3days of developmental period (Sahoo *et al*.,2004). 3rd instar larva has a brown head with inter-segmental band (Sahoo *et al.*, 2004). About 3 days was required for the development of 3rd instar larva. 4th instar larva was almost similar to 3rd instar larva in consideration of external morphology. The duration of development was of about 2-3days (Sahoo *et al*.,2004). 5th instar larva had dark brown head with sclerotized mandibles,3 pairs of thoracic legs and 5 pairs of abdominal legs. Duration of development was about 2 days (Sahoo *et al*.,2004).

Pupa: Pupation occurred when the larva leaves the mango fruit. At pre-pupal stage the larva was usually blue-green in colour (Trinca and Foulis, 2002). Krull and Basedow (2006) had reported that pupation occurred in the bark of the trunks of infested tree at the end of mango season. In Papua New Guinea, Gibb *et al*. (2006) had observed that during November many dormant stages of larva were observed under the bark of mango trees. During pupation, the larva made a hole in deep crevices into the bark.

Mature moths were found to fly away from the pupation sites (Sengupta and Behura,1955). Krull,(2004) on the other hand had noted that mango tree was the only host of this pests in Papua New Guinea as the caterpillar had not form any exit hole in the fruit. Zeheruddin and Sujatha (2002) had observed that this pest required one month to complete life cycle and covered about 3 to 4 generations. Pupae were dark brown in colour with compound eye, antennae and legs. Leefmans and Van der Vecht (1930) found that this pupae had about11-12 long spun around itself within the soil or bark. Mature pupae were dark brown in colour (Tenakanai *et al.* 2006).

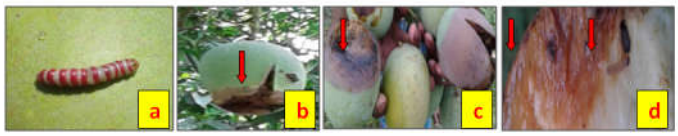

Fig 1 Mango red banded caterpillar at different sites (a) adult mango red banded caterpillar (b) mango red banded caterpillar infesting growing mango (c)mango red banded caterpillar infesting mature mango (d)mango red banded caterpillar causing tissue necrosis to mango flesh (arrow indicates the point of interest).

Adult*:* Butani (1993) had recorded that adults were brown coloured with wing span of 20 -24mm. Mature male had tubular blunt body covered with black brown hair and a brown snout in head (Golez 1991).The adult moth had characteristic antennae. Thorax is brown in colour while wings are ashy wood in colour. Brush like dark brown hairs are noted on the lower side of the tibia tarsus of male only. Mesothoracic legs are without hairs (Bhattacharyya, 2014). Mature adult moth made their exit after 12-15 days of pupation. Bhattacharyya (2014) had noted that time of emergence of adult from pupa was about at 8.00 to 8.15 pm. Golez (1991) reported that adults were usually nocturnal in habit and are generally observed under the tree leave during day time. Sujatha and Zaheruddeen (2002) reported that adult moths were very sluggish in nature and could fly a short distance.

Symptoms of attack: Mostly MRBC attacks all of the growth stages of mango fruits. The caterpillar fed on the mango pulp and seeds. Early instars generally prefer small seed while the later instars preferred larger fruits. Sahoo and Jha (2009) has recorded that MRBC fed on seed in laboratory compared to mango pulp while early instars usually had a preference on pea shaped fruit. First and second instar larvae actually made a hole to reach the seeds (Fig.1b).. Larvae consumes the inner content of the mango seed. Secondary infestation following the infestation by caterpillar occurs by the fungi and bacteria which results in pre-mature falling of mango fruit (Fig.1c). Marble sized mango fruits are comparatively damaged (Fig.1d). Krull (2004) had reported that MRBC attacked many marble sized fruit to obtain same amount of food that could be provided by larger fruits. All the larval instars fed on mango fruit but MRBC generally prefers to lay egg in marble sized fruits (Krull, 2004). Zaheruddeen and Sujatha (1993) found that MRBC attacked the mango fruit in the different developing stages. Gibb et al.(2007) recorded that mature pest population were found in peak number during the month of September and October in Australia which was also also similar to the observation of Yarrow and Chandler (2007).

In West Bengal, MRBC damages mango fruits at two stages. After hatching MRBC enters into the pulp and makes a tunnel towards to reach the seed (Fig.1a and Fig.1b). Second stage of infestation occurs in marble shaped mango. Mango seeds are usually fed by these larvae. At both the stages the 'entry hole' was observed due to the accumulation of faecal matter of the larva. Early larval instar prefers small fruit size while the later prefers medium sized fruits. Royer (2009) from Australia had reported that the fruit borer, *D. sublimbalis* infested mango pulp and seeds. Fruits infested by MRBC are not suitable for human consumption due to oozing of the mango pulp. Golez (1991) had recorded that infestation of this caterpillar was observed at about 45-55 days after flower formation and lasted

up to fruit maturation. Medium sized mango fruits were heavily affected by this caterpillar. Secondary infection by bacteria and fungi was noted that leaded to the necrosis of mango pulp tissue. When infested artificially, the caterpillar took about 507 minutes to reach the site of 'entry hole' in a mango fruit. Laboratory trial indicated that the caterpillars preferred to feed on seeds than the mango pulp (Sahoo *et al*., 2004). Cracking of fruits and fruit falling recurrently occurred due to heavy infestation.

Infection in the internal parts of mangoes were not seen from outside but when they are screened, defects were noted. Mangoes were screened through X-ray analysis and image found in computer monitor were then put into photographic plate to measure the extent of abnormalities. Length and breadth of affected mangoes were calculated by using centi-meter scale. Pixel and intensity based feature with grey level concurrence matrix feature helped in recognition and also in identification of the extent of damage. Maximum pixel density ensured the degree of damage to mango fruits. Extent of tissue necrosis was associated with the degree of damage to the mango **(Fig. 2)**.

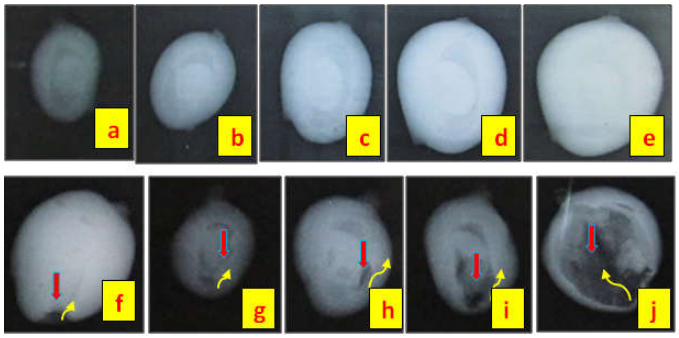

Fig 2 Pathway of penetration of MRBC in *Lakhanbhog* mango cultivar during the stage of development 1.(a-e): mango with no damage symptom that was considered as control. 2.(f-j):stages of tissue necrosis during the penetration of the caterpillar in mango (red arrow indicated the location of the larva, yellow arrow indicated the path of tissue necrosis)

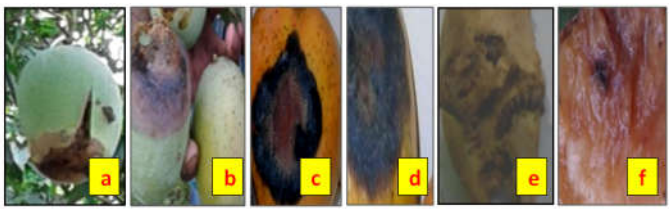

Fig 3 External damage symptom of *Lakhanbhog* mango cultivar (a) entry point of MRBC in to mango (b) tissue necrosis at point of entry (c) rotten issue at the entry point (d) tissue necrosis followed by fungal infestation (e) blackening of the mango tissue at the entry point (f) completely spoiled mango

At the entry point of the larva of MRBC in to the mango a greyish spot immediately appeared. The spot then turned in to black (Fig. 3a). Oozing of the mango flesh and fluid was noted from the damaged area (Fig. 3b). Fungal infestation then occurred that ultimately blacken tissue (Fig. 3c and Fig. 3d). Soon after penetration the larva bored in the mango flesh in order to migrate to the seed (Fig. 3e). The pulp pH was found crucial for such migration. The internal tissue adjacent to the migratory path of the larva turned red(Fig. 3f). Externally black patches appeared at point of larvae into mango.

Impact of agro-ecological factors on the infestation of MRBC: Ecological factors such as maximum temperature (Tmax), minimum temperature (Tmin), maximum relative humidity (RHmax), minimum relative humidity (RHmin) and (Rfall) rainfall at regional level influenced the extent of infestation of MRBC. Bhattacharya (2014) had recorded that MRBC attacked small sized mango during the month of March and April. Sahoo *et al.,* (2004) had noted somewhat similar observation. Sahoo and Jha (2009) observed that incidence of MRBC initiated from the early part of March and maximum infestation was noted at the later part of the March but peak infestation was recorded from the last week of April. Peak infestation of insect pest was found either in March or April according to Golez (1991).

Bhattacharya (2014) had observed that the periodicity of MRBC on sixteen mango cultivars during Feb-March of 2009-2010 when temperature, relative humidity were 29.04-42.48 ºC and 14-100% respectively with no record of rainfall. The pest population subsequently subsumed at the end of May when temperature, relative humidity and rainfall were 25.3-36.2 ºC, 63-97% 5.7 mm. respectively. Extent of damage was maximum (3.81%) at marble shaped fruit at the last week of March when Tmax and Tmin were 36.6 ºC and 16.9 ºC respectively. RH (%) was 31.4-98% at that time. Incidence of this pest was lowest at the 2nd week of May when temperature, relative humidity and rainfall were 22.8-38.4 ºC, 51.6-93% , 27.1 mm respectively.

Varietal Preference of MRBC: Sahoo and Jha (2009) had observed that *Gopalbhog* and *Rakhalbhog* mango variety were comparatively less affected by MRBC. Percentage of infestation (%) was very high in *Himsagar* variety. Relative varietal preferences of this caterpillar were Himsagar> *Kesar*> *Suvernerekha*> *Amrapali*> *Langra*> *Arka Anmol* in descending order out of the variety considered. MRBC were found to infest the mango fruits comparatively more that were in West direction compared to other directions (Bhattacharyya, 2014). Bhattacharyya (2014) further had noted that during 2010 the extent of infestation was ranked as *Himsagar* > *Prabhashankar*> *Neeluddin*> *Langra* > *Neeleshan*> *Neelgoa* (Bhattacharyya,2014). Further direction of infestation within a mango orchards was recorded as West>South>North> East in descending order. He further had observed that maximum infestation in *Himsagar* variety was noted in pulp and seed when total free amino acid were 0.045mg/kg and 0.167 mg/kg respectively. Lowest infestation in *Mallika* at marble shaped mango was noted when the total free amino acid was 1.032 mg/kg. The free amino acid content of mango pulp and seed showed negative correlation with the incidence of mango red banded caterpillar. Bhattacharyya (2018) reported that phenol content was one of the vital factors involving the infestation of Mango red banded caterpillar. Incidence of MRBC was inversely proportional with the pulp phenol content as 'peak population of MRBC was noted when phenol level was low in the mango variety *Himsagar* as reported by Bhattacharyya (2018) from West Bengal.

Control Measures: In Australia, synthetic pesticides such as thiacloprid (Calypso), Lorsban (chlorpyrifos), Supracide (methidathion) and Success (spinosad) were generally used to check MRBC. However out of all of the varieties, thiacloprid (Calypso) was very efficient to reduce the pest population. First instar of MRBC experiences very short time of exposure to synthetic insecticides as after hatching the larva bores into the fruit. Ovicides further are less effective as MRBC eggs as eggs were generally laid on the peduncle under dried sepals (Krull 2004).

As cultural control measure, sticky bands are wrapped around the mango trees to prevent MRBC caterpillar. Weaver ant, *Oecophylla smaragdina*, performs as natural enemy against MRBC in field condition as recorded by Krull and Basedow (2006) in Australia. Bagging of mango fruits with paper bags or towels was a good option to reduce the number of infestation (Krull, 2004). Pheromone trap was used to catch male moth in New Zealand and Papua New Guinea to interrupt mating (Gibb *et al*., 2007).

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As a part of biological control, *Trichogramma chilonis* and *T. chilotraeae* (Trichogrammatidae) were observed as potent egg parasites of MRBC in the Philippines (Golez,1991). *Trichogrammatidae* was found as effective predator to minimize lepidopteran pests population (Krull, 2004). *Trichogramma* wasps were applied successfully in Australia had recorded that the weaver ant, *Oecophylla smaragdina* was an abundant predator found in Australia .

CONCLUSION

MRBC attacks the mango fruit from pea shaped to maturity covering the entire fruit season. Caterpillars hatched from the eggs usually penetrate the mango pulp to reach the seed. Secondary infection occurred by the fungi and bacteria causes tissue necrosis to mango pulp resulting mango fruit unsuitable for human consumption. Synthetic pesticides, pheromone trapping, sticky bands, parasite on egg are very useful for reduction of pest numbers. Tmax, Tmin, RHmax and Rfall are the prime agro-ecological factors that are responsible for MRBC infestation.

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How to cite this article:

Ajoy Sarkar and Kaushik Chakraborty (2020) 'Mango Red Banded Caterpillar, Autocharis Albizonalis Hampson,A Destructive Insect Pest of Mango Orchards at Upper Gangetic Plains of West Bengal: A Comprehensive Analysis', *International Journal of Current Advanced Research,* 09(04), pp. 21868-21872.
DOI: http://dx.doi.org/10.24327/ijcar.2020.21872.4305

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