Testing the Relative Efficacies of Three Different Integrated Pest Management (IPM) Modules for Controlling Mango Mealy Bug (*Drosicha mangiferae* G.) at Malda, West Bengal

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**ABSTRACT**

**Background:** Mango mealy bug (*Drosicha mangiferae* G.) is a notorious pest of mango and when infestation reaches severity quantum fruit loss takes place. Control of this pest had been found to be impossible with conventional chemical pesticide spray. So, the urgent need is to find some non conventional management practices. Therefore, the current study was undertaken to test three different combinations of available pest management practices.

**Methods:** To test the efficacy of the three Integrated Pest Management Modules (IPM modules) control vs. treated trees were tagged and then mango mealy bug number found in inflorescence was counted. The difference in the number of mealy bug at the peak time infestation (12 SMW) in control vs. treated trees and fruit loss reduction in control vs. treated plants gave the idea about relative efficacy of the different modules.

**Result:** 99.46% of mango mealy bug number and 47.52% fruit drop reduction were achieved by adopting module I. Whereas up to 64.33% mealy bug and 22.84% fruit drop reduction was achieved by module II. The module III was found to be the most effective module and adoption of this module attained 54.72% fruit loss control and 97.10% mealy bug control.

**Key words:** Chemical practices, Cultural practices, Mango mealy bug (*Drosicha mangiferae*), Mango mealy bug IPM modules (MMBM), Mechanical practices, Non conventional practices.

**INTRODUCTION**

Control of mango mealy bug is a burning issue, universally as it is one of the major mango pest and according the extent of damage caused it ranks 2nd after mango hopper (Atwal, 1976). Further the extent of damage is region specific depending on mango cultivars, orchard management practices and agro-ecological conditions. Waxy coating over the mealy bug colony provides a cushion and that makes it difficult to control the pest with any kind of contact pesticide. Cultural, mechanical, biological and chemical methods of control have to be adapted in consideration of the regional necessity to prevent the yield loss. Insecticides, though used widely, have environmental constrains. Sensing the ground reality of the problem of mango mealy bug at Malda District of West Bengal a more realistic time-fitted mango-IPM with suggestive direction is required. Such schedule, will no doubt, will have to be ecologically viable, easily applicable and also economically feasible. However, mango growers generally rely on agro-chemicals of different newer brand to keep the fruit production stable without any concern to the agro-ecosystem. It had reported elsewhere that synthetic insecticides could not check mealy bug incidence effectively (Yousuf and Ashraf, 1987). Nevertheless, for instant management, mango growers apply huge amount of insecticides in the orchards to control this notorious pest (Lakra et al.1980, Suresh and Kabita, 2008, Karar et al. 2010). Problem of such quantum application of broad spectrum insecticides is multidimensional. Indiscriminate and over reliance on insecticide lead to of pest resistance and also augments cost of mango production (Yousuf and Ashraf, 1987).

So, injudicious application of pesticide also increases human health risk due to direct or indirect exposure and needed to be addressed. In this scenario, it becomes imperative to look for an effective alternative. Further farmer in general, expend a considerable amount of money in ‘agro-chemicals’ for agricultural production (Schnitkey, 2018). In this back drop revalidation of the existing mango-IPM practice with necessary alteration of the available ‘package of practices’ for orchard management at regional level at Malda, West Bengal is urgently required. Such effort will minimize the use of ‘agro-chemicals’ with suggestive forecast of the pest population and also assure the nutritional quality of mango without the application of any supplementary resources.
MATERIALS AND METHODS

The experiment

In 2019, three orchards of Kaligram and Ramnagar, Malda were selected having the history of mealy bug infestation to test the relative superiority of three different modules of IPM. Three trees were selected and treated as per each IPM module and one tree two trees in different orchards were selected where no treatment was given and it was considered as control in different modules and ten inflorescences/panicle of control and test trees were tagged with white and red tape. To check the efficacy of IPM module adopted, the mealy bug number /inflorescence and number of fruits at the onset (9th SMW) and unripe mature stage (16th SMW) were counted as mealy bug can cause fruit damage up to this unripe mature stage of mango. The methodology of mealy bug counting and mango yield estimation is depicted in Fig 1.

Calculation of direct damage

The % of mealy bug reduction at peak time was calculated as:

\[
\text{Number of mealybug/panicle in control tree - Number of mealybug/panicle in treated tree} \\
\text{Number of mealybug in control trees} \times 100
\]

The % fruit loss was quantified by:

\[
\text{Number of fruit / in florescence in initial fruit setting stage-Number of fruit/panicle in unripe mature stage} \\
\text{Number of fruit / in florescence in initial fruit setting stage} \times 100
\]

So, fruit loss reduction is calculated as:

\[
\text{Fruit loss reduction = fruit loss % in control - fruit loss % in treatment.}
\]

The protocol and components of mango-IPM

Mango-IPM modules have three components (i) cultural practice, (ii) mechanical practice and (iii) chemical practice. The ‘practice’ under each component varies in consideration of concerned IPM schedule (Table 1 and Fig 2, Fig 3, Fig 4). Different combinations of these practices were used in three modules of IPM. The rationale of the mango-IPM protocol is to reduce the injudicious application of the field fertilizer and insecticide without any compromise to the final yield generation.

Specific strategies were taken for the execution of particular orchard management practice.

Removal of the alternative weeds

In the year 2019, removal of weeds was done. The main weed which acted as alternative host for mango mealy bug was observed to be Clerodendrum spp. and emphasis was given to remove this from the orchard floor.

Mud plustering

A plastic sheet of 1 meter wide and 5 meter in length were tied in the main tree trunk so that mature female were prevented from descending down to lay eggs in the soil surrounding the tree trunk and root system.

Plastic mounding

Mounds were made on the plastic sheet around the trunk with the materials present under the tree like dried leaves, weeds, mud, grass, debris and small dried branches up to 0.2 meter high in the first week of April, 2018 to trap the gravid females falling from the trees and effect of this practice was observed in 2019.

Four such mounds were formed in the base of the trees in four different directions, East, West, North and South within the orchard.

Fig 1: Methodology of mealy bug counting and fruit loss estimation in control vs. IPM treated trees(a) twig tagging of control tree with white cloth, (b) twig tagging of treated tree with red rope, (c) mealy bug in inflorescence of control tree, (d) mealy bug in inflorescence of treated tree, (e) fruits in the fruit setting stage in control tree, (f) fruits in fruit setting stage in treated trees, (g) unripe mature fruit in twigs of control tree, (h) unripe mature fruits in twigs of treated trees(arrow indicates the point of interest).
Table 1: Different combinations of management practices adopted in three mango-IPM modules to curb mango mealy bug population.

| Components          | IPM modules          |          |
|---------------------|----------------------|----------|
|                     | MMBM1                | MMBM2    | MMBM3          |
| Cultural practice   | Ploughing in November to expose MMB eggs to sun’s heat. Flooding of orchards with water. | Recurrent weed removal around the orchard | Recurrent removal of weeds especially Clerodendrum spp which acts as the alternative host of MMB, Employment of greasy band fastening |
| Mechanical practice | 0.5 meter wide mud plastering and plastic banding with liquid grease along the middle of the plastic band of the tree trunk at 3 about 0 cm. above the ground in the 3rd week of January to restrict upward migration of MMB nymph along the tree trunk. Aggregated nymphs below the band were killed with 2% profenophos. | Recurrent removal of weeds especially Clerodendrum spp which acts as the alternative host of MMB, Employment of greasy band fastening | 1 meter wide and 5 meter length plastic sheet of were spread around the trunk to stop the entry of gravid females in the root of the host plant. Mounds were made on the plastic sheet around the trunk with dried leaves, weeds, mud, grass, debris and small dried branches up to 0.2 meter high in the first week of April. For the female MMB that falls directly to the ground to search for suitable hibernation place, four mounds were made under the tree with same materials in four different directions, East, West, North and South within the orchard. |
| Chemical Practice   | Infested trees were sprayed once with 3g/L of Beauveria bassiana in the 2nd week of February with pump operated sprayer (3-4 liter/tree) | Soil around the trees was mixed with 2% fenvelerate dust at the rate of 200 g/tree during first week of February. Tobacco-water with added detergent was sprayed in the 2nd week of February. Then 0.5% dimethoate was applied in 1st week of March. In the same tree 2% profenophos was sprayed in 1st week of April. | 1% imidachloroprid + 0.5% acephate was applied in the second week of February as 1st spray. 2% profenophos was applied thereafter in the 2nd week of March. |
Fig 2: Cultural, mechanical and chemical management practices under MMBM1 mango-IPM module for MMB control (a) weed removal, (b) ploughing of orchard, (c) flooding of orchard, (d) mud plastering, (e) plastic banding to prevent the ascend of nymph, (f) Fungal pesticide formulation preparation, (g) spray of fungal pesticide.

Fig 3: Mechanical and chemical management practices under MMBM2 mango-IPM module for MMB control (a) Cledodendrum spp with mango mealy bug infestation, (b) removal of Cledodendrum spp. which is an important alternative host of MMB, (c) fenvalerate dusting in the soil around the trees, (d) digging the soil around the trees for dusting of fenvalerate, (e) grease banding, (f) tobacco water formulation, (g) insecticide spray.

Fig 4: Cultural, mechanical and chemical management practices under MMBM3 mango-IPM module for MMB control (a) Fastening the plastic band, (b) Grease application to the plastic band, (c) removal of weeds, (d) plastic sheet mound, (e) imidacloprid formulation preparation, (f) imidacloprid spray.
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Application of synthetic insecticide formulations
Soil around the trees was mixed with 2% fenvelarate dust and a dose of 200 g/tree was applied during first week of February in the treatment trees. Different combinations of chemical pesticides were also applied as foliar spray. Tobacco-water with added detergent was sprayed in the 2nd week of February. Then 0.5 % dimethoate was applied in 1st week of March. In the same tree 2 % profenophos was sprayed in 1st week of April.

Preparation of organic (herbal) insecticide formulations
100 g of tobacco dry leaf was placed in 50 liter of warm water. 50 drops of liquid soap was added to that warm water. Solution was kept for 30 minutes as such. Then the solution was filtered through cheese cloth into a bucket or bin with a lid. Then it was stored for the spray.

The botanical formulations were prepared in the Department of Zoology of Gour Banga University, Malda.

RESULTS AND DISCUSSION
Relative superiority of mango mealy bug IPM module 1 (MMBM1)
The peak infestation of mango mealy bug at about was noted 12 SMW with 36.4 MMB individuals/panicle in the untreated tree (control). While there was only 0.13 MMB individuals/panicle in the treated trees (Fig 5). So, the extent of mealy bug reduction was 96.46 %. At fruit setting stage 7.1 fruit/inflorescence was noted during 9 SMW and that was subsequently reduced to 0.9 fruit/inflorescence in control tree. The percentage of fruit drop in control plant was about 87.32 %. Percentage of fruit drop in treated plant was 39.80 % where 5.2/panicle and 3.13 cumulative average fruit number/panicle at fruit setting stage and unripe mature stage respectively. Therefore 47.52 % fruit loss reduction due to adoption of this module (MMBM1) was noted. MMBM1 can effectively check MMB number by 99.64 % and fruit yield loss by 47.62 % (Fig 6). So it can be concluded that the extent of fruit drop in treated tree (T1, T2 and T3) was significantly lower.

Relative superiority of mango mealy bug IPM module 2 (MMBM2)
In MMBM2, the peak infestation of MMB was noted at about 12 SMW with 44.6 mealy bugs/panicle in the untreated (control) tree. While in treated tree only 15.3 MMB individuals/panicle was noted. So, the percentage of mango mealy bug reduction was 65.69 % (Fig 7). During fruit setting stage, the number of fruit/inflorescence at 9 SMW was 7.05 in the

![Fig 6: Number of fruits/inflorescence in MMBM module against control during 2019 fruit season.](image-url)
control trees and that gradually reduced to 2.50 fruit/inflorescence at unripe mature mango stage (Fig 8). So, the extent of fruit drop in control tree was 64.53% where 7.05 fruit number/inflorescence at fruit setting stage and 2.50 fruit number/inflorescence at unripe mature stage was noted. Similarly, extent of fruit drop in treated plant was 41.69% where 5.66 fruit number/inflorescence and 3.30 cumulative averages fruit number/inflorescence was noted at fruit setting stage and unripe mature stage respectively. Therefore, fruit loss reduction (%) of 22.84% and 65.69% control of MMBM2 was possible (Fig 8).

Relative superiority of mango mealy bug IPM module 3 (MMBM3)
Maximum infestation under MMBM3 module was noted at about 12 SMW with 49.45 MMB individuals/panicle in the untreated tree while only 1.43 individuals/panicle was noted in the treated trees (Fig 9). At about 9 SMW, during fruit setting stage, the number of fruits/inflorescence was calculated to be 3.85 in the control trees and it gradually reduced to become 0.45 till they become unripe mature. Whereas, in the treated trees the magnitude of fruit drop was found to be radically lower. The amount of fruit drops in

Fig 7: Numerical abundance of mealy bug/inflorescence in MMBM2 module against control during 2019 fruit season.

Fig 8: Number of fruits/inflorescence in MMBM2 module against control during 2019 fruit season.

Fig 9: Numerical abundance of mealy bug/inflorescence in MMBM3 module against control during 2019 fruit season.
control plant was 85.71% where, 3.85/inflorescence and 0.55/inflorescence are fruit number/inflorescence at fruit setting stage and unripe mature stage of mango respectively. Similarly, extent of fruit drop in treated plant was 30.99 % where, 3.13/inflorescence and 2.16 fruit number/inflorescence were the cumulative average fruit number/panicle at fruit setting and unripe mature stage respectively. Therefore, extent of control of fruit loss was 54.72%. Further 97.10 % control of MMB was also possible in MMBM3 module (Fig 10).

The comparison of cumulative population of MMB present in inflorescence of control vs. treated trees is depicted in the Table 2.

Out of the three alternative mango-IPM, MMBM3 was found to be the most effective practice to check population MMB by 97.10% or fruit drop by 54.72%. MMBM3 is an integration of mechanical, cultural and chemical practices offering maximum pest control. MMBM3 module consisted of cultural practice of plastic sheet mounding around the trees using straw, soil, fallen leaves, mechanical practice of

| SMW | C1   | T1   | C2   | T2   | C3   | T3   |
|-----|------|------|------|------|------|------|
| 5   | 14.3 | 14.0 | 30.8 | 29.66| 13.4 | 19.3 |
|     | (3.85)* | (3.81) | (5.59) | (5.49) | (3.73) | (4.45) |
| 6   | 15.6 | 10.23| 32.7 | 33.03| 13.2 | 9.73 |
|     | (4.01) | (3.28) | (5.76) | (5.79) | (3.70) | (3.20) |
| 7   | 17.2 | 6.56 | 41.6 | 30.3 | 13.4 | 3.93 |
|     | (4.21) | (2.66) | (6.49) | (5.55) | (3.73) | (2.10) |
| 8   | 20.4 | 4.36 | 43.9 | 28.23| 31.1 | 7.90 |
|     | (4.57) | (2.20) | (6.66) | (5.36) | (5.62) | (2.90) |
| 9   | 21.8 | 3.63 | 44.2 | 25.56| 35.4 | 2.70 |
|     | (4.72) | (2.03) | (6.69) | (5.10) | (5.99) | (1.79) |
| 10  | 23.5 | 1.76 | 32.9 | 20.16| 40.6 | 7.30 |
|     | (4.90) | (1.50) | (5.78) | (4.55) | (6.41) | (2.79) |
| 11  | 26.7 | 1.36 | 45.0 | 18.03| 43.0 | 3.36 |
|     | (5.22) | (1.36) | (6.75) | (4.30) | (6.60) | (1.96) |
| 12  | 36.4 | 1.30 | 48.2 | 15.3 | 49.1 | 1.43 |
|     | (6.07) | (1.34) | (6.98) | (3.97) | (7.04) | (1.39) |
| 13  | 22.9 | 0.60 | 37.5 | 12.36| 43.6 | 1.23 |
|     | (4.84) | (1.05) | (6.16) | (3.59) | (6.64) | (1.32) |
| 14  | 20.8 | 0.13 | 33.9 | 9.86 | 35.9 | 1.13 |
|     | (4.62) | (0.79) | (5.87) | (3.22) | (6.03) | (1.28) |
| 15  | 10.6 | 0.06 | 23.5 | 8.00 | 26.7 | 0.86 |
|     | (3.33) | (0.75) | (4.90) | (2.92) | (5.22) | (1.17) |
| 16  | 6.4  | 0.1  | 8.1  | 7.73 | 15.9 | 0.73 |
|     | (2.63) | (0.77) | (2.93) | (2.87) | (4.05) | (1.11) |

*Figure in the parenthesis is the square root transformed value. T1, T2 and T3 denote average pest number/panicle.
grease banding in the tree trunk and chemical practice as foliar spray of application imidacloprid and acephate. Present observation corroborates with the finding of others (Karar et al. 2009) where it had also been reported that plastic mounding together with grease banding and acetamiprid, a neonicotinoid spary is the best suitable method to curb MMB number. The present observation on mango-IPM module to control MMB number is in agreement with the findings of others (Bajwa and Gul, 2000) where somewhat similar technique had been adopted like egg destruction, tree banding and insecticide application to control mealy bug on Paulownia spp.

In MMBM1 combination of (i) cultural practices like ploughing and recurrent flooding of orchard to kill MMB eggs, (ii) mechanical practice like grease banding and weed removal and (iii) chemical practice like the application of fungal pesticide was also found to be significantly effective to control mealy bug by 96.46% and fruit drop by 39.80 % respectively. Such observation is in agreement with others where it has also reported that destruction of eggs, tree banding and application of insecticide is the most successful control strategy to check D.stebbingi population( Gul et al.1997). Present study is also partially supported by other finding (Tandon and Verghese, 1985) where it had also been noticed that combination of various cultural, mechanical and chemical practices like summer ploughing to expose egg, weed removal, fastening of alkathene band, natural enemy conservation and application of neem seed extract or garlic oil were effective method to control Drosichas pp. and Rastrococcus iceryoides in mango orchards.

In the module MMBM2 the incorporation of only mechanical and chemical practices were adopted. The extent of MMB reduction was 65.69 % and fruit drop was 22.84 % respectively and the value is least amongst all other combinations of management practices. Such observation is partially supported by the finding reported elsewhere (Karar et al. 2009) who also had reported that combination of mechanical and chemical practices could reduce MMB by 78.03 %. The present findings are in agreement with those of several other studies (Ali 1980, Lakra et al. 1980B, Anwar 1991, Jia et al. 2001, Ishaq et al. 2004) with marginal variation. So, it can be deciphered from the current finding that greater control of mango mealy bug and fruit drop reduction can be achieved by adopting III rd module (MMBM3) with a combination of cultural× mechanical× chemical practices and the immediate impact will be on mango production.

CONCLUSION
Out of all of the three modules, proper combination of cultural× mechanical× chemical management practices in module III when applied together yielded the best result with low MMB infestation and minimum fruit loss. Module III includes removal of alternative host especially Clerodendrum spp., employment of plastic grease band around the tree trunk, plastic mounding around the trees together with imidacloprid spray as chemical control device. So, implementation of this III rd IPM module combining cultural, mechanical and chemical practices should be propagated by mango farmers to achieve good control of MMB and also increase yield.

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