**ABSTRACT**

Mango, *Mangifera indica* (L.) is the important fruit crop in production in Nepal. *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae) is major monophagous insect pest which causes loss of both quantitative and qualitative value. To mitigate this problem, we designed and conducted experiment in Randomized Complete Block Design to evaluate effective insecticide against mango stone weevil on station and farmers orchard in two consecutive years at Sunsari and Dhapur districts. We sprayed five insecticides namely: azadirachtin, thiamethoxam, flubendiamide, lamda cyhalothrin and dimethoate in recommended doses on mango plant when the fruit was of pea size for four times at ten days interval. The damage was recorded at harvesting stage. Significantly less damage was recorded on thiamethoxam treated plants followed by flubendiamide and lamda cyhalothrin. The interaction of the treatments with the location and years was not significantly different suggesting that the year and location had not any influence on the treatment effect. Our result suggested that thiamethoxam is effective to manage mango stone weevil.

**KEYWORDS**

Thiamethoxam, flubendiamide, mango stone weevil, qualitative value, insecticides

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**1. INTRODUCTION**

Mango, *Mangifera indica* (L.), is major fruit crop terms of production (453,416 mt) as well as cultivation area (51,163 ha) in Nepal (MoALD, 2021). There are various problems associated with mango production. Among which mango stone or nut weevil, *Sternochetus mangiferae* (F.) cause serious problem in the mango growing area of Nepal and it is also prioritized pests of eastern hills of Nepal (Bajracharya et al., 2012; Neupane, 1990; Thapa and Karmacharya, 2000). The monophagous pest, mango stone weevil *Sternochetus mangiferae* (Fabricius) (Coleoptera: Curculionidae) is widely distributed in major mango growing tropical regions of the words (Shukla et al., 1985). United States of America (USA), Japan, China, and some Arabian Gulf countries impose quarantine restrictions and in importing mango from stone weevil infested areas by (Seo et al., 1974; Hensen 2000). Infested mango seeds affect their germination (Mulungu et al., 2006) but seed germination rates for polybryonic varieties are not affected by weevil infestation (Follett and Gabbard 2000; Follett 2002). Tunneling and presence of frass are the key features of damaged seeds (De, 2010). In South Africa, described that, in late-maturing varieties adults leave the seed and bore tunnel through the fruit which create scar on the fruit surface which than open chances for secondary fungal infection (Kok, 1979). These damages render the fruit unfit for human consumption. Mango stone weevil can cause losses of fruit estimated between 5% and 80% by premature fruit drop and 5 to 90% of marketable fruits (Bagle and Prasad, 1985; Verghese 2000; Verghese, 1996). Mango stone weevil is univoltine and females lay eggs on immature fruits which are 1.9 cm in diameter or larger (Follett and Gabbard, 2000). Larvae develop within the seed which takes 20-30 d to pupate under field conditions (Follett and Gabbard, 2000). The majority of infested seeds contain one or two weevils, however their number can go up to five or more (Hansen et al., 1989; Balock and Kozuma, 1964).

Various insecticides such as acephate, deltamethrin, thiamethoxan, monocrotophos, carbaryl, dimethoate, ethofenprox, endosulfan, fenthion, fenvalerate, prothiofos and imidacloprid were applied two times during flowering and early fruiting to control this weevil (Villiers 1987; Smith 1996; Verghese et al., 2003; Verghese et al., 2005). Earlier effective insecticide for the management of the mango stone weevils was monocrotophos, carbaryl, and endosulfan which were already banned to use in Nepal (Bajracharya et al., 2012; Verghese, 2000; Verghese et al., 2005; Bajracharya 2012). Furthermore, in conventional management practices, effective control was obtained by endosulfan, carbaryl, fenvalerate, monocrotophos and acephate (Villiers, 1987; Joubert, 1997; Verghese, 2000; Anonymous, 2002; Verghese et al., 2003b) which were subsequently been either banned or in restricted use in several countries due to their negative impact. Therefore, novel insecticide test is essential to keep the weevil damage below threshold. Therefore, in this study we evaluated those insecticides which were earlier found effective in earlier studies and are registered in Nepal with less toxicity compared to conventional ones.

**2. MATERIALS AND METHODS**

Different insecticide (Table 1) was evaluated in eastern terai orchard at Directorate of Agricultural Research, Province no.1 (DoAR), Tarahara, Sunsari, Nepal (450 masl) as well as at farmer’s mango orchard, during 2014 and 2015 mango fruiting season. The experiment was designed in randomized complete block design (RCBD) with four replications. Dasher
and Maldah were the varieties in the orchard having 18 years old plant. Different insecticides, some of having low mammalian toxicity, (Table 1) was tested with control (water sprayed). Four mango trees represent four replications for each treatment. Altogether 40 trees were treated, 20 at each location (on-farm and on-station). Portable foot sprayer was used to spray trees. Each tree acquired 30L of water with recommended dose of pesticide into it. Application of insecticide were started when fruits attained pea size. Insecticide was applied at 10 days interval for three times. Randomly 10 fruits were sampled from each tree after 15 days of last spraying. Infested and non-infested fruit were separated from sample and observed with hand-lens for the presence of *S. mangiferae* thus damage was confirmed. Leven’s test of equality of error of variance showed insignificant results for the number of damaged fruits ($F_{23, 72} = 1.77$, $P=0.293$), thus percentage damage was analyzed without transformation of data. Data were managed in spread sheet and which was subjected to the ANOVA analysis. Means were compared with Tukey’s HSD post-hoc using SPSS 2016 (SPSS, 2016).

### Table 1: Description of different insecticides used in the mango orchard against *Sternochetus mangiferae* during 2014 and 2015 Nepal

<table>
<thead>
<tr>
<th>S.N</th>
<th>Common Name</th>
<th>Trade Name</th>
<th>Mode of Actiona</th>
<th>Formulation</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Azadiractin</td>
<td>Nico Neem</td>
<td>UNb</td>
<td>0.15% w/w EC</td>
<td>5 ml/L water</td>
</tr>
</tbody>
</table>
| 2   | Thiamethoxam| Actara     | Nicotinic Acetylcholine Receptor (nAChR)  
Competitive Modulators | 25% WG | 1 gm/2L water |
| 3   | Flubendiamide| Fame      | Rynodine Receptor Modulator | 39.35% m/m SC | 1 ml/3L water |
| 4   | Lambda Cyhalothrin | Sumo | Sodium Channel Modulator | 2.5% EC | 1.5ml/L water |
| 5   | Dimethoate  | Rogar      | Acetylcholinesterase Inhibitor | 30% EC | 1.5ml/L water |

*aSource- IRAC, 2019  
bUN - Compounds of unknown or uncertain MoA*

### 3. RESULTS

Mean percentage infestation of *S. mangiferae* were significantly effective when treated with different insecticides compared to control both orchards at farm and farmers field during 2015 and 2016. However, minimum percent damage was found with thiamethoxam on-farmer’s orchard on both 2015 ($F_{5, 18}=10.234$, $P \leq 0.001$) and 2016 ($F_{5, 18}=14.409$, $P \leq 0.001$) with 26.25 and 23.00% respectively followed by flubendiamide and lambda cyhalothrin (Figure 1, Figure 2). Similarly average low damage (23.50 and 25.75%) was observed treated with thiamethoxam on station during 2015 ($F_{5, 18}=31.945$, $P \leq 0.001$) and 2016 ($F_{5, 18}=11.724$, $P \leq 0.001$) respectively followed by flubendiamide and lambda cyhalothrin (Figure 3, Figure 4). Pooled analysis ($F_{5, 72}=57.467$, $P=0.01$) between both year and both sites also revealed that the thiamethoxam is better among all tested treatment for minimum damage percentage followed by flubendiamide and lambda cyhalothrin (Table 2).

### Table 2: Pooled damage percentage of *Sternochetus mangiferae* among treated orchards in 2015 and 2016 on station and on farm

<table>
<thead>
<tr>
<th>SN</th>
<th>Treatment</th>
<th>Damage(±SE)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Azadirachtin</td>
<td>59.1±2.0c</td>
</tr>
<tr>
<td>2</td>
<td>Thiamethoxam</td>
<td>24.6±0.8a</td>
</tr>
<tr>
<td>3</td>
<td>Flubendiamide</td>
<td>41.0±1.2b</td>
</tr>
<tr>
<td>4</td>
<td>Lambda cyhalothrin</td>
<td>41.9±0.8b</td>
</tr>
<tr>
<td>5</td>
<td>Dimethoate</td>
<td>53.0±1.5c</td>
</tr>
<tr>
<td>6</td>
<td>Control</td>
<td>74.4±1.5d</td>
</tr>
</tbody>
</table>

Interaction of the treatment with the year, and location was found insignificant ($F_{5, 72}=0.257$, $P=0.935$) which implies that the location and year does not have any influence on treatment efficacy.

**Figure 1:** *Sternochetus mangiferae* mean damage percentage on mango in 2015 on farm (Bars with same alphabet for each treatment indicated the damage was not significantly difference at $P < 0.05\%$.)
Figure 2: *Sternochetus mangiferae* mean percentage damage on mango in 2016 on farm (Bars with same alphabet for each treatment indicates the damage was not significantly different at P <0.05%.)

Figure 3: *Sternochetus mangiferae* mean percentage damage on mango in 2015 on station (Bars with same alphabet for each treatment indicates the damage was not significantly different at P <0.05%.)

Figure 4: *Sternochetus mangiferae* mean percentage damage on mango in 2016 on station (Bars with same alphabet for each treatment indicates the damage was not significantly different at P <0.05%.)
4. DISCUSSION

Our study revealed that all treatments were effective to control Sternochetus mangiferae in varying proportions however systemic neonicotinoids, thiamethoxam was found to be best among tested insecticide in both years. Similar result was found with two different dose with, i.e. 1.44 (6 ml) and 1.92 gai. (8 ml/tree) with two different methods of application i.e. by dripper or sprinkler around the base of the stems. Thiamethoxam is a second generation neonicotinoid with stomach and contact activity (Devine et al., 1969). During a study, thiamethoxam is a neonicotinoid precursor to clothianidin in insects and plants (Rauch et al., 2003). Thiamethoxam was found effective against storage pest Sitophilus zeamais Motschulsky, the maize weevil, Oryzaephilus surinamensis (L), the red flour beetle, S. oryzae (L), the rice weevil, Rhynchopertha dominica (F), the lesser grain borer, T. castaneum, and the saw-toothed grain beetle, Tribolium castaneum (Herbst), (Arthur 2004). Thiamethoxam also affect termites at low rates, and against blueberry maggot flies exposed on spheres coated with thiamethoxam (Delgarde and Rouland-Lefevre, 2002; Ayappath et al., 2000). Thiamethoxam protects crops from pests including whiteflies, aphids and leafhoppers (Nault et al., 2004; Moser and Ohadi 2009). Seed treated with thiamethoxam were also affect against thrips (El-Naggar 2013). Recent research found that thiamethoxam proved significantly better in controlling aphids and jassids (Mira, 2002). Thiamethoxam have less effect on natural enemies which also has minimal effects on other beneficial insects, low toxicity toward mammals, and does not produce teratogenic or mutagenic effects (Prabhaker et al., 2011; Lawson et al., 1999).

In our research work we found that flubendiamide was effective against S. mangiferae which was also effective to control litchi fruit and shoot borer (Upadhyay et al., 2020). There also reported that flubendiamide was effective in controlling Leucinodes orbonalis (Kshushwaha and Painkara, 2016). Similarly, we found that Lambda cyhalothrin showed more effective against S. mangiferae than dimethoate. This was also found effective at laboratory experiments against S. mangiferae (Prseetha, 2013). Similarly, a study also found effective with the lowest mean percentage weevil infestation (Tandon and Shukla, 1989).

Have suggested that deltamethrin 0.003% could be alternative to manage this insect when infestation percent is 20.25% to 25% (Bagale and Prasad, 1988). Though, Azadirachtin 0.001% was statistically effective than control, mean per cent infestation was very high in both years. Other research also reported that synthetic insecticides are relatively more effective for managing S. mangiferae (3.3% to 14.8% infestation) than Azadirachtin (27.4% infestation) (Vergeese et al., 2005).

5. CONCLUSION

Based on our results we could say that application of Thiamethoxam (25% WG) or flubendiamide (39.3% m/m) could be effective against the major pest of mango, stone weevil. Thiamethoxam could be applied @ 1 gm per 2 liter of water however flubendiamide could be applied @ 1 ml per 3 liter of water. At least three applications with 10 days’ interval is suggested. Since these insecticides have lower affinity toward mammalian receptors, it may reduce the risk to human and livestock health.

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