Entomology

Effective control of invasive grape mealybugs (*Maconellicoccus hirsutus*) involves cautious release of ladybird beetles in variable temperature parameters

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Received 7 Nov 2025; Accepted 19 Dec 2025; Published 3 Jan 2025

Abstract

Objective: The investigation on mealybug *Maconellicoccus hirsutus* control in grape (*Vitis vinifera)* has not been carried out in Jumla, Nepal. So, a study was carried out in Chandannath, Jumla in selected grape vineyards (*Vitis vinifera*) to understand the effectiveness of various treatments in the mealybug *M. hirsutus* population.

Methods: The vineyard was screened with net that were deployed to find out the efficacy of 3 treatments namely seven spotted ladybird beetles *Coccinella septempunctata* (10 ladybird beetles released just before the monitoring and prior surveillance of beetles carried in the field), Imidacloprid 200 SL @1.5 ml/l of water/plant), and untreated control in controlling mealybugs *Maconellicoccus hirsutus*. In addition, laboratory study was conducted to understand the effect of fluctuating temperature and mealybug population in presence of ladybird beetles.

Results: At 10^0c the numbers of mealybugs were 500, and they decreased to 450 and 395 at 12 and 14^0c respectively. At 28 and 30^0c they became 9 and 2 in numbers. The temperature was found significant to the population of mealybugs *M. hirsutus*, however the growth and development of ladybird beetles *C. septempunctata* were severely affected, while their feeding habit was directly correlated with increased temperature. The effect of ladybird beetles was highly effective in controlling the population of mealybugs in grape vineyards followed by the effect of imidacloprid and untreated control. The average yield (kg/plant) were 6, 8 and 4 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed vineyard respectively. Grape cluster and yield were highest in ladybird beetle released vineyards followed by imidacloprid and untreated control.

Conclusion: Therefore, the ladybird beetle *C. septempunctata* could be the effective strategy in controlling invasive mealybug *Maconellicoccus hirsutus* in grape (*Vitis vinifera)* vineyards at changing temperature.

Keywords: Imidacloprid, Natural Enemy, Pest, Population, Yield

1. Introduction

Grape (*Vitis vinifera* L.) considered as most valuable commercial fruits crops grown in sub-tropical, tropical, and temperate regions of the world. High level of sucrose and berry yield has been well recognized better in the places of sub-tropical and tropical climatic condition of India.

Within many pests of grapes flea beetle, *Sceledonta strigicollis* Mots. and mealy bug, *Maconellicoccus hirsutus* (Green) were known for the major yield declining pest of the crop. According to Lower (1968) [24] the mealy bug is “hard to kill pest of fruit trees” as they are saved by waxy filaments; that creates complex to penetrate the sprayed insecticides on them. In recent years, *M. hirsutus* has become very damaging pest in grape vineyards. Mealybugs (Hemiptera: Pseudococcidae) are a diverse group of sap-sucking insects that pose a significant threat to global agriculture. The infestation range is quite extended as a host plant, that contain huge economically important agriculture crops including grapes, causing substantial yield losses and economic damage. The behavior of mealybugs to withstand at extreme climatic condition, even at very low temperature, and polyphagous nature has increased their population to decline the production and productivity of agricultural crops (Pimentel *et al*., 2001) [32].

Grape production is often highly reduced because of the mealybugs that causes extreme reduction in yield up to 100% found in India (Babu & Azam, 1983) [3]. In most parts of India the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) were generally distributed that results heavy loss in many varieties of grapes (Mani & Thontadarya, 1987a) [25]. One of the research projects conducted in Karnataka and Maharashtra recently found that the abundance of citrus mealybug, *Planococcus citri* (Risso) is also one of the major pests of grapes (Mani and Kulkarni, 2007) [26]. This pest has devasted many grape vineyards at global scenario (Agran *et al*., 1990; Cabaleiro & Segura, 1997; Gonzalez, 2003) [1, 7, 17]. The consequence of mealybug infestations is not limited to direct feeding damage. Mealybugs are considered to secrete honeydew, which promotes the growth of sooty mold, and declines the photosynthetic ability of plants resulting great loss in quality and quantity of crops. Furthermore, mealybugs transmit diseases that multiply their devastating effect in agriculture, especially in grape vineyards (Joshi, 2017) [23]. The pest has unlimited damage symptoms and crop loss that also minimizes the marketable good quality and returnable cost.

It has been complex to control the mealybugs *H. hirsutus* in grapefruits with conventional and traditional type of insecticides due to the presence of concealed habitat and waxy coating over their bodies. On the other hand, the resurgence and insecticide resistance are other negative consequence of insecticide application to control mealybug population (Manjunath, 1986) [29]. But some studies such as (Franco *et al*., 2009) [13] reflected the effectiveness of insecticides. Similarly, the study of (Ishaaya & Horowitz 1998) [20] have also presented effective control of mealybugs in grape vineyard. Continuously researchers have focused their investigation to determine effect of insecticides in managing such pests, and farmers have been practicing so. However, the natural enemy, Australian ladybird beetle, *Cryptolaemus montrouzieri Mulsant* have been investigated as appropriate method in controlling *M. hirsutus* on grapevine peninsular India (Mani & Thontadarya, 1988) [27]. The study of biological control agents deployed over the mass of mealybugs are rarely found. The management of mealybugs has primarily targeted on biological control strategies. Chong *et al*. (2015) [8] reported the value of biocontrol agents in reducing the population of mealybug *M. hirsutus.*

This study evaluates the effectiveness of insecticides and biological control agents in managing mealybug *M. hirsutus* grapefruits field and laboratory condition.

2. Materials and Methods

The study was conducted from May 2021 to October 2021 in Chandannath, Jumla district in selected grape vineyards (*Vitis vinifera*). The vineyard was screened with net and 3 treatments namely seven spotted ladybird beetles *Coccinella septempunctata* (10 ladybird beetles released just before the monitoring, prior surveillance of beetles carried in the field), Imidacloprid 200 SL @1.5 ml/l of water/plant), and untreated control were used to understand their effectiveness in controlling mealybugs *Maconellicoccus hirsutus* in already installed grape vineyard. Five sample plants from the middle row of the yard were selected, and the regular data on effect of treatments in mealybugs *M. hirsutus* population and yield and yield attributes of the fruit crop were recorded regularly. Simultaneously, the interrelationship between population of mealybugs *M. hirsutus* and temperature was measured in laboratory condition, where plant parts were collected with the sample pest including ladybird beetle *C. septempunctata* and reared at artificially maintained variable temperature. 2 ladybird beetle and 500 numbers of aphids were subjected for the study. The collected data were the all systematically arranged deploying MS- Excel which were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT-0.05 level) for mean separations using Gen stat software.

3. Results and Discussion

3.1 Effect of temperature in mealybug *Maconellicoccus hirsutus* population in presence of ladybird beetle *Coccinella septempunctata*

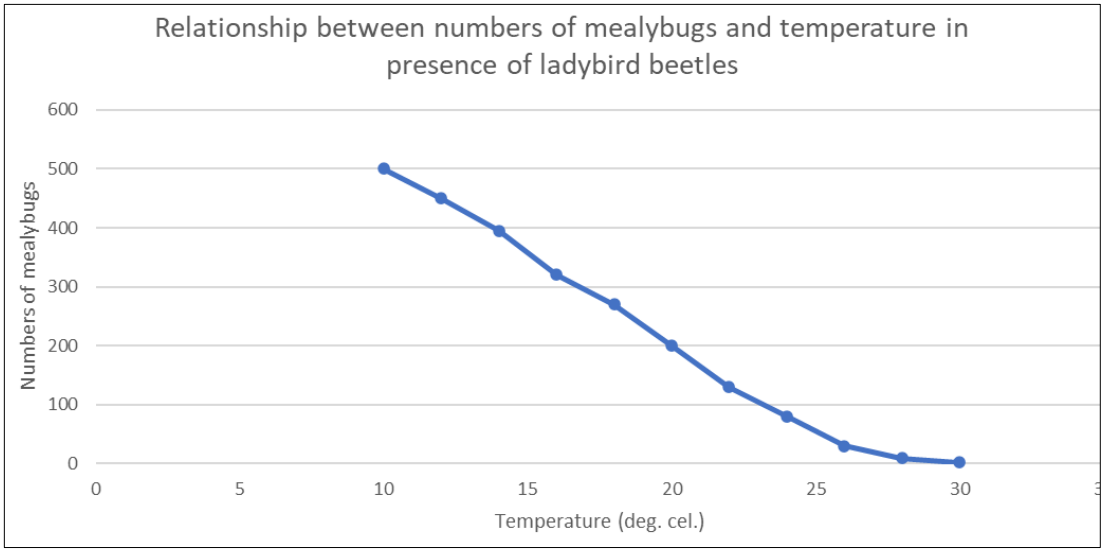


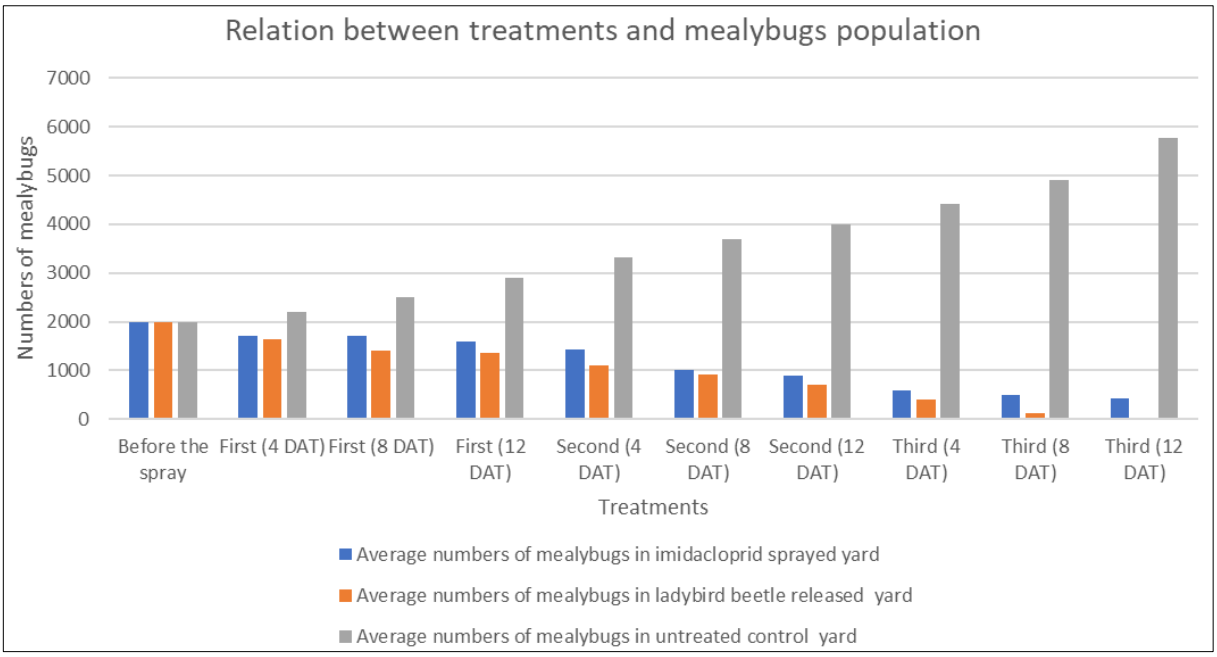
Fig 1: Effect of temperature in mealybug *Maconellicoccus hirsutus* population in presence of ladybird beetle *Coccinella septempunctata*

It was found that average numbers of mealybugs *Maconellicoccus hirsutus* in presence of ladybird beetle *Coccinella septempunctata* were 500 installed at 10^0c temperature. The average numbers of mealybugs *M. hirsutus* recorded to be 450, 395, 320, 270, 200, 130, 80, 30, 9 and 2 at 12, 14, 16, 18, 20, 22, 24, 26, 28 and 30^0c respectively. The mean value of mealybugs *M. hirsutus* in grape yards was 217 at 20^0c temperature (Figure 1).

With increase in temperature the population of mealybugs *M. hirsutus* increased while the feeding efficiency of ladybird beetles *C. septempunctata* also increased with the temperature. Though the growth and reproduction of ladybird beetles *C. septempunctata* are affected by the increased temperature, the raised capacity to feed the pest manages their population. Burgio *et al*. (2004) [6] and Daane *et al*. (2008) [12] reported that the natural enemies could be found in the vineyard to suppress

the population of mealybugs at variable climatic factors. Interpretation of Mineo (1967) [30] and Anon (2006) [2] found that the numbers of mealybugs increases with increase in temperature, however, they are suppressed by the population of biocontrol agents ladybird beetles. The investigation of s (Bartlett 1974; Jalali, Singh & Biswas 1999) [5, 22] also confirms that temperature have significant relation with mealybug population though it become complex for them to survive in presence of natural enemies at the variable temperature. Persad & Khan (2002) [31] found that in laboratory with increase in temperature the activity of natural enemies also increases and correlated with the mealybug mass as well. Ghorbanian *et al*. (2011) [15] also have similar findings of significant increase in mealybug population and equally their suppression by biological control agent with respect to increased temperature.

3.2 Effect of treatments in the population of mealybug *Maconellicoccus hirsutus*



Note DAT: Days After Treatments

Fig 2: Effect of treatments in the population of mealybug *Maconellicoccus hirsutus*

It was recorded that the average numbers of mealybugs *Maconellicoccus hirsutus* were 2000 in every research yards. After 4 days of first treatment the average numbers of mealybugs were observed to be 1700, 1650 and 2200 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively. Similarly, the average numbers of mealybugs found to be 1700, 1400 and 2500 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively after 8 days of first treatment. After 12 days of first treatment the average numbers of mealybugs found to be 1600, 1370 and 2900 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively. Finally, after 4 days of third (last) treatment the average numbers of mealybugs counted as 600, 413, and 4420 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively. After 8 days of third treatment the average numbers of mealybugs found to be 500, 120, and 4900 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively. After 12 days of third treatment the average numbers of mealybugs found to be 420, 17, and 5760 in imidacloprid sprayed, ladybird beetle released and untreated control sprayed yard of grapevine respectively (Figure 2).

The mealybugs *M. hirsutus* were found to be effectively controlled by ladybugs *Coccinella septempunctata*. Mani *et al*. (1987) [28] described the importance of biological control agents in managing mealybug population. An investigation of Kairo *et al*. (2000) revealed that natural enemies are significant control agents of mealybug pest population compared with insecticides and other methods. Some studies have also resulted that the natural enemies have potential result over the mass of mealybugs in field condition, especially in vineyards (Tauber *et al*., 2000; Collier & Van Steenwyk, 2004; Daane *et al*., 2006) [34, 9, 10].

Ladybird beetles are considered as the most beneficial insects in the vineyard (Ghosh, 2022) [16]. Both young and adult larvae are potential feeders; larvae which are young shows their movement by penetrating and sucking nutrients from the preys and make themselves keep alive (Rashed, 2020) [33]. It has been found that the ladybugs assist to engulf moths' egg, certain pathogens, minute insects' pests, pollen, and nectar from nearby grape vineyards (Hodek *et al*., 2012) [18].

The analysis of French & Reeve (1979) [14] found that the application of insecticides has low effectiveness In mealybugs thereby increasing their infestation level in grape fruits. Study of (Babu & Ramanamurthy 1998) [4] provided the findings concerned with insecticide have negative effect in the

population of natural enemies also. Application of imidacloprid have negative influence in the population of predators and also have residual effect in crops, which has been described by (Jacas Miret & Garcia-Marí 2001) [21]. Most of the insecticides have detailed the indirect effect resulting insecticide resistance in the pest population.

3.3 Effect of treatments in the yield and yield attributes of grapefruits (*Vitis vinifera*)

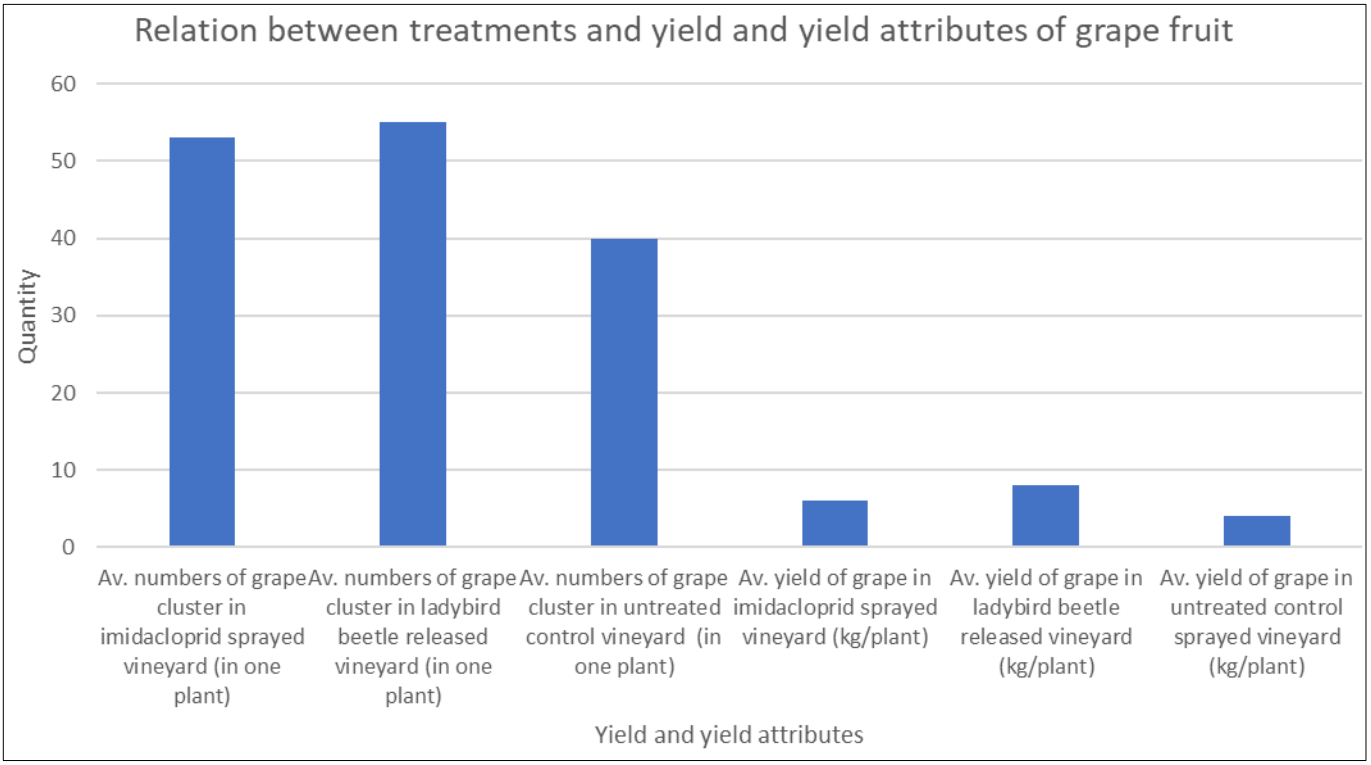


Fig 3: Effect of treatments in the yield and yield attributes of grapefruits (*Vitis vinifera*)

It was found that the average numbers of grape cluster (in one plant) in imidacloprid sprayed, ladybird beetle released, and untreated control sprayed vineyard were 53, 55 and 40 respectively. Similarly, the average yield (kg/plant) in imidacloprid sprayed, ladybird beetle released, and untreated control sprayed vineyard were 6, 8, and 4 respectively. Mean value for grape cluster was 49.33 and grape yield was 5.25 kg/plant against all the treatments (Figure 3).

The effect of ladybird beetle was found highest both in grape cluster and grape yield followed by imidacloprid and untreated control spray. The findings of Daane *et al*. (2012) [11] supports our investigation that the production and productivity of grape fruits are effectively influenced by the release of biological control agent ladybird beetle *Coccinella septempunctata*. Scientific study of Tollerup (2007) [35] revealed that though imidacloprid are effective control mechanism of mealybugs they have numerous side effects. As IPERTI (1999) [19] suggest that the abundance of ladybird beetle *C. septempunctata* have beneficial impact in the quality and quantity of vegetations. So, application of biological control agents is mostly found beneficial compared with the insecticides that have numerous negative consequences.

4. Conclusion

A study was carried out from May 2021 to October 2021 in Chandannath, Jumla district in selected grape vineyards (*Vitis vinifera*). The vineyard was screened with net that were deployed to find out the efficacy of 3 treatments namely seven spotted ladybird beetles *Coccinella septempunctata* (10 ladybird beetles released just before the monitoring, prior surveillance of beetles carried in the field), Imidacloprid 200 SL @1.5 ml/l of water/plant), and untreated control in controlling mealybugs *Maconellicoccus hirsutus*. Laboratory study was conducted to understand the relationship between temperature and mealybug population in presence of ladybird beetles. The temperature was found significant to the population of mealybugs *M. hirsutus*, however the growth and development of ladybird beetles *C. septempunctata* were severely affected, while their feeding habit was directly correlated with increased temperature. The effect of ladybird beetles was found highly effective in controlling the population of mealybugs in grape vineyards followed by the imidacloprid and untreated control. Grape cluster and yield were found highest in ladybird beetle released vineyards followed by imidacloprid and untreated control.

Funding: *The research was conducted without financial support from external bodies.*

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