



## Studies on the Efficacy of various Plant Products Against the Pink Mealy bug *Maconellicoccus hirsutus* (Green) in mulberry Garden

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**ABSTRACT:** The study was carried out at Adhiyamaan College of Agriculture and Research, Athimugam, Krishnagiri District. Study conducted efficacy of various treatments of plant products against pink mealy bug *Maconellicoccus hirsutus* on mulberry recorded neem oil (3.00), neem seed kernel extract (5.33) was found most effectively in controlling *Maconellicoccus hirsutus* population, *Pongamia* oil (7.00), and *Vitex negundo* (8.33) were found to be moderately controlling in the pink mealy bug population. In the following study, the efficacy of various treatments against pink mealy bug *Maconellicoccus hirsutus* egg masses in nodal region of apical shoot in mulberry plant was recorded. Neem oil (1.33) treatment was recorded highest number of reductions in the number of egg masses in the apical shoots of the mulberry followed by neem seed kernel extract (1.67) and *Annona squamosa* seed extract (2.33) were observed significant. Further, after the third spray with neem oil, neem seed kernel extract and *Vitex negundo* reduced the tukra occurrence from 11.08 to 5.58, 13.91 to 2.75, and 13.91 to 5.58 percent, respectively. Neem seed kernel extract (81.00) has the significantly highest influence on moisture content (%) in mulberry leaves with mealy bug infestation, followed by neem oil (80.00), which shows a moderate influence of plant extract on moisture content in mulberry leaves with mealy bug infestation. Neem seed kernel extract (19.00) significantly influences moisture loss (%) in mulberry leaves with mealy bug infestation. The neem seed kernel extract (80.33) significantly influenced moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field, followed by neem oil (79.33) treatment. The study concluded that two botanicals, like neem oil and neem seed kernel extract, were found to effectively control the mealy bug population, followed by other botanicals that had a moderate and minimum reduction in the mealy bug population.

**Keywords:** Mulberry silkworm, plant products, pink mealy bug, tukra occurrence, moisture content.

### INTRODUCTION

Mulberry is the indispensable food for mulberry silkworm and is known for its luxuriant growth. About 300 insect and non-insect species of pests are known to inflict damage on mulberry in different parts of the world. The pests of mulberry were classified as defoliators (leaf-eating pests), sucking pests (sap suckers), stemborers, and root feeders. Among these, sucking pests, viz., mealy bugs, Spiralling whitefly, jassids, thrips, scale insects, and mites, are causing considerable damage to mulberry depending on the season, region, and mulberry varieties (Reddy and Narayanaswamy 2003). Being a perennial, evergreen, and high biomass-producing plant, mulberry offers ideal conditions for uninterrupted and rapid multiplication of

these pests in space and time, often reaching alarming proportions (Manjanth, 2004). In India, 28 plant species have been reported as hosts, and more than 125 plant species worldwide (Reddy *et al.*, 2009). It prefers hibiscus in all seasons, and it is known as the hibiscus mealy bug (Williams, 1986) in many countries. Since the adult females are pink, it is also called a pink mealy bug. It is very difficult to kill this pest because of its protected habitat and waxy coating over its body. It sucks the sap simultaneously, releasing toxins that result in short internodes, curling, wrinkling, and crumpling of apical leaves, virtually stopping the growth of the plant by suppressing stem elongation and affecting the yield of leaves. Further, the affected region swells and turns a deep green colour. Therefore, the symptoms of mealy

bug infestation in mulberry are collectively called as tukra (Misra, 1919). Mulberry mealybug (*Maconellicoccus hirsutus*) Hemiptera, Pseudococcidae, was a minor pest, but recently it was recorded as a serious polyphagous pest feeding voraciously on mulberry leaves (Manjunath *et al.*, 2006; Mala *et al.*, 2007) in India. The mealy bug *Maconellicoccus hirsutus* infestation is found to be more destructive owing to the extent of qualitative and quantitative damage (Manjunath *et al.*, 1993). It infests tender shoots and causes bunchy tops, which leads to retarded growth of the plants. The leaves on the infested shoots become unfit for young silkworm rearing. The symptoms caused by the mealy bug *M. hirsutus* are generally called Tukra (Reddy *et al.*, 1988). Though the intensity of damage differed among the varieties, the symptoms were similar in all the varieties (Mahimasanthi and Kumar 2011). The yield loss of mulberry ranged from 2.45 to 44.33 percent, depending on the intensity of the mealy bug infestation (Veeranna *et al.*, 2001). Muthulakshmi *et al.* (2004) reported 50.6 percent damage during the summer months. Sathyaprasad *et al.* (2000) have pertained that the mealy bug prevalence caused an estimated leaf yield loss of 4500 kg/ha/year amounting to 34.24% (Manjunath *et al.*, 2003), resulting in less brushing of 450 dfls/ha/year, which led to a decline in cocoon production by 150 kg/ha/year (10–15%). Mostly, insecticides are not desirable for mulberry ecosystems due to the residual toxicity that can directly affect silkworm rearing (Yamamoto *et al.*, 2007). *M. hirsutus* on mulberry is reported so far from India throughout the area. This study will be helpful for the control of this menace pest in the mulberry crop. The present examination on the management of mulberry pink

mealybug carried out under the mulberry ecosystem is new evidence.

## MATERIALS AND METHODS

The present study was conducted to determine the efficacy of various plant products against the pink mealy bug in the mulberry ecosystem from 2022 to 2023. To evaluate botanicals, 5 percent of seed kernel extract, 2 to 10 percent of leaf extract, and 4 to 8 percent of rhizome were sprayed on mulberry under field conditions during the summer season. The following observations were made three and five days after spraying the well-established V1 variety of mulberry garden located at the Department of Agricultural Entomology, Adhiyamaan College of Agriculture and Research, Athimugam. Mulberry plants from each treatment were marked with a paraffin-coated paper tag for identification. On the mulberry plant, the efficacy of various treatments was assessed by recording the number of crawlers, nymphs, and adults in each treatment, which is taken as a pre-treatment count one day before treatment. Subsequent observations were made on post-treatment counts (number of crawlers, nymphs, and adults present after botanical treatment) after spraying for the third and fifth days. The second and third sprays were conducted at a seven-day interval. All the agronomic practices were followed as per the package of practices for higher yields, except the plant protection schedule.

### Evaluation of the Effectiveness of Botanical Extracts.

The effectiveness of botanicals was assessed by calculating the percent protection over the untreated control and the percent reduction in pest population from the pre-treatment count, using the pre- and post-treatment observations recorded after the final spray and applying the following formulas (Madhuri, 2012).

$$\text{Mortality of bugs (\%)} = \frac{\text{Population at Pre-count} - \text{Population after spray}}{\text{Population at Pre-count}} \times 100$$

$$\text{Protection over control (\%)} = \frac{\text{Population in the control} - \text{Population after spray}}{\text{Population in the control}} \times 100$$

**Tukra incidence and occurrence.** The total number of infested and healthy leaves in each plant (sprayed and unsprayed) was recorded, and the percentage of Tukra

occurrence was calculated using the following formula. (Madhuri, 2012).

**The percentage of Tukra occurrence was calculated using the following formula.**

$$\text{Tukra occurrence (\%)} = \frac{\text{No. of branches infested/plant}}{\text{Total number of branches/plants}} \times 100$$

### Per cent protection over pre-treatment count from incidence

$$\text{Tukra occurrence (\%)} = \frac{\text{Incidence in the pre-treatment count} - \text{incidence after spray}}{\text{Incidence in the pre-treatment count}} \times 100$$

### Morpho-physiological parameters. Moisture content.

Fresh, healthy, and infested leaves (10 leaves from each replication) were collected before and after the application of plant extracts. The leaves were immediately weighed to determine their fresh weight

(mf). Subsequently, the samples were dried in an oven at 80°C until a constant dry weight was obtained. The moisture content (mc) was then calculated using the formula given by Turner (1981) and (Madhuri, 2012)

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

**Moisture Loss.** Moisture loss (%) = 100 - Moisture content

**Moisture retention capacity.** To determine moisture retention capacity, fresh leaves were weighed (WI) and incubated at  $27^{\circ}\text{C} \pm 10^{\circ}\text{C}$  with a relative humidity of 45-50% for 12 hours in a BOD incubator and weighed (WF) again. Further, leaves were dried in an oven and weighed (Madhuri, 2012).

#### Moisture Retention Capacity (MRC)

$$\text{MRC (\%)} = \frac{\text{Moisture content after 12 hr of incubation} - \text{Moisture content}}{\text{Moisture content}} \times 100$$

**Statistical analysis.** The data were analysed using Agress. The level of significance was tested at 5 per cent.

## RESULTS AND DISCUSSION

The present study on Management of pink mealy bug *Maconellicoccus hirsutus* in mulberry at Department of Agricultural Entomology, Adhiyamaan College of Agriculture and Research, Athimugam.

#### A. Efficacy of various botanicals treatments against pink mealy bug in mulberry ecosystem

The data on the efficacy of various treatments against the pink mealy bug *Maconellicoccus hirsutus* on mulberry recorded in terms of the number of bugs per shoot one day before spray and three and five days after the first, second, and third sprays are presented in Table 1.

**One day before spray.** The population of nymphs was significantly reduced by neem oil (17.00) and neem seed kernel extract, followed by *Pongamia* oil (21.00) and *Annona squamosa* kernel extract (23.00). They are on par with each other. Other treatments of the population were not significant, such as neem leaf extract, *Vitex negundo*, *Lantana* leaf extract, *Allium sativum* rhizome, and *Zingiber officinale*. The control population recorded no significant difference compared to the others (Table 1).

**Three days after first spray.** The result showed that the treatments of neem oil (12.67) and neem seed kernel extract (15.33) effectively declined the mealy bug population, followed by *Pongamia* oil (18.00), *Annona squamosa* seed extract (19.33), and *Vitex negundo* (20.00), which are on par with each other as compared to the control treatments. The remaining treatments slightly reduced the nymph population in the mulberry apical shoots (Table 1).

**Five days after first spray.** The data pertaining to the table revealed that neem oil (12.67) and neem seed kernel extract (15.33) showed a reduction in the population, and they were on par with each other, followed by *Pongamia* oil (18.00) and *Annona squamosa* seed extract (19.33), which moderately reduced the population. For the remaining treatments, there is no significant difference, such as *Vitex negundo*, *Lantana* leaf extract, *Allium sativum* rhizome, and *Zingiber officinale*, respectively (Table 1).

**Third days after second spray.** The efficacy of botanical treatment in the second spray is given in Table

1. The plant products like neem oil (9.00) and neem seed kernel (12.00) extract were found to be effectively controlled in the mealy bug population.

**Five days after second spray.** The efficacy of the botanical treatment five days after the second spray was mentioned in Table 1. It showed that neem oil (6.33) and neem seed kernel extract (8.33) were found to be efficiently controlling the pink mealy bug population, and treatments like *Pongamia* oil (11.00) and *Annona squamosa* (12.33) seed extract were found to be moderately controlling the pink mealy bug population.

**Three days after third spray.** The significant reduction in the mealy bug population using neem oil (4.67) and neem seed kernel extract (7.33), followed by *Pongamia* oil (8.67) and *Annona squamosa* seed extract (10.33), were found to be on par with each other in their efficacy in controlling the pink mealy bug population (Table 1).

**Five days after third spray.** The data revealed that, using the different treatments, they were controlling the pink mealy bug in the fifth day after the third spray, as shown in Table 1. It was discovered that neem oil (3.00), neem seed kernel extract (5.33), *Pongamia* oil (7.00), and *Vitex negundo* (8.33) were all moderately effective in controlling the pink mealy bug population.

Mahesh Kumar (2008) reported that the least number of colonies were observed in grapevine by using Dimethoate 30 EC at 1.7 ml and fish oil rosin soap at 5 g/l, followed by *Lantana camera* @ 5 %. The next best treatment includes neem oil @ 2 % + soap powder at 1 % and neem cake extract at 5%. The data showed that, five days after the third spray, Dimethoate 30 EC + 1.7 ml and fish oil rosin soap @ 5 g/l were superior compared to the other treatments, followed by neem seed kernel extract and neem oil, found moderately significant. So, the present study is on par with each other. Ravikumar *et al.* (2010) showed that mulberry ecosystems using botanicals like neem oil at 1%, 2% and 3% concentrations in a 10 days interval showed great efficacy in controlling pink mealy bugs and extremely improved the population of coccinellids, spiders, and soil macrofauna in the mulberry ecosystem, which favors the control of the pink mealy bug population. The present study was found to be on par with each other.

#### B. Efficacy of various botanicals against pink mealy bug *Maconellicoccus hirsutus* egg masses in nodal region of apical shoot in mulberry plant

The data on the efficacy of various treatments against the pink mealy bug *Maconellicoccus hirsutus* egg masses in the nodal region of the apical shoot of a mulberry plant recorded in terms of the number of egg masses per shoot one day before spray and three and five days after the first, second, and third sprays are presented in Table 2.

**One day before spray.** The data indicated that neem oil (5.00), *Vitex negundo* (5.00), *Annona squamosa* seed extract (5.00), and *Zingiber officinale* (5.00) had equal egg masses in the apical shoots of mulberry, whereas *Pongamia* oil (6.00), *Lantana* leaf extract (6.00), and *Allium sativum* rhizome (6.00) had equal egg masses in the apical shoots of mulberry in the pre-treatment count (Table 2). So, there was no significance in this study.

**Table 1: Efficacy of various botanicals against pink mealy bug *Maconellicoccus hirsutus* in mulberry.**

| Sr. No. | Treatments                              | Pre-treatment count<br>1 DBS | Post treatment count after |                 |                 |                 |                 |                 | Mean value      |
|---------|-----------------------------------------|------------------------------|----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|         |                                         |                              | I Spray                    |                 | II Spray        |                 | III Spray       |                 |                 |
|         |                                         |                              | 3 DAS                      | 5 DAS           | 3 DAS           | 5 DAS           | 3 DAS           | 5 DAS           |                 |
| T1      | Neem oil @ 3%                           | 22.00<br>(4.69)              | 17.00<br>(4.12)            | 12.67<br>(3.56) | 9.00<br>(3.00)  | 6.33<br>(2.52)  | 4.67<br>(2.16)  | 3.00<br>(1.73)  | 8.77<br>(2.96)  |
| T2      | <i>Pongamia</i> oil @ 3%                | 24.12<br>(4.91)              | 21.00<br>(4.58)            | 18.00<br>(4.24) | 13.33<br>(3.65) | 11.00<br>(3.32) | 8.67<br>(2.94)  | 7.00<br>(2.65)  | 11.28<br>(3.36) |
| T3      | Neem leaf extract @ 8%                  | 25.66<br>(5.07)              | 24.33<br>(4.93)            | 22.67<br>(4.76) | 18.67<br>(4.32) | 15.67<br>(3.96) | 14.33<br>(3.79) | 11.33<br>(3.37) | 17.82<br>(4.22) |
| T4      | <i>Vitex negundo</i> @ 10 %             | 24.00<br>(4.90)              | 23.33<br>(4.83)            | 20.00<br>(4.47) | 16.67<br>(4.08) | 13.67<br>(3.70) | 11.67<br>(3.42) | 8.33<br>(2.89)  | 16.81<br>(4.10) |
| T5      | Lantana leaf extract @ 2%               | 30.89<br>(5.56)              | 26.00<br>(5.10)            | 25.33<br>(5.03) | 21.67<br>(4.66) | 18.67<br>(4.32) | 16.67<br>(4.08) | 15.00<br>(3.87) | 20.55<br>(4.53) |
| T6      | <i>Annona squamosa</i> seed extract@ 5% | 27.33<br>(5.23)              | 23.00<br>(4.80)            | 19.33<br>(4.40) | 15.33<br>(3.92) | 12.33<br>(3.51) | 10.33<br>(3.21) | 9.33<br>(3.06)  | 14.94<br>(3.87) |
| T7      | Neem seed kernel extract @ 5%           | 23.67<br>(4.87)              | 19.33<br>(4.40)            | 15.33<br>(3.92) | 12.00<br>(3.46) | 8.33<br>(2.89)  | 7.33<br>(2.71)  | 5.33<br>(2.31)  | 11.27<br>(3.36) |
| T8      | <i>Allium sativum</i> rhizome@ 4%       | 25.33<br>(5.03)              | 24.33<br>(4.93)            | 22.67<br>(4.76) | 19.00<br>(4.36) | 16.67<br>(4.08) | 14.67<br>(3.83) | 13.33<br>(3.65) | 18.44<br>(4.29) |
| T9      | <i>Zingiber officinale</i> @ 8%         | 31.33<br>(5.60)              | 26.67<br>(5.16)            | 23.33<br>(4.83) | 20.00<br>(4.47) | 17.67<br>(4.20) | 16.00<br>(4.00) | 15.00<br>(3.87) | 19.77<br>(4.45) |
| T10     | Untreated control                       | 32.67<br>(5.72)              | 33.00<br>(5.74)            | 32.67<br>(5.72) | 36.00<br>(6.00) | 37.33<br>(6.11) | 43.67<br>(6.61) | 40.67<br>(6.38) | 37.22<br>(6.10) |
|         | CD at 0.05 %                            |                              | 3.01                       | 3.51            | 3.36            | 3.29            | 3.14            | 3.68            |                 |
|         | SEd                                     |                              | 1.43                       | 1.67            | 1.60            | 1.56            | 1.49            | 1.75            |                 |

**Note:** DBS: Day before spray, DAS: Days after spray; Figures in parentheses are  $\sqrt{}$  transformation values

**Three days after first spray.** The experiment data revealed that neem oil (4.33) and *Vitex negundo* (4.00) were found to significantly reduce egg masses in the apical shoots of the mulberry, and *Pongamia* oil (5.67), *Lantana* leaf extract (5.67), and *Zingiber officinale*

(5.00) recorded a moderate reduction in the egg masses population in the apical shoots, whereas other treatments showed that slight reduction in egg masses in the nodal region of apical shoots (Table 2).

**Table 2: Efficacy of various botanicals against pink mealy bug *Maconellicoccus hirsutus* egg masses in nodal region of apical shoot in mulberry plant.**

| Sr. No. | Treatments                              | Pre treatment count<br>1 DBS | Post treatment count after |                |                |                |                |                | Mean value     |
|---------|-----------------------------------------|------------------------------|----------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |                                         |                              | I Spray                    |                | II Spray       |                | III Spray      |                |                |
|         |                                         |                              | 3 DAS                      | 5 DAS          | 3 DAS          | 5 DAS          | 3 DAS          | 5 DAS          |                |
| T1      | Neem oil @ 3%                           | 5<br>(2.24)                  | 4.33<br>(2.08)             | 3.67<br>(1.91) | 3.33<br>(1.83) | 2.67<br>(1.63) | 2.33<br>(1.53) | 1.33<br>(1.15) | 2.94<br>(1.71) |
| T2      | <i>Pongamia</i> oil @ 3%                | 6<br>(2.45)                  | 5.67<br>(2.38)             | 4.33<br>(2.08) | 3.67<br>(1.91) | 3.33<br>(1.83) | 2.67<br>(1.63) | 2.67<br>(1.63) | 3.72<br>(1.93) |
| T3      | Neem leaf extract @ 8%                  | 7<br>(2.65)                  | 6.67<br>(2.58)             | 5.33<br>(2.31) | 4.67<br>(2.16) | 4.00<br>(2.00) | 3.33<br>(1.83) | 3.00<br>(1.73) | 4.50<br>(2.12) |
| T4      | <i>Vitex negundo</i> @ 10 %             | 5<br>(2.24)                  | 4.00<br>(2.16)             | 4.00<br>(2.00) | 3.67<br>(1.91) | 3.33<br>(1.83) | 3.33<br>(1.83) | 3.00<br>(1.73) | 3.55<br>(1.88) |
| T5      | Lantana leaf extract @ 2%               | 6<br>(2.45)                  | 5.67<br>(2.38)             | 5.33<br>(2.31) | 5.00<br>(2.24) | 4.67<br>(2.16) | 4.33<br>(2.08) | 4.00<br>(2.00) | 4.83<br>(2.20) |
| T6      | <i>Annona squamosa</i> seed extract@ 5% | 5<br>(2.24)                  | 5.00<br>(2.24)             | 4.00<br>(2.00) | 3.67<br>(1.91) | 3.33<br>(1.83) | 2.67<br>(1.63) | 2.33<br>(1.53) | 3.50<br>(1.87) |
| T7      | Neem seed kernel extract @ 5%           | 5<br>(2.24)                  | 4.67<br>(2.16)             | 3.67<br>(1.91) | 3.67<br>(1.91) | 3.00<br>(1.73) | 2.00<br>(1.41) | 1.67<br>(1.29) | 3.05<br>(1.75) |
| T8      | <i>Allium sativum</i> rhizome@ 4%       | 6<br>(2.45)                  | 6.00<br>(2.45)             | 5.67<br>(2.38) | 5.33<br>(2.31) | 5.00<br>(2.24) | 4.67<br>(2.16) | 4.33<br>(2.08) | 5.20<br>(2.28) |
| T9      | <i>Zingiber officinale</i> @ 8%         | 5<br>(2.24)                  | 5.00<br>(2.31)             | 4.67<br>(2.24) | 4.67<br>(2.16) | 4.33<br>(2.08) | 4.00<br>(2.00) | 3.67<br>(1.91) | 4.39<br>(2.10) |
| T10     | Untreated control                       | 6<br>(2.45)                  | 5.33<br>(2.31)             | 6.00<br>(2.45) | 6.67<br>(2.58) | 5.67<br>(2.38) | 6.67<br>(2.58) | 7.00<br>(2.65) | 6.22<br>(2.49) |
|         | CD at 0.05 %                            |                              | 1.33                       | 1.33           | 0.91           | 1.11           | 1.67           | 1.26           |                |
|         | SEd                                     |                              | 0.63                       | 0.63           | 0.43           | 0.53           | 0.79           | 0.60           |                |

**Note:** DBS: Day before spray, DAS: Days after spray; Figures in parentheses are  $\sqrt{}$  transformation values

**Five days after first spray.** Neem oil (3.67), neem seed kernel extract (3.67), and neem seed kernel extract (3.67) were found to have a superior reduction in the number of egg masses in the mulberry plant's apical shoots, whereas *Vitex negundo* (4.00) and *Annona squamosa* seed extract (5.00) showed a moderate reduction in the number of egg masses in the mulberry plant's apical shoots. The remaining treatments of *Pongamia* oil (5.67) and *Zingiber officinale* (4.67) recorded slightly reduction in the number of egg masses in the apical shoots of the mulberry (Table 2).

**Third days after second spray.** The results of Table 2 provided that neem oil (3.33) caused the highest reduction in the number of egg masses in the apical shoots of mulberry and neem seed kernel extract (3.67), *Pongamia* oil (3.67), *Annona squamosa* leaf extract (3.67) caused a moderate reduction in the number of egg masses in the apical shoots of the mulberry plant (Table 2).

**Five days after second spray.** The number of colonies per shoot five days after the second spray was furnished in Table 2 showed the highest reductions in the number of egg masses in the apical shoots of the mulberry plant. *Pongamia* oil (3.33), *Vitex negundo* (3.33), and *Annona squamosa* seed extract (3.33) have shown a slight reduction in the egg masses of the apical shoots of mulberry. The other treatments were a slight reduction in the number of egg masses in the apical shoots of mulberry.

**Three days after third spray.** The experiment data revealed that the highest reduction of egg masses in the apical shoots of the mulberry was found in the neem seed kernel extract (2.00). The next best treatment, neem oil (2.33) significantly decreased in the number of egg

masses in the apical shoots of the mulberry. *Pongamia* oil (2.67), *Vitex negundo* (2.67), *Annona squamosa* seed extract were observed to have a moderate reduction in the number of egg masses in the apical shoots of the mulberry.

**Five days after third spray.** The data observed in Table 2 have shown that the neem oil (1.33) treatment was recorded to have the highest number of reductions in the number of egg masses in the apical shoots of the mulberry followed by neem seed kernel extract (1.67) and *Annona squamosa* seed extract (2.33), which were observed to have significant reductions in the number of egg masses in the apical shoots of the mulberry, whereas *Vitex negundo* and neem leaf extract, which are on par with each other, presented a slight reduction in the number of egg masses in the apical shoots of the mulberry

### C. Influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation

The data on influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation in terms of 10 random plants taken in each subplot of every treatment in field recorded at seventh, fourteenth, twenty first day are presented in Fig. 1.

**Seventh day after spray.** Fig. 1 shows that neem seed kernel extract (70.00) and *Vitex negundo* (77.33) have the significantly highest influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation, followed by neem oil and *Pongamia* oil (74.33) have shown moderate influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation. The other treatments show a slight influence on the moisture content of mulberry leaves.

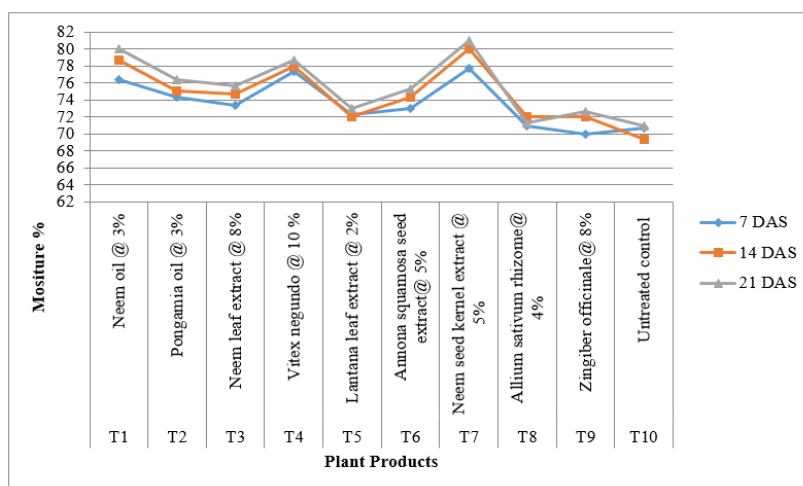


**Fig. 1.** Influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation.

**Fourteenth day after spray.** Fig. 1 revealed that neem seed kernel extract (80.00) had the highest influence of plant extract on moisture content (%) in mulberry leaves with mealy bug infestation, followed by neem oil (78.67) and *Vitex negundo* (80.00). The *Pongamia* oil (75.00) recorded slight influence of plant extracts in moisture content (%) in mulberry leaves with mealy bug infestation.

**Twenty first days after spray.** Fig. 1 shows that the neem seed kernel extract (81.00) has the significantly highest influence of plant extract on moisture content (%) in mulberry leaves with mealy bug infestation, followed by neem oil (80.00) shows a moderate influence of plant extract on moisture content in mulberry leaves with mealy bug infestation.

Further, a small study was conducted on the moisture content of tukra and healthy leaves of mulberry. The

results revealed that the tukra-affected leaves showed a high moisture content (75.92%) compared to normal healthy leaves (71.32%). This was in agreement with Babu *et al.* (1994), who showed that tukra-affected leaves have a higher moisture content (73.50%) when compared to healthy leaves (68.90%) and stated that in general, tukra-affected leaves showed a higher moisture content compared to normal healthy leaves. Further, Shree *et al.* (1989) also reported that tukra-affected leaves showed a higher moisture content (74.50%) compared to healthy mulberry leaves (70.30%) in the Kanva-2 mulberry variety. The same trend was also followed in the Kajili variety, where the tukra affected had 38.00 percent moisture content and 37.60 percent was recorded from healthy leaves. However, the moisture content was almost identical in the Kajili variety, whereas in Kanva-2, there was an increase in the tukra-affected leaves compared to healthy ones. This research also states that the botanicals have shown greater influence on the moisture content of the plant, so they are on par with each other.

Bose *et al.* (1992) reported that the tukra-affected mulberry leaves showed higher moisture content when compared to healthy leaves. After conducting the tests on six mulberry varieties, viz., Local (74.15 and 70.10%), K2 (73.40 and 72.14%), S30 (72.53 and 72.43%), S36 (73.92 and 72.28%), S41 (73.08 and 71.37%), and S54 (75.49 and 73.71%), Similar observations were recorded on the M5 mulberry variety in the present investigation. Bose *et al.* (1992) have concluded that neem oil and neem seed kernel extract have improved the moisture content of mulberry and which is on par with each other.

Babu *et al.* (2001) reported that tukra-affected mulberry leaves recorded a high moisture content compared to healthy leaves. It is due to the curling and wrinkling of the tukra-affected leaf and the only little surface of the

leaf exposed to the sun. In addition, the presence of sooty mould and a higher trichome density may reduce moisture loss. After botanical spray, the affected leaves did not show any alteration with respect to moisture content, moisture loss, or moisture retention capacity in M5 mulberry leaves. There is no significant difference among the botanicals with respect to the above morpho-physiological parameters in the affected mulberry leaves. The research done by Babu *et al.* (1992) shows that the pink mealy bug infestation reduces moisture content, which contradicts my research as applying botanicals has increased predators and reduced tukra infestations

#### *D. Influence of plant extracts in moisture loss (%) in mulberry leaves with mealy bug infestation*

The data on the influence of plant extracts on moisture loss (%) in mulberry leaves with mealy bug infestation in terms of 10 random plants taken in each subplot of every treatment in the field recorded on the seventh, fourteenth, and twenty-first days are presented in Fig. 2.

**Seventh day after spray.** Fig. 2 shows that the neem seed kernel extract (22.33) has a highly significant influence of plant extracts on moisture loss (%) in mulberry leaves with mealy bug infestation, followed by *Vitex negundo* (22.67) and neem oil (23.67). Pongamia oil (25.67) and neem leaf extract (26.67) have shown a moderate influence of plant extracts on moisture loss (%) in mulberry leaves with mealy bug infestation.

**Fourteenth day after spray.** The neem seed kernel extract (20.00) highly significant influence of plant extracts in moisture loss (%) in mulberry leaves with mealy bug infestation, followed by neem oil (21.33), and the other treatments show a slight influence of plant extracts in moisture loss (%) in mulberry leaves with mealy bug infestation (Fig. 2).

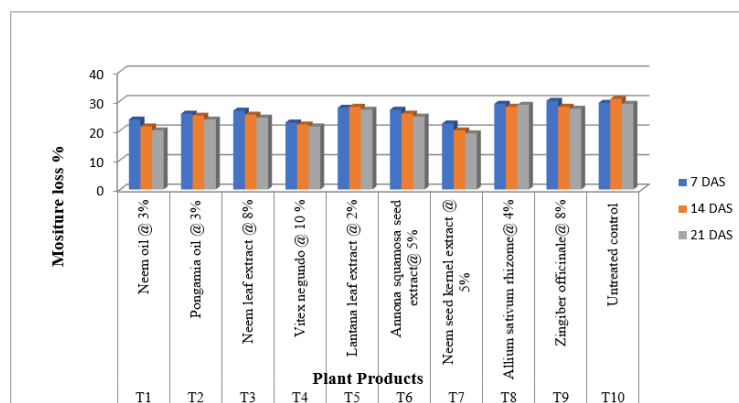


**Fig. 2.** Influence of plant extracts in moisture loss (%) in mulberry leaves with mealy bug infestation.

**Twenty first days after spray.** Finally, Fig. 2 results showed that the neem seed kernel extract (19.00) significantly influenced plant extracts in moisture loss (%) in mulberry leaves with mealy bug infestation. The neem oil (20.00) has shown a moderate influence of plant extracts on moisture loss (%) in mulberry leaves with mealy bug infestation.

#### *E. Influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation*

The data on the influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in terms of 10 random plants taken in each subplot of every treatment in the field recorded on

the seventh, fourteenth, and twenty-first days are presented in Fig. 3.

**Seventh day after spray.** The neem seed kernel extract (79.00) significantly had the highest influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field,

followed by neem oil (78.00) and *Pongamia* oil (77.00) treatments. The other treatments have shown a moderate influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation (Fig. 3).

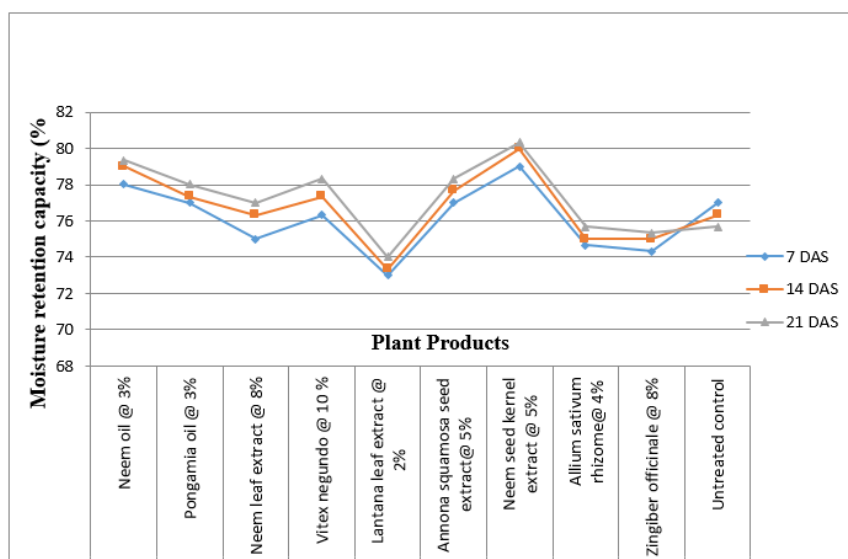


**Fig 3.** Influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation.

**Fourteenth day after spray.** The neem seed kernel extract (80.00) significantly highest influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field. The neem oil (79.00) treatment has shown moderate influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field (Fig. 3).

**Twenty first days after spray.** Fig 3 revealed that the neem seed kernel extract (80.33) significantly highest influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field followed by the neem oil (79.33) treatment. *Vitex negundo* (78.33), *Annona squamosa* seed extract (78.33), *Pongamia* oil (78.00), neem leaf extract (77.00) have shown a moderate influence of plant extracts on moisture retention capacity (%) in mulberry leaves with mealy bug infestation in the mulberry field. Babu *et al.* (1994), who reported that the application of foliar sprays of plant extracts did not affect water loss, relative water content, or moisture retention capacity of tukra diseased mulberry leaves, the research is on par with each other regarding the moisture retention capacity of the pink mealy bug infested mulberry plants.

#### F. Tukra occurrence in mulberry leaves (%)

The botanical spray on tukra-affected leaves was assessed based on infestation by mealy bugs and presented in Table 3. The data revealed that after the first spray, there was no reduction in tukra occurrence,

whereas after the second spray of different botanicals, there was a significant reduction in the infestation.

**After the second spray.** The second spray with neem oil, *vitex*, and neem seed kernel extract resulted in reduced tukra occurrence from 13.91 to 11.08, 22.25 to 13.91, and 16.99 to 13.91 percent, respectively. Remaining plant products had a moderately reduced tukra occurrence (Table 3). The maximum percent protection over pre-count of tukra occurrence was reported in Neem oil @ 3%, Neem seed kernel extract @ 5%, *Vitex negundo* @ 10 % followed by *Pongamia* oil @ 3%, Neem leaf extract @ 8%, Lantana leaf extract @ 2%, *Annona squamosa* seed extract @ 5%, *Allium sativum* rhizome @ 4%, *Zingiber officinale* @ 8% Significant differences among the treatments were observed (Table 3).

**After the third spray.** After the third spray with neem oil, neem seed extract and *Vitex negundo* reduced the tukra occurrence was reduced from 11.08 to 5.58, 13.91 to 2.75, and 13.91 to 5.58 percent, respectively. The following treatments slightly decreased the tukra occurrence in the mulberry field. The maximum percent protection over pre-count of tukra occurrence was reported maximum in Neem oil @ 3%, Neem seed kernel extract @ 5%, *Vitex negundo* @ 10 % followed by *Pongamia* oil @ 3%, Neem leaf extract @ 8%, Lantana leaf extract @ 2%, *Annona squamosa* seed extract @ 5%, *Allium sativum* rhizome @ 4%, *Zingiber officinale* @ 8% Significant differences among the treatments were observed (Table 3).

**Table 3: Effect of plant extracts on tukra occurrence due to *Maconellicoccus hirsutus* in mulberry.**

| Sr. No. | Treatments                               | Pre treatment % | Post treatment % |        |        | % Protection over pre - treatment count |        |
|---------|------------------------------------------|-----------------|------------------|--------|--------|-----------------------------------------|--------|
|         |                                          |                 | 7 DAS            | 14 DAS | 21 DAS | 14 DAS                                  | 21 DAS |
| T1      | Neem oil @ 3%                            | 13.91           | 13.91            | 11.08  | 5.58   | 20.35                                   | 59.88  |
| T2      | <i>Pongamia</i> oil @ 3%                 | 19.41           | 19.41            | 16.66  | 11.08  | 14.17                                   | 42.92  |
| T3      | Neem leaf extract @ 8%                   | 22.25           | 22.25            | 19.41  | 13.91  | 12.76                                   | 37.48  |
| T4      | <i>Vitex negundo</i> @ 10 %              | 22.25           | 22.25            | 13.91  | 5.58   | 37.48                                   | 74.92  |
| T5      | Lantana leaf extract @ 2%                | 25.00           | 25.00            | 19.41  | 8.33   | 22.36                                   | 66.68  |
| T6      | <i>Annona squamosa</i> seed extract @ 5% | 22.25           | 22.25            | 16.66  | 11.08  | 25.12                                   | 50.20  |
| T7      | Neem seed kernel extract @ 5%            | 16.66           | 16.66            | 13.91  | 2.75   | 16.51                                   | 83.49  |
| T8      | <i>Allium sativum</i> rhizome@ 4%        | 27.75           | 27.75            | 25.00  | 13.91  | 9.91                                    | 49.87  |
| T9      | <i>Zingiber officinale</i> @ 8%          | 25.00           | 25.00            | 19.41  | 16.66  | 22.36                                   | 33.36  |
| T10     | Untreated control                        | 38.91           | 38.91            | 30.58  | 22.25  | 21.41                                   | 42.82  |

**Note:** DAS: Days after spray

## CONCLUSION

Mulberry is an inevitable food for silkworms, and the superior quality of cocoon has directly contributed to mulberry leaves. Improper qualities of the mulberry leaf are the feeding of silkworm larvae, which affects larval growth and the weight of the cocoon. Mulberry gardens are undesirable for pesticides due to residue that directly causes silkworm growth and later, the death of larvae. In this study, botanical pesticides significantly decreased the pest population, besides avoiding environmental health hazards. Among the plant products, neem oil and neem seed kernel extract were effective in reducing the mealy bug population in the mulberry field.

## FUTURE SCOPE

- Further research can evaluate different botanical pesticides for effective pest control in mulberry cultivation.
- Studies may focus on integrating botanical pesticides with biological control methods for sustainable pest management.
- Future work can assess the long-term effects of botanical pesticides on silkworm growth, cocoon quality, and silk yield.
- Large-scale field trials can be conducted to confirm their effectiveness under different environmental conditions.

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