GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(RESEARCH ARTICLE)

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Effect of neem derivatives (*Azacdirachta indica*) on the mango mealybug (*Rastrococcus invadens*) for biological control

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GSC Advanced Research and Reviews, 2022, 10(03), 025–031

Publication history: Received on 10 October 2022; revised on 03 March 2022; accepted on 05 March 2022

Article DOI: https://doi.org/10.30574/gscarr.2022.10.3.0215

Abstract

Pest insects are a major constraint on fruit production in Senegal. In order to find an alternative to the chemical control of these pests, the insecticidal effect of neem derivatives (*Azadirachta indica*) formulated at different doses on the mango mealybug (*Rastrococcus invadens*) was studied. The powders obtained from the different parts of the neem were mixed with distilled water in different proportions, namely for 100ml 0g (control), 1g, 2g, 4g, 8g, 16g, 32g, 64g and 124g. The whole, consisting of water and powders of the different parts of neem, was homogenized. For each treatment, 5 repetitions were made over 5 days.

The results obtained show that neem significantly reduced the populations of mealybug on the mango tree. The results also showed that neem is a very effective insecticide against these pests. This effectiveness is all the more important with almond derivatives (100% mortality at a dose of 32g per 100ml) compared to other neem derivatives.

Keywords: *Rastrococcus invadens*; Host plants; Biological control; Senegal

1. Introduction

Rastrococcus invadens known as the mango mealybug is a polyphagous insect native to Southeast Asia, frequently found on many woody, fruit or ornamental plants [1]. Since 1982, this scale has been found in several West African coastal countries such as Togo, Benin, Ivory Coast, Ghana and Nigeria [2]. Its presence in Senegal, in the Dakar region, was first reported in 1995 [3]. It grows on many host plants and can cause extensive damage through stunted leaves, reduced flowering and premature leaf and fruit drop.

On mango, the preferred location for mealybugs is on the underside of the leaves, along the main and secondary veins. But during large infestations of mango, scale insects are also found on the upper surface of leaves, petioles, inflorescences, fruits and peduncles. On well-developed mango leaves are found all stages of development, as well as empty cocoons of males and the resulting exuviae of insect molts [4].

The mealybug attaches to the mango leaf and feeds on the sap of this mango tree. It secretes a substance called honeydew, i.e. a sweet substance that falls on the leaves and in contact with humidity, a black fungus called sooty mold, develops on the plant organ and c is what is found all over the foliage which is covered with the completely black

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substance. So it is this substance, being deposited in abundance on the organs, prevents photosynthesis from occurring properly. The pest has spread extremely quickly and chemical control has not proved effective as up to 80% of the mango harvest is lost in some producing countries such as the Ivory Coast. In order to find new products of natural origin against this insect, plant extracts, accessible and less expensive, are the subject of several investigations. These fall within the framework of the biological control of insect pests since the excessive and uncontrolled use of synthetic insecticides poses a real problem of human health, food safety, environmental pollution and persistence [5].

The objective of this study is to determine the efficacy of neem derivatives on *Rastrococcus. invadens* responsible for the infestations of mango trees in the thies region**.**

2. Material and methods

2.1. Animal material

It consists of the *Rastrococcus invadens* (Hemiptera: Pseudococcidae) [6]. It is a species native to Southeast Asia and remains today one of the most formidable crop pests in the world and particularly mango trees in Senegal. Sampling was carried out on a farm located in Malicounda (Mbour department, Thies region). In this farm we harvested a single variety of mango tree, namely keitt, which is one of the most attacked by *R. invadens* [7]. On this variety, our work relates to three different plants. In each plant, we collected per day at random 27 infested leaves per day for 5 days; which allowed us to have a total of 135 sheets for the experiments.

The work took place during the month of May corresponding to the period of heavy infestation of the mango tree by the insect [8] and [7].

2.2. Plant material (harvest and preparation of neem extracts)

The plant material is made up of different parts of *Azardirachta indica* (Meliaceae): leaves, rinds and almonds**.**

2.2.1. The leaves

The fresh neem leaves were harvested during the day in Malicounda (Department of Mbour, Region of Thiés), dried and spread, stirring them regularly morning and evening in the shade for a week. Then they were crushed using a pestle and mortar well cleaned with toilet paper wrapped around a stick and dry. After sieving, the powder obtained is directly used as active ingredients on mealybugs.

2.2.2. The bark

The neem bark was harvested using a chopper. These were dried in the shade for a week. After drying, they were ground as before and the powder obtained was applied to the cochineals.

2.2.3. Almonds

The fallen ripe neem fruits were picked and shelled to obtain the almonds. These were dried in the shade for a week. After drying, they were ground as before. The resulting powder was applied to the mealybugs.

2.3. Biological tests

The various powders obtained were mixed with distilled water in different proportions, namely for 100ml 0g (control), 1g, 2g, 4g, 8g, 16g, 32g, 64g and 124g. The whole, consisting of water and powders of the different parts of neem, was homogenized. For each treatment, 5 repetitions were made over 5 days. Each day, a batch of 24 leaves (Figure 1) is treated with increasing doses of the mixture obtained with the extracts of neem, 3 leaves for white control. In total, a batch of 8 leaves was treated with neem leaves, a second batch of 8 leaves treated with neem bark and a third batch with neem kernels. The treatment is carried out using a disinfectant sprayer allowing spraying at height with a jet with a range of up to 5 meters (Figure 2). Spraying consists of releasing on each leaf a volume approximately equal to approximately 10 ml of water of the mixture used (ie approximately 5 jets per sheet). These treated leaves are then kept in a container protected by a mosquito net to avoid contact with predators. After each treatment the next day, we find that most of the mealybugs that lost their lives fell off and only the survivors remained hanging on the leaves. We then evaluated the average percentage of insects remaining on each leaf and therefore the percentage for each batch of leaves.

Figure 1 Infested mango leaf

Figure 2 Sprayer

3. Results

Figures (1, 2 and 3) provide information on the sensitivity of insects from the keitt variety to our three extracts from the leaves, bark and seed of neem (*Azacdirecta indica*). The results showed that the mortality varies depending on the product used but also when the dose becomes more and more concentrated. Regarding the white control, the tests carried out during the 5 days of experimentation show that the number of insects remaining in each leaf is still high (90%).

3.1. With neem leaves

As shown in Figure 3, the number of insects on the leaf decreases with concentrations and over time compared to the control (Figure 3).

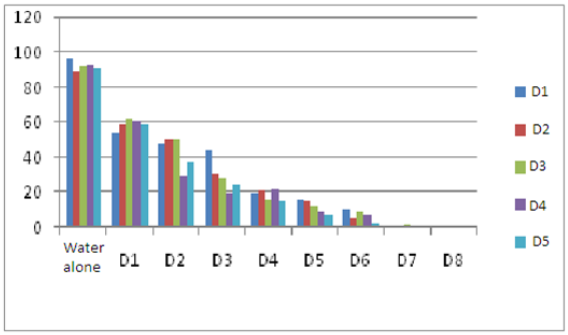

Figure 3 Assessment of the number of insects remaining following the action of the leaves

3.2. With neem bark

With neem bark, the number of insects present decreases depending on the dose until D8 where no insect survives (Figure 4). However, compared with the previous results, there is more insect remaining after treatment.

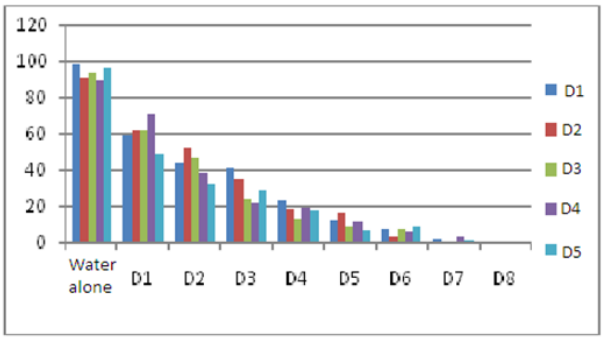

Figure 4 Assessment of the number of insects remaining following the action of the bark

3.3. With neem almonds

For the experiments carried out with neem kernel derivatives, the number of insects present decreases considerably depending on the dose. From the dose (D6), the number of insects present is zero (Figure 5).

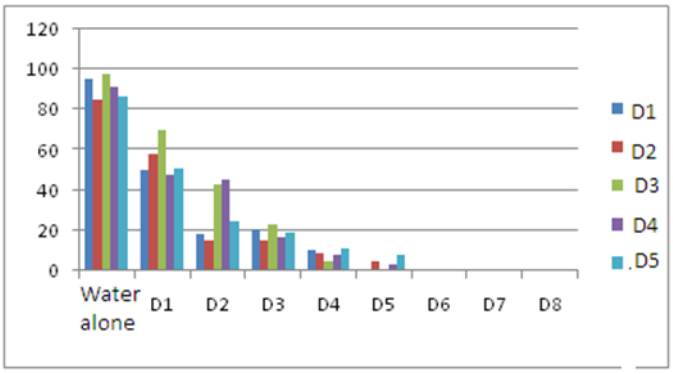

Figure 5 Assessment of the number of insects remaining following the action of the almond

Table 1 Evaluation of the average of the insects surviving on the leaf in each operation for the leaves

	Water alone	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Day 1	98	59	44	41	23	12	07	02	0
Day 2	91	62	52	35	18	16	03	0	0
Day 3	94	62	46	24	13	08	07	0	0
Day 4	89	71	38	22	19	11	05	03	0
Day 5	96	48	32	28	17	06	08	01	0
Medium	93.6	60.4	42.4	30	18	10.6	6	1.2	0
Standard deviation	3.64	8.26	7.6	7.9	3.6	3.8	2	1.3	0

Table 2 Evaluation of the average in each operation for the bark

	Water alone	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Day 1	96	54	48	44	19	16	11	0	0
Day 2	89	59	50	31	21	15	05	0	0
Day 3	92	62	50	28	16	12	09	02	0
Day 4	93	61	29	19	22	09	07	0	0
Day 5	91	59	37	25	15	07	03	0	0
Medium	92.2	59	37	25	15	7	3	0	0
Standard deviation	2.5	3	9.4	9.2	3	3.8	3.2	0.9	0

Tables (1, 2 and 3) show the efficacy of neem-derived products: leaf, bark and seed powders on crop pests (the mealybug of the mango tree).

After treatment after 5 days, we see that the effectiveness of neem varies depending on the parts used and the doses applied.

The results obtained with the standard deviations also show a significant variation in the number of insects depending on the products used.

At a dose (16g / l), neem almond powders induced 100% mortality. At the dose (32g / l), neem bark powders produced 100% mortality and finally at the dose (124g / l), neem leaf powders produced 100% mortality.

Table 3 Evaluation of the mean in each operation for the seed

	Water alone	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Day 1	95	50	18	21	10	0	0	0	0
Day 2	85	58	15	15	09	05	0	0	0
Day 3	98	70	43	23	05	0	0	0	0
Day 4	91	48	45	17	08	03	0	0	0
Day 5	87	51	25	19	11	08	0	0	0
Medium	91.2	55.4	29.2	19	8.6	3.2	0	0	0
Standard deviation	5.4	9	14	3.2	2.3	3.4	0	0	0

Table 4 Summary of the average of the insects surviving on the leaf in each operation for the different parts of the neem

	Water alone	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
Leave	93.6	60.4	42.4	30	18	10.6	6	1.2	0
Bark	92.2	59	37	25	15	7	3	0	0
Almond	91.2	55.4	29.2	19	8.6	3.2	0	0	0

4. Discussion

Despite the application of traditional methods (slaughter and incineration), the infestation remains increasingly high. However, with neem derivatives, insects are completely eliminated with high doses. This confirms the toxicity of neem products against phytophagous pests [9]. Indeed, our results have shown that the different parts of neem exhibit this insecticidal effect against the mealybug. This toxicity depends on the doses of the different parts of the neem plant used. However, our results also showed that scale insects exhibit some sensitivity to water. This explains why the insects are practically washed away by the rains during the rainy season [10]. They are even more sensitive when water is mixed with different neem derivatives (leaves, bark and almonds).

However, this fight only concerns females and immature males. This is because adult males are winged and make good sailors. From the adult stage, males stop feeding and fly off in search of females in order to mate [11]. As females lay several hundred eggs during a lay with 2 to 4 generations per year [12] if the control method used is effective, most insects eventually disappear. But these mealybugs feed on the raw, processed sap, so they can colonize all parts of the host plant. Thanks to their stylet, these stinging-sucking insects pierce plant tissue and collect the sap content [13].

During this study, it was noticed that the cochineals were preferentially found near the flower and vegetative buds, in other words the development organs. The sap produced, containing amino acids and sugars, comes mainly from photosynthetic leaves. The exchanges take place from the leaves to the reserve organs but also from the reserve organs to the stems in formation. Mealybugs therefore go to the places richest in sap. This study confirmed that the neem extract

contains a mixture of several compounds that are responsible for insect mortality. However, the active ingredient in neem is Azadirachtin which is more concentrated in neem seeds. In our work, we found that the mortalities are higher with neem almonds. These results confirm those of [14] who state that neem seed extract is more effective than neem leaf extract in controlling insect pests, thanks to its high concentration of Azadirachtin.

Azadirachtin is believed to cause more than 90% of the effects of most conventional insecticides. This natural active ingredient does not kill insects, at least not immediately, but acts as a repellent, disrupts their growth and reproduction. Research over the past few years has shown it to be one of the most potent growth regulators and feeding deterrents ever discovered in several insect pest species [15].

The analysis of variance shows that there is not a significant difference between the mortality rates induced by the different products derived from neem to different mealybugs.

To date, several previous works have shown the effectiveness of neem and presented it as the main source of botanical pesticides [16], [17], [18], [19], [20].

The use of neem products is considered as alternatives to dangerous synthetic insecticides because they are biodegradable, fertilizing and widely used in traditional and modern pharmacopoeia [21], Faye, 2010[22], [23]. Neem has no harmful effects on beneficial insects and pests cannot develop any resistance to it [24].

The difference in insecticidal activity observed between the different products derived from neem (Tables 2, 3 and 4) could be explained by a differential concentration of azadirachtin in the different parts tested. Indeed, many studies have shown the high concentration of azadirachtin in leaves and especially in neem seeds [25], [26], [22], [23].

5. Conclusion

This study made it possible to understand that the neem plant (*Azacdirachta indica*) is a very effective biological insecticide against the mango mealybug (*Rastrococcus invadens*). However, this effectiveness varies depending on the plant parts used. In fact, for a given dose, mortality is greater with almond powder than with powders from other parts of the plant (bark and leaves).

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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