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The Role of Bio, Organic and Chemical Fertilizers in Enhancing Induced Resistance of Fig Trees (Ficus Carica L.) Against the Fig Wax Scale (Ceroplastes Rusci L.)

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Annotation: A field study was conducted in Bani Muslim village, Babylon Governorate, during the 2024 growing season to evaluate the efficacy of three fertilizer types (bio-, organic, and chemical) and two application methods (foliar application and soil addition) in inducing systemic resistance in fig trees (Ficus carica L.) against the fig wax scale, Ceroplastes rusci L. The study assessed biochemical resistance indicators—specifically Jasmonic Acid (JA), Peroxidase (PO), and Polyphenol Oxidase (PPO)—and their correlation with pest mortality rates. Results demonstrated that organic treatments (Humic acid and Compost) were significantly superior, recording the highest concentrations of defensive compounds (97.5 ppm for JA and 90.4 ppm for PPO). This biochemical enhancement resulted in the highest mortality rates for both nymphs (93.70%) and adults (77.00%). Bio-fertilizers (Bacillus amyloliquefaciens) followed in efficacy, whereas chemical fertilizers (NPK) exhibited the lowest efficacy. These findings suggest that organic and biofertilizers can be integrated as effective components in Integrated Pest Management (IPM) programs for fig orchards to enhance host plant resistance.

Keywords: Ceroplastes rusci, Ficus carica, Induced Resistance, IPM, Jasmonic Acid, Peroxidase.

INTRODUCTION

The fig tree (*Ficus carica* L.) is a major economic fruit crop widely cultivated across the Mediterranean basin and the Middle East, including Iraq. Fig fruits are valued for their high nutritional and medicinal properties, being rich in carbohydrates, proteins, minerals, and vitamins (Askoy et al., 2003; Goziekci, 2010). However, fig production faces significant constraints due to various biotic and environmental stresses that adversely affect vegetative growth and yield (Morales-González et al., 2019).

Insect pests represent a primary biological constraint to fig production. The fig wax scale, *Ceroplastes rusci* L. (Hemiptera: Coccidae), is considered a key pest. It causes direct damage by sucking plant sap from leaves, branches, and fruits, and indirect damage via the excretion of honeydew. This excretion facilitates the growth of sooty mold fungi, which inhibits photosynthesis and respiration, thereby reducing the marketability of the fruit (El-Gali et al., 2019; Sarita and Tecchio, 2009; Al-Mallah and Al-Mallah, 2017).

Due to environmental and health concerns associated with the excessive use of synthetic pesticides, plant protection research has shifted toward eco-friendly alternatives." Induced Resistance" via bio- and organic fertilizers offers a promising approach. These treatments stimulate the plant's immune system to produce secondary metabolites, oxidative enzymes such as Peroxidase (PO) and Polyphenol Oxidase (PPO), and defense hormones like Jasmonic Acid, which play a pivotal role in deterring insect attacks (Zhang et al., 2006; Beneduzi et al., 2012). This study aims to compare the efficacy of bio-, organic, and chemical fertilizers (applied via foliar spray or soil drench) in inducing systemic resistance in fig trees against *C. rusci*.

MATERIALS AND METHODS

The field experiment was conducted in a private orchard in Bani Muslim village, Babylon Governorate, on 15-year-old fig trees (cv. 'Sultani') from April 7, 2024, to May 7, 2024. The experiment was laid out in a Randomized Complete Block Design (RCBD). Three homogenous trees were selected for each treatment (3 replicates), in addition to a control treatment (water spray only).

The study included the following treatments:

1. **Bio-fertilizers:** A commercial formulation (Amyloland) containing *Bacillus amyloliquefaciens* (20×10^9 CFU/g) was used. For foliar application, 100 g was dissolved in 30 L of water. For soil application, the solution was added as a drench around the root zone.
2. **Organic Fertilizers:**

- **Humic Acid:** Applied as a foliar spray at a concentration of 1.5 ml/L (0.015%).
- **Compost:** Decomposed animal manure was added to the soil at a rate of 5 kg/tree in a circular trench 20 cm from the trunk.

3. **Chemical Fertilizers (NPK):** A balanced fertilizer (15:15:15) was used. For foliar application, the concentration was 0.5 g/L (10 g/20 L water). For soil application, 300 g/tree was incorporated into the soil.

Insect populations (nymphs and adults, live and dead) were recorded pre-treatment and at 3, 5, 7, 10, 14, 21, 28, and 30 days post-treatment (DAT). Mortality percentages were calculated using standard correction formulas.

Leaf samples were collected post-treatment for the following assays:

- **Peroxidase (PO) Activity:** Extracted using sodium phosphate buffer (0.1M, pH 6.5) and quantified spectrophotometrically at 420 nm following (Al-Sufi., 2001; Hameed., 2002).

The enzyme activity was calculated based on the following equation:

Activity = $\frac{\Delta A/\Delta t}{\Delta t/W}$

Where: ΔA: Change in absorbance (device reading). Δt: Change in time (minute). W: Fresh weight (g).

- **Polyphenol Oxidase (PPO) Activity:** Assayed using catechol as a substrate, with absorbance measured at 495 nm according to (Abdul-Rahim.,1983). The activity was calculated based on the equation:

- ✓ A = E × B × C
- ✓ Where: A: Absorbance (495 nm)
- ✓ E: Extinction coefficient =2.5 × 10^4 mol/cm

- **Jasmonic Acid (JA) Concentration:** Extracted with methanol and quantified using High-Performance Liquid Chromatography (HPLC) at 254 nm following (Islam et al.,2019).

Data were analyzed statistically, and means were compared using the Least Significant Difference (L.S.D) test at a probability level of 0.05.

RESULTS AND DISCUSSION

Effect of Treatments on *C. rusci* Mortality

Table (1) illustrates the efficacy of different treatments on nymph mortality. Foliar application of Humic acid (organic) was significantly superior to other treatments, recording the highest mortality rate of 93.70% at 30 DAT, followed by Compost (85.80%). Chemical treatments (NPK) and soil-applied bio-fertilizers recorded the lowest mortality rates.

Table (1): Effect of bio-, organic, and chemical fertilizers on the mortality percentage (%) of C. rusci nymphs under field conditions.

Treatments	Application Method	3 Days	7 Days	14 Days	21 Days	28 Days	30 Days	Mean
B. amyloliquefaciens	Foliar	8.10%	14.20%	57.70%	63.50%	72.10%	77.10%	38.66%
B. amyloliquefaciens	Soil	34.30%	35.50%	42.70%	38.80%	53.30%	55.20%	40.52%
Humic Acid	Foliar	16.40%	55.80%	64.80%	88.80%	90.10%	93.70%	62.39%
Compost	Soil	3.10%	7.00%	32.40%	34.60%	82.50%	85.80%	27.16%
NPK	Foliar	12.50%	7.20%	19.90%	33.70%	38.60%	47.80%	21.46%
NPK	Soil	12.00%	5.20%	13.10%	30.90%	34.10%	42.70%	18.00%
L.S.D (0.05)								

Effect of Treatments on C. rusci Adult Mortality

Data in Table (2) show a similar trend for adults, where organic treatments demonstrated the highest efficacy. Humic acid treatment achieved 77.00% mortality at 30 DAT, with no significant difference compared to Compost (74.12%). Chemical treatments remained relatively less effective.

Table (2): Effect of treatments on the mortality percentage (%) of C. rusci adults under field conditions.

Treatments	Application Method	3 Days	7 Days	14 Days	21 Days	28 Days	30 Days	Mean
B. amyloliquefaciens	Foliar	2.60	9.10	40.40	67.10	69.50	71.00	40.02
B. amyloliquefaciens	Soil	1.70	0.00	21.10	49.00	12.57	67.00	29.09
Humic Acid	Foliar	8.30	57.70	68.00	71.80	75.00	77.00	73.10
Compost	Soil	1.70	21.12	65.70	68.00	70.00	74.12	61.09
NPK	Foliar	0.00	18.90	34.00	51.00	12.57	60.40	71.14
NPK	Soil	0.00	16.60	49.70	55.08	58.79	67.99	77.62
L.S.D (0.05)								24.9

Effect of Treatments on Defense Compound Concentrations

Table (3) indicates a positive correlation between specific treatments and the levels of defense compounds. Humic acid treatment caused a significant increase in Jasmonic Acid (97.50 ppm) and PPO (90.40 ppm) compared to the Control. The bio-fertilizer (*B. amyloliquefaciens*) also showed notable activity in elevating these compounds.

Table (3): Concentrations of induced defense compounds (ppm) in fig leaves.

Treatment	Application Method	Jasmonic Acid (JA)	Peroxidase (PO)	Polyphenol Oxidase (PPO)
Control	-	34.30	0.10	0.30
Humic Acid	Foliar	97.50	20.95	90.40
Compost	Soil	77.00	2.21	0.60
B. amyloliquefaciens	Foliar	71.00	0.30	91.40
B. amyloliquefaciens	Soil	56.70	0.45	16.33
NPK	Foliar	64.40	10.82	56.50
NPK	Soil	49.00	40.80	27.73

CONCLUSIONS

The study showed that the biofertilizer Bacillus amyloliquefaciens was effective in controlling the pest through a dual mechanism involving production of secondary metabolites and activation of defense enzymes (Jamil, 2007; Beneduzi et al., 2012). It also found that organic fertilizers, such as humic acid and compost, were the most effective in controlling fig wax scale insect. These fertilizers enhanced the immune system of fig trees by increasing defense compounds like jasmonic acid, peroxidase enzymes, and polyphenol oxidase, leading to enhanced systemic acquired resistance (Ghebrial et al., 2020). Organic amendments also contributed to improved tree growth and fruit production (Sarita and Tecchio, 2009). In contrast, chemical fertilizers were less effective in pest control compared to organic and biological methods, despite improving vegetative growth (Wang et al., 2013; Morales-González et al., 2019). The study recommends integrating organic and biofertilizers as a sustainable strategy in integrated pest management programs in fig orchards.

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