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Original Research Paper

Evaluating the efficiency of some pesticides and insect growth regulators in controlling the whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae) on eggplant plants in the field

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Abstract:

The study was conducted to evaluate the efficacy of certain insect growth regulators Match (lufenuron) and Denim Fit (lufenuron + emamectin benzoate), and Applaud (Buprofezin) and the botanical pesticide Oxymatrine in controlling the whitefly *Bemisia tabaci* on eggplant plants in Green houses during the 2023–2024 growing season. The study results showed that all growth regulators and pesticides reduced the number of whitefly nymphs, particularly 7 and 14 days after treatment, compared to an increase in the control treatment. The growth regulator Applaud was the most effective at reducing nymph numbers; the number of nymphs in the Applaud treatment 61 nymphs per 6 leaves, compared to 622 nymphs per 6 leaves, respectively, while the control group had 1,745 nymphs 28 days after treatment. The highest relative efficacy was achieved by the growth regulators Applaud and Match and the insecticide Oxymatrine 14 days after treatment, reaching 96.70%, 62.80%, and 66.70% respectively, while that of the chemical pesticide Ballistic was 50%. The results showed that the reduction in whitefly populations in the treatments with growth regulators and the pesticide Oxymatrine was reflected in improved production traits—namely, the number of flowers, the fruit-setting rate, and the number and weight of fruits compared to the decline observed in the control treatment. The growth regulator Applaud and the Ballistic-based insecticide can be considered among the best pesticides for controlling whiteflies.

Keywords: Whitefly—*Bemisia tabaci*—insect growth regulators—Match, Denim Fit , and Applaud.

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A Plastic greenhouse measuring 19 × 3 meters was set up in Salman Pak, Baghdad, during the 2023–2024 growing season, where all agricultural operations were carried out to prepare the soil for planting, and a drip irrigation system was installed, , The greenhouse was divided into three sections representing three replicates, and 100 eggplant seedlings were planted at 40 cm intervals, with an average of 8 plants per replicate for each treatment. The treatments were assigned randomly, and spraying was conducted on March 17, 2024, Various treatments were conducted, including Match 50 EC (lufenuron) at 1 mL/L, Denim Fit UV 45WG (lufenuron + emamectin benzoate) at a concentration of 1 g/L, Applaud 25WP (buprofezin at 1 g/L), the Ballistic insecticide (emamectin benzoate2%+ Abamectin2%) at 1 mL/L, and Oxymatrine 2.4 SL at 1 mL/L. For the control treatment, and for the purpose of evaluating the efficacy of the growth regulators and Oxymatrine, the following criteria were adopted:

1. Evaluation of the efficacy of growth regulators and the insecticide Oxymatrine on the population density of whitefly nymphs:
   To evaluate the efficacy of growth regulators and the pesticide Oxymatrine, I collected 6 leaves from each replicate one day before treatment and at 1, 3, 7, 14, 21, and 28 days after treatment. The leaves were placed in sealed Plastic bags and transported to the laboratory to count the number of Sitting stages. The number of Sitting stages was counted using a light microscope at 2X magnification on the underside of each leaf (Stansly and Natwick, 2009). To calculate relative efficiency, the equation by Henderson and Tilton (1955) was used.

   Relative Efficacy (%) = (1 − [(Live individuals in control before treatment × Live individuals in treatment after treatment) / (Live individuals in control after treatment × Live individuals in treatment before treatment)]) × 100.

2. Effect of treatments on production traits (number of flowers, number of fruits, fruit set percentage):
   Eight plants were selected from each replicate of each treatment at the onset of flowering. The number of flowers and the number of fruits formed after fruit set were counted, along with the percentage of fruit set one day before the treatment and at 1, 3, 7, 14, 21, 28days after the treatment. Harvesting began, and the number of fruits was counted upon observation of fully ripe fruits on all plants; the final number and weight of fruits per plant were then calculated for the different treatments.

I. Introduction:

The eggplant (*Solanum melongena* L.) is one of the most important plants in the nightshade family (Solanaceae) and is a major crop grown in various tropical and 15 temperate regions around the world (Kashyap et al., 2002), Eggplant is susceptible to numerous insect pests, including fruit and stem borers, leaf miners, aphids, whiteflies, thrips, and other pests (Srinivasan, 2009).

The whitefly *B. tabaci* is one of the most economically significant agricultural pests in the world, due in part to its widespread distribution, adaptability, broad host range, and ability to transmit more than 110 plant-pathogenic viruses (Malumphy et al., 2017), The whitefly *B. tabaci* causes direct damage to plants through its feeding activity and indirect damage by contaminating leaves with honeydew, which leads to the development of black mold, thereby limiting photosynthesis (Nomikou et al., 2003), Outbreaks of the whitefly *B. tabaci* worldwide cause yield losses and economic damage to many crop species (Ahmad, 1996; Gerling and Mayer, 1996).

To meet the need for greater diversity in insecticides for controlling *B. tabaci* through the development of non-toxic insect growth regulators (IGRs) (Horowitz and Ishaaya, 1996) , and that buprofezin was the first selective IGR introduced to control *B. tabaci* in cotton (Horowitz and Ishaaya, 1992), and the growth regulator novaluron, a chitin synthesis inhibitor belonging to the benzoylphenyl urea (BPU) class, also has some effect on *B. tabaci* (Ishaaya et al., (2003), as insect growth regulators (IGRs) provide a good alternative for selective insect pest control, with minimal impact on predators (Al-Shannaf, 2012).

The growth regulator lufenuron also demonstrated a highly significant effect on *B. tabaci* populations over two consecutive seasons, 2017 and 2018 (El-Kawas and Khedr, 2019).

Given the economic importance of the eggplant crop, the significant economic damage caused by the whitefly, the increasing damage it inflicts in greenhouses, the rapid development of resistance to pesticides, the search for safe alternatives to chemical pesticides, and the goal of safe, sustainable agriculture, this study aimed to evaluate the effectiveness of certain growth regulators and insect growth regulators Match (lufenuron), Denim Fit (lufenuron + emamectin benzoate), and Applaud (buprofezin) as well as the Ballistic Insecticide(emamectin benzoate+ Abamectin)and the botanical pesticide Oxymatrine—in reducing whitefly populations on eggplant plants in greenhouses.

Materials and Methods:

whitefly sitting nymphs on eggplantplants treated with various growth regulators and pesticides

Number of seated nymphs one day after treatment (nymph per 4 leaves)							
Tretmeant	**Before the tretmeant**	**After 1**	**After 3**	**After 7**	**After 14**	**After 21**	**After28**
Match (lufenuron)	**521.00**	**532.00**	**143.00**	**309.00**	**387.00**	**597.00**	**594.00**
Applaud (Buprofezin)	**383.00**	**516.00**	**542.00**	**308.00**	**45.00**	**40.00**	**61.00**
Oxymatrine	**888.00**	**902.00**	**312.00**	**401.00**	**702.00**	**520.00**	**622.00**
Denim Fit +lufenuron) (Emamectin benzoate	**183.00**	**256.00**	**96.00**	**178.00**	**846.00**	**1202.00**	**1326.00**
Control tretmeant (distilled water only)	**307.00**	**370.00**	**245.00**	**559.00**	**1395.00**	**1739.00**	**1745.00**
BallisticPesticide (Emamectin benzoate+ Abamectin **)**	**258.00**	**319.00**	**110.00**	**262.00**	**405.00**	**790.00**	**775.00**
LSD5%	**694.00**						
Mean	**423.33**	**482.50**	**241.33**	**336.17**	**630.00**	**814.67**	**853.83**
LSD 5%	283.3						
LSD Tretmeant= 262.3 **LSDTime=** 283.3 **LSDTretmeant×Time=** 694.0							

3. Statistical Analysis:

A completely randomized block design was used to conduct the studies; the least significant difference criterion was applied; and GenStat 2012 was used for data analysis.

Results and Discussion:

The results of the study showed that the growth regulators Applaud and Match, and the pesticide Oxymatrine, were effective in reducing the number of sitting nymph, minimising the damage caused and its was reflected in the increase in the number of flowers and the fruit-setting rate.

A-The effect of growth regulators and pesticides on the numbers of whitefly's sitting nymphs:

It is clear from the results in Table (1) that the growth regulators and insecticides had their greatest effect 7 and 14 days after treatment, and the numbers of sitthing nymphs began to increase gradually, with the exception of Applaud, whose effect continued to reduce numbers until 28 days after treatment. All treatments were effective in reducing the nymph population compared with the increase observed in the control treatment.

The growth regulator Applaud outperformed the other treatments and the control treatment at 14, 21 and 28 days after treatment, recording the lowest number of nymph—45, 40 and 61 nymph per 6 leaves, respectively—with statistically significant differences compared to the control treatment, which recorded 1,395, 1739 and 1,745 nymph per 6 leaves. As for the insecticides, the Oxymatrine insecticide proved to be more effective than **Ballistic** in reducing the nymph population.

The results of the study showed that relative efficiency varied depending on the type of growth regulator and pesticide and the duration (Table 2); as can be seen from the results in Table 2 the growth regulator Applaud outperformed the other treatments 14 days after application, recording the highest relative efficacy of 96.70 %, whilst Match and Oxymatrine recorded 62.80 % and 66.70 %respectively; Denim Fit , however, recorded the lowest relative efficacy of 38 %14 days after application. After 28 days, Applaud outperformed the other treatments by statistically significant margins, recording a relative efficacy of 83.50 % whilst Match and Oxymatrine recorded efficacies of 62.60 % and 57.80 % respectively, and the **Ballistic** insecticide recorded a relative efficacy of 55 %. Denim Fit , however, was the least effective 28 days after treatment, with an efficacy of 25.10%.**able (1) Number of *B. tabaci***

chitin, the procuticle of the whitefly loses its elasticity and the insect is unable to moult (De Cock and Degheele, 1998). Furthermore, buprofezin is effective against the immature stages but not against adults.

El-Kawas and Khedr (2019) carried out a study on the effect of four insect growth regulators belonging to two main groups: chitin synthesis inhibitors (CSIs) – lufenuron and teflubenzuron – and non-steroidal esteroid agonists (NEAs) – methoxyfenozide and chromafenozide – compared with two conventional insecticides: chlorfenapyr and profenofos, against the cotton leafworm *Spodoptera littoralis* (Boisd.) and sucking pests: *Bemisia tabaci* (Genn.), *Empoasca* spp. and Koch's *Tetranychus urticae*. The results showed that lufenuron demonstrated high efficacy against all pests tested, particularly against *S. littoralis*, which exhibited a very significant initial and residual reduction compared with the other compounds in 2017 and 2018.

Al-Ani (2020) also noted that treatment with the growth regulator Applaud achieved a relative efficacy of 82.83 % on the sitting stages of whitefly nymphs following treatment (first week) and helped to protect the fruit from deformities during the 2018 spring season. Furthermore, laboratory and field studies confirm the effectiveness of insect growth regulators (IGRs), particularly in targeting the larval stage of mosquitoes (Okugbo and Sahabi, 2025).

B. The effect of treatment with growth regulators and pesticides on certain production characteristics:

The results of the study demonstrated the effectiveness of growth regulators and pesticides in reducing the damage caused by whitefly infestation, which was reflected in certain production traits; the treatments proved effective in reducing flower drop and increasing fruit set, fruit number and fruit weight.

It is clear from the results in Table (3) that all growth regulators outperformed the control in increasing the total number of flowers per plant during the season, followed by the chemical pesticides; the lowest figures were recorded in the control treatment, whilst the highest were observed in the Applaud and Denim Fit treatments, at 43.33 and 42.66 respectively. whilst in the Match treatment the figure was the lowest at 30.99; for the **Ballistic** pesticide it was 46; for Oxymatrine it was 35; and the lowest figure in the control treatment was 30.67 flowers.

As for the fruit set rate in the treated eggplant plants, the results in Table (4) show that the growth regulator Applaud achieved the highest fruit set rates compared with the other

Table (2) Relative efficacy (%) of growth regulators and pesticides (Applaud, Match, Denim Fit and Oxymatrine) against the whitefly *B. tabaci* on eggplant plants in green house

Relative efficiency (%)						
Tretmeant	**After1**	**After3**	**After7**	**After14**	**After21**	**After28**
Match (lufenuron)	**25.00**	**56.90**	**53.20**	**62.80**	**62.80**	**62.60**
Applaud (Buprofezin)	**14.80**	**21.30**	**66.70**	**96.70**	**61.80**	**83.50**
Oxymatrine	**19.50**	**37.20**	**51.90**	**66.70**	**60.00**	**57.80**
Denim Fit) lufenu +ron (Emamectin benzoate	**13.30**	**39.00**	**51.50**	**38.00**	**26.50**	**25.10**
Ballistic Pesticide (Emamectin benzoate+ Abamectin **)**	**17.00**	**45.80**	**39.20**	**50.00**	**51.60**	**55.00**
LSD5%	**18.16**					
Mean	**17.92**	**40.04**	**52.50**	**62.84**	**52.54**	**56.80**
LSD 5%	**8.12**					
LSD Tretmeant= 7.41 LSDTime= 8.12 LSDTretmeant×Time=18.16						

The effectiveness of the growth regulator Applaud may be attributed to the fact that it is a growth regulator specifically designed for the whitefly and that it affects the insect's incomplete life stages through contact and physiological mechanisms.

The active ingredient, buprofezin, is a compound similar to thiadizine; it has long-lasting activity and persistence, acts as a chitin synthesis inhibitor, and exerts its effect through contact and vapour action. It affects the nymph stages of sucking insects, particularly whiteflies (De Cock, 1988; Deghele; Ishaaya et al., 1988),Its mode of action is similar to that of BPU units, although its structure is not the same. Due to a lack of

							after treatment
Match (lufenuron)	**4.33**	**4.33**	**5.33**	**5.33**	**5.67**	**6.00**	30.99
Applaud (Buprofezin)	**4.67**	**4.67**	**7.33**	**8.00**	**10.33**	**8.33**	43.33
Oxymatrine	**4.33**	**4.33**	**6.00**	**6.00**	**5.67**	**8.67**	35
Denim Fit) lufenuron + (Emamectin benzoate	**6.00**	**6.00**	**7.33**	**7.33**	**6.33**	**9.67**	42.66
Control tretmeant (distilled water only)	**5.00**	**5.00**	**5.00**	**5.00**	**3.67**	**7.00**	30.67
Ballistic Pesticide (Emamectin benzoate + Abamectin)	**5.67**	**5.67**	**8.33**	**8.33**	**8.00**	**10.00**	46
LSD5%	**ns (**2.967**)**						
Mean	**5.00**	**5.00**	**6.55**	**6.67**	**6.61**	**8.28**	
LSD 5%	1.211						
LSD Tretmeant= 1.122 **LSDTime=** 1.211 **LSDTretmeant×Time=** 2.967							

Table (4) Fruit-setting rate in eggplants treated with various growth regulators and pesticides

treatments and the control treatment, recording 41.10%, compared with 29.40% for the **Ballistic** pesticide, whilst the control treatment recorded 0% 14 days after treatment. 28days after treatment, Oxymatrine achieved the highest rate of 47.60 % , followed by the Applaud pesticide at 43.50 % and the **Ballistic** pesticide at 43.30 %, followed by Denim Fit at 32.10 %, Match at 29.20 % and, finally, the control at 26.80 %.

As for the final yield of Eggplant plants treated with growth regulators and pesticides, Table (5) shows that they are effective in increasing yield compared with the control treatment, with statistically significant differences. The highest number of fruits was recorded in the Applaud treatment (12 fruits), followed by the **Ballistic** pesticide treatment (9 fruits), Denim Fit (8.33 fruits), and Match and Oxymatrine (7.00 fruits), whilst the lowest was in the control treatment (5.67 fruits). The total fruit weight corresponded with the number of fruits; the highest was recorded in the Applaud treatment at 1,755.00 g, followed by the **Ballistic** treatment at 1,290.67 g, whilst the lowest was in the control treatment at 531.00 g.

The effect of growth regulators on productive traits may be due to their ability to reduce infestation by whitefly nymphs, which in turn leads to increased plant growth and higher yields, as well as a reduction in the toxins secreted by whiteflies that cause flower drop; furthermore, these regulators have a direct effect on the plant by stimulating plant growth and increasing its productivity.

The growth regulator Applaud has demonstrated high efficacy in reducing whitefly infestation; it can therefore be used as a product that is safe for both humans and the environment, acting as a slow-acting pesticide and an alternative to conventional chemical pesticides.

It can be concluded from the study that the use of growth regulators offers a promising and safe alternative to chemical pesticides, promoting a clean and safe environment, sustainable agriculture, and the protection of beneficial organisms and consumers from the side effects of chemical pesticides and pesticide resistance in the control of the whitefly.

Table (3) Flower number on eggplant plants treated with various growth regulators and pesticides

Total number of flowers							
Tretmeant	**After 1**	**After 3**	**After 7**	**After 14**	**After 21**	**After28**	**Total number of flowers**

Fruit set percentage %							
Tretmeant	Before the tretmeant	After1	After3	After7	After14	After21	After28
Match (lufenuron)	0.00	0.00	0.00	20.80	20.80	27.50	29.20
Applaud (Buprofezin)	0.00	0.00	0.00	36.10	41.10	37.00	43.50
Oxymatrine	0.00	0.00	0.00	22.00	22.00	81.50	47.60
Denim Fit (Emamectin benzoate +lufenuron)	0.00	0.00	0.00	16.90	16.90	48.80	32.10
Control tretmeant (distilled water only)	0.00	0.00	0.00	0.00	0.00	40.00	26.80
Ballistic Pesticide (Emamectin benzoate+ Abamectin)	0.00	0.00	0.00	29.40	29.40	56.40	43.30
LSD5%	ns(22.54)						
Mean	0.00	0.00	0.00	20.87	21.70	48.53	37.08
LSD 5%	9.20						
LSD Tretmeant= 8.52 LSDTretmeant×Time= 22.54						LSDTime= 9.20	

Table (5) Number and weight of fruits on eggplant plants treated with various growth regulators and pesticides.

Tretmeant	Final number of fruits	Fruit weight(g)
Match (lufenuron)	7.00	858.67
Applaud (Buprofezin)	12.00	1755.00
Oxymatrine	7.00	1643.33
Denim Fit (Emamectin benzoate +lufenuron)	8.33	1110.33
Control tretmeant (distilled water only)	5.67	531.00
Ballistic Pesticide (Emamectin benzoate + Abamectin)	9.00	1290.67
LSD5%	1.82	76.91

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