Research Article

Effect of Insecticides Spartan EC, Appland WP and Bestor10EC on the Pathogencity of Some Soil-Borne Fungi

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Abstract | The study investigated the impact of the insecticides Spartan EC, Appland WP, and Bestor 10EC on the pathogenic interactions of soil-Borne non-target organisms. The results showed these pesticides stimulated the growth of certain fungi, including *Aspergillus terreus* and *Aspergillus clavatus*. Specifically, the application of Spartan and Appland increased the prevalence of *A. terreus* and *Botrytis cinerea*, while Bestor enhanced fungal growth to percentages of 53.78%, 74.15%, 30.92%, 45.31%, 8.95%, and 51.94% on solid culture media (PDA). In liquid media (PDB), which was used to measure the wet biomass weight, stimulation effects were observed with Spartan and Bestor on *A. terreus*, *A. flavus*, *A. clavatus*, and *B. cinerea*. For Appland, significant interactions were observed with *A. terreus*, achieving biomass increases of 39.91%, 14.54%, 70.62%, 13.16%, 34.95%, 48.35%, 25.83%, 4.02%, and 59.27%, respectively. Furthermore, dry biomass weight measurements in PDB revealed that Bestor promoted growth in all fungi tested, Spartan enhanced all fungi except *A. flavus*, and Appland stimulated *A. terreus* and *B. cinerea*, with growth percentages recorded at 24.39%, 48.48%, 71.21%, 73.91%, 51.16%, 29.54%, 42.42%, 87.50%, 72.72%, 51.56%, and 75.00%, respectively. These results underscore the potential of these insecticides to indirectly influence soil fungal populations, emphasizing the need for further ecological risk assessments.

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Introduction

Chemical pesticides have achieved incredible effectiveness in promoting and improving agricultural productivity, making them the most acceptable and frequently utilized compared to other approaches, despite the severe side effects induced by the process of employing these chemicals in the environment (Al-Mallah, 2015), As the unconsidered excessive use of chemical pesticides has led to contamination of the aquatic environment, air, and soil, which subsequently harms living creatures in contaminated areas in all parts of the world, due to the build up of hazardous compounds within

the many food chains (Beyer and Biziuk, 2008). Using pesticides in any pest management program helps to ensure timely control of pests before they reach economically harmful levels. However, some pesticides negatively affect the environment, especially when using broad-spectrum pesticides that affect other non-target organisms (Al-Shafi'i, 2022). The soil biota constitutes a highly intricate and dynamic system, encompassing diverse genera of bacteria, fungi, actinomycetes, and algae (Lehmann *et al*., 2017). These microbial communities engage in complex interactions that regulate fundamental ecological processes, including the recycling of essential nutrients, organic matter decomposition, humus formation, stabilization of soil structure, and the degradation of pesticides (Morris and Blackwood, 2024). They also facilitate critical biochemical activities such as nitrogen fixation, mineralization of carbon, nitrogen, phosphorus, and other essential elements, as well as the synthesis of organic compounds through chemo- and photosynthesis (Cao *et al*., 2018). These collective processes are pivotal for maintaining soil fertility, reflecting a delicate equilibrium between microorganisms, soil, and plants (Aqeel *et al*., 2023). Disruptions to this finely balanced system, particularly through the application of insecticides, can profoundly alter microbial-mediated functions, with cascading effects on soil fertility (Gupta *et al*., 2024). The indiscriminate use of chemical agents, without consideration of the intricate microbiological networks involved, risks undermining the natural processes essential for sustaining soil health and productivity (Reddy, 2013). Since it is difficult to dispense with chemical pesticides to produce crops that are safe from infection with various pests, the focus has become on using specialized pesticides, while reducing spraying times, adopting monitoring methods, and calculating economic limits, to reduce their damage as much as possible to human health and the safety of the agricultural ecosystem from problems of pollution and its residues in parts of the biosphere (Shaaban and Mallah, 1993). Therefore, the objective of this study was to demonstrate the effect of the insecticides Spartan EC, Appland WP, and Bestor10EC on the pathogenic behaviour of non-target fungi which are endemic in the soil.

Materials and Methods

Pesticides

The following insecticides: Spartan EC, Appland WP, and Bestor10EC, where Spartan EC (Deltamethrin 25%) manufactured by Agria (Agria/Sciences) and was used at a dosage of 75 ml/100 liters. Appland WP (Buprofezin 25%) produced by Nihon (Nohyaku) with a dosage of 100-150 gm/100 liters, and Bestor 10EC (Alpha- cypermethrin10%) manufactured by FMC (Belgian) and used at 100 ml/100 L water.

Types of media culture

Potato dextrose agar (PDA) medium: This medium was prepared by dissolving 39 grams of pre-formulated powder in one litre of distilled water, following the manufacturer's guidelines. The medium was sterilized by autoclaving in flasks at 121°C and 15 psi for 20 minutes. After sterilization, the flasks were allowed to cool to room temperature. Before the medium solidified, it was aseptically poured into sterile plastic Petri dishes. Once solidified, the Petri dishes were stored at 4°C in a refrigerator until future tests.

Potato sucrose broth

This culture medium was prepared in the same way as mentioned in previously, without adding agar to it. Then it was added to glass flasks in an amount of 150 ml for each flask. It was closed and sterilized in the same way, and then it was stored in the refrigerator until use. This medium was to obtain fungal filtrate and determine the biomass of the fungi used in pesticide analysis.

Isolation of pathogenic fungi

Soil samples were collected from the orchards of the Najaf Governorate and from specific areas by the Najaf Agriculture Directorate, and the thinning method was used, as 1 gram of the soil to be isolated was taken after it was taken randomly, mixed, sieved, and stored in plastic bags. Isolation was made from these samples by dilution taking 1 gram of soil from the sample and then adding it to test tubes containing 9 ml of distilled and sterile water and shaking well. Then 1 ml was taken from the first dilution and added to the second, then the third, and the fourth dilution, respectively. To the seventh dilution, then we took 1 ml of each of the dilutions 10^{-5}, 10^{-6}, and 10^{-7} and added it to the Petri dish. Then added the previously prepared potato medium to it after thawing and stirring with a rotary motion to ensure homogeneity. The dishes were left to solidify, then incubated in the incubator properly. Inverted at a temperature of 25±2°C and repeated with 3 replicates for each dilution.

Laboratory experiments

Percentage of germination of radish seeds: In this experiment, we used 10 seeds, placed in a petri dish having a diameter of 9 cm after placing a piece of medical cotton saturated with water in the dish to provide the necessary moisture for seed germination. They were incubated at 25 °C for 72 hours. This experiment was conducted to determine the percentage of germination of the seeds used. In the study, the percentage of seed germination was calculated according to the following equation:

$$Germination\ percentage = \frac{No.of\ emeraged\ seeds}{No.of\ total\ seeds} \times 100$$

Pathogenicity of isolated fungi

Pathogenicity of fungi isolated from soil in Petri dishes: PDA culture medium was prepared, as previously mentioned, this medium was then poured into petri dishes, and after the medium had solidified, it was inoculated with a disk with a diameter of 0.5 cm from the edge of the pure colony at 7 days old culture for each fungal isolate, and for each isolate there were 3 replicates. Then these dishes were placed in the incubator at a temperature of 25±2 °C for 3 days. Then, the radish seeds were surface sterilized using a sodium hypochlorite solution at a concentration of 1% of the commercial solution for two minutes. Then the seeds were washed several times with sterile distilled water in order to get rid of the traces of the sterile solution. After that, the seeds were placed on sterile filter paper to get rid of the remaining free water. The seeds were then planted on the edge of the growing fungal colonies in petri dishes at 3 days old cultures, with ten seeds per dish. While making three dishes not inoculated with fungi as a comparison treatment, the dishes were placed in the incubator for 7 days at a temperature of 25±2 °C. The germination percentage was calculated according to the following equation:

$$Germination\ percentage = \frac{No.of\ emeraged\ seeds}{No.of\ total\ seeds} \times 100$$

Effect of chemical pesticides (Spartan EC, Appland WP, and Bestor10EC) on the pathogenic behaviour of fungi isolated from soil

PDA culture medium after 7 days: The PDA culture medium was thawed and distributed into five 250 ml flasks, each containing 150 ml of PDA medium. The flasks were left to cool and before they reached the solidification stage at a temperature of 45 ^{0}C, the pesticide was added according to the recommended concentrations (Spartan 75 ml/100 litres, Appland 150 ml/100 litres, and Bestor 100/100 litres) from the dissolved medium, and the control treatment was carried out without the use of pesticides, with three replicates for each. Treatment was poured into petri dishes with a diameter of 9 cm. As for the control treatment, a medium not poisoned with pesticides was poured into the petri dishes. The centres of the dishes were inoculated with a 0.5 cm disc taken from the edge of the fungal culture at 7 days old with the fungi. The dishes were incubated at a temperature of 25 ± 2 °C. The radial growth of the fungi was measured after 7 days by taking the average of two perpendicular diameters from the back of the dish passing through the centre of the disc, and the percentage of inhibition was calculated according to the Abbot equation mentioned in (Shaaban and Al-Mallah, 1993).

$$Inhibition\ percentage = \frac{Mean\ of\ growth\ diamter\ in\ control - Mean\ of\ growth\ diameter\ in\ treatment}{Mean\ of\ growth\ diamter\ in\ control} \times 100$$

$$Promating\ percentage = \frac{Mean\ of\ growth\ diamter\ in\ control - Mean\ of\ growth\ diameter\ in\ treatment}{Mean\ of\ growth\ diamter\ in\ treatment} \times 100$$

Liquid culture medium PSB after 30 days

In this test, the liquid culture medium PSB was used. The sterilizer was distributed in 250 ml beakers, each containing 100 ml. The beakers were inoculated with three tablets of each of the fungi isolated from the soil in the medium poisoned with chemical pesticides, according to the recommended proportions (Spartan 75 ml/100 litres, Appland 150 ml/100 litres, Bestor 100/100 litres (and non-poisoned). Three replicates for each treatment, then incubated at a temperature of 25±2°C for 30 days, taking care to shake the flasks every 2-3 days. After that, the biomass was extracted with sterile forceps and placed on blotting paper to get rid of free water. Then its fresh weights were taken with a sensitive balance, then dried. In the oven at a temperature of 70°C for 48 hours, that is: until the weight was constant and their dry weights were taken. Either the toxic or non-toxic fungal exudates were filtered more than once through two layers of filter papers to get rid of impurities and fungal remains. The percentage of inhibition was calculated according to the Abbot equation stated in (Shaaban and Al-Mallah, 1993).

$$Inhibition\ percentage = \frac{Mean\ of\ growth\ diamter\ in\ control - Mean\ of\ growth\ diameter\ in\ treatment}{Mean\ of\ growth\ diamter\ in\ control} \times 100$$

$$Promating\ percentage = \frac{Mean\ of\ growth\ diamter\ in\ control - Mean\ of\ growth\ diameter\ in\ treatment}{Mean\ of\ growth\ diamter\ in\ treatment} \times 100$$

Statistical analysis

Laboratory experiments were conducted based on a

Completely Randomized Design (CRD). The means were statistically analyzed using the Least Significant Difference (LSD) test at a 0.05 probability level, following the methodology described by Al-Rawi and Khalafallah (2000). The collected data underwent analysis through various statistical techniques utilizing GenStat software, version 18.

Results and Discussion

Pathogenicity of fungi isolated from soil in Petri dishes

The results in Figure 1 reveal that the maximum percentage of germination emerged in the control treatment and the lowest percentage of germination appeared in the *A. niger* treatment, followed by the fungus *A. terreus* and *A. flavus*, which achieved (100.00, 46.67%), respectively. They showed pathogenicity as a result of enzymes, which they secrete, as well as the widespread spread of its germs (Hakwenye, 2018).

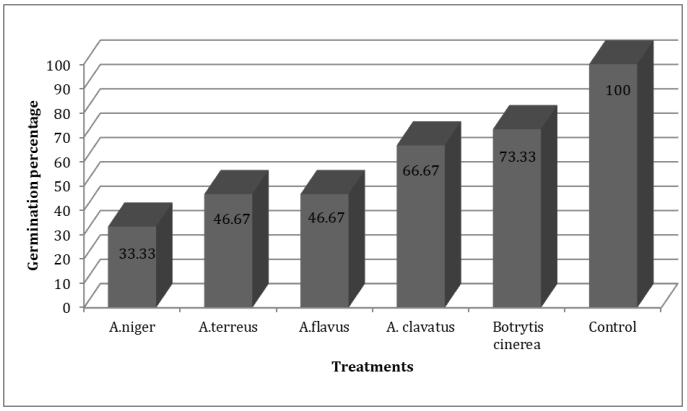

Figure 1: *The pathogenicity of fungi isolated from the soil and its effect on the percentage of germination and rot of radish seeds after seven days.*

Effect of chemical insecticides (Spartan EC, Appland WP, and Bestor10EC) on the radial growth of fungi isolated from the soil

PDA culture medium after 7 days: The results in Table 1 indicate that there are no significant differences between the effects of fungi. The highest percentage of inhibition appeared in the treatment of the fungus *B. cinerea*, and the lowest rate of the percentage of inhibition and encouragement appeared in the treatment of the fungus *A. flavus*, as it reached (43.03 and 16.19%). respectively. While the results of the effect of pesticides showed that there were significant differences, as the highest rate of the percentage of inhibition and encouragement appeared in the pesticide Appland, and the lowest rate of the percentage of inhibition and encouragement appeared in the pesticide Spartan, which amounted to (48.61, 35.65%), respectively, while the results of the interaction showed that there was Significant differences, as the highest percentage of inhibition and encouragement appeared in the treatment of the pesticide Appland + the fungus *B. cinerea*, and the lowest percentage of inhibition and encouragement appeared in the control treatments for all fungi, amounting to (81.81, 00.0%), respectively, and encouragement occurred in the treatments (the two fungi *A. terres* and *A. clavatus*, the pesticides Spartan and Applan, the fungi *A. terres* and *B. cinerea*, and the pesticide Bestor) amounted to (53.78, 74.15, 30.92, 45.31, 8.95, 51.94%), respectively.

Table 1: *Effect of chemical pesticides (Spartan EC, Appland WP, and Bestor10EC) on the radial growth of fungi isolated from soil at a temperature of 25 ± 2 °C on the culture medium P.D.A. After 7 days, calculate the percentage of discouragement and encouragement.*

Treatments effect	Bestor	Appland	Spartan	Control	Fungi
34.22	8.95+	74.15+	53.78+	0.00	*A.terreus*
21.56	33.58-	19.08-	33.58-	0.00	*A.flavus*
16.19	20.45-	22.72-	21.59-	0.00	*A.niger*
37.62	74.28-	45.31+	30.92+	0.00	*A. clavatus*
43.03	51.94+	81.81-	38.38-	0.00	*Botrytis cinerea*
	37.84	48.61	35.65	0.00	Pesticides effects
Interaction = 18.8457	Pesticides = 7.3782		Fungi = 8.3782		L.S.D. 0.05

+: Promoting; -: Inhibition.

The results obtained can be explained by calculating the radial growth of the pathogenic fungus *A. niger*. This might be attributed to the fungus' capacity to degrade the harmful material and transform it into a non-toxic substance. The fungus metabolizes pesticides in the following way. The organism secretes enzymes specific to metabolizing pesticides, which perform their work in two ways. Two interconnected processes: in the first, the partial composition of the pesticide is changed to become less toxic than the original substance, and in the second, the part is converted into a more polar compound, which then becomes more soluble in water and can be eliminated from the body, as most chemical pesticides are insoluble in water, even if they are oxidized or decomposed (Abd-Elkareim *et al.*, 2019). Waterwise, it aids in the introduction of polar groups into the molecule, making it more soluble in water and preparing it for further reactions. This stage is known as primary metabolism, and in most situations, the chemical produced by primary

metabolism is connected to endogenous substances inside the organism's tissues, such as carbohydrates (Shaaban and Mallah, 1993; Allobawi *et al.*, 2024).

Many pesticides have the ability to kill an organism by disrupting the mitochondria's energy generation and cellular respiration processes, or by altering the biological packaging of vital components like proteins and nucleic acids (DNA and RNA) (Kannan and Jain, 2000). Consequently, the Krebs cycle and the cytoplasmic glycolysis pathway are impacted. Moreover, mitochondrial oxidative phosphorylation (Shaaban and Mallah, 1993; Karem *et al.*, 2019). The results showed that cases of fungal encouragement occurred. This is the result of the fungus adapting to the pesticide after being exposed to the pesticide more than once, and it converts the toxic substance of the pesticide into a non-toxic substance that is used for nutrition.

The lack of susceptibility to pesticides may also be attributed to the ability of the fungi to tolerate or resist the action of pesticides, and this is consistent with what was mentioned by (Bollen and Scholten, 1971). The fungi that were severely affected by pesticides may be due to the disruption of the work of some enzymes necessary in the feeding process. This is consistent with what was mentioned by (Koller *et al.*, 1982) that some pesticides work to inhibit the action of the cutinase and phosphatase enzymes, or that pesticides affect the growth through its effect on DNA synthesis and cell division, or by inhibiting some important enzymes in mitochondria (Shaaban and Mallah, 1993).

Liquid culture medium PDB after 30 days

Measure the wet weight of biomass: The results obtained from Table 2 showed that there were significant differences between the effect of fungi, as the highest rate of the percentage of inhibition and promotion of biomass of the fungi appeared in the *A. terres* treatment, and the lowest rate of the percentage of inhibition and promotion of biomass appeared in the *A. flavus* treatment, which amounted to (47.03, 17.05%), respectively, while the effect of pesticides showed significant differences, as the highest rate of the percentage of inhibition and encouragement of biomass was reported in the Appland pesticide treatment, and the lowest rate of percentage of inhibition and encouragement of biomass appeared in the treatment of the pesticide Bestan, reaching (48.64 and 3.75%), respectively. Significant differences were found for the intervention treatments, as the highest rate of the percentage of inhibition and promotion of biomass appeared in the treatment of the pesticide Appland + the fungus *Botrytis cinerea*, and the lowest rate of the percentage of inhibition and promotion of biomass appeared in the control treatment for all fungi, as it amounted to (75.48 and 00.0%), respectively. The state of encouragement occurred in the treatments (for the pesticides Spartan and Bestan and for the fungi *A. terreus*, *A. flavus*, *A. clavatus* and *B. cinerea*, and the treatment of the pesticide Appland and the fungus *A. terreus*), as it reached (39.91, 14.54, 70.62, 13.16, 34.95, 48.35, 25.83, 4.02, 59.27%), respectively.

Table 2: *Effect of the insecticides (Spartan EC, Appland WP, and Bestor10EC) used on palm insects on fungal biomass fresh weight of fungi isolated from the palm trees soil.*

Fungi	Insecticides				Average
	Control	Spartan	Appland	Bestor	
A. terreus	0.00	39.91+	59.27+	34.95+	47.03
A. flavus	0.00	14.54+	5.31-	48.35+	17.05
A. niger	0.00	46.08-	47.00-	45.62-	34.67
A. clavatus	0.00	70.62+	56.17-	25.83+	38.15
Botrytis cinerea	0.00	13.16+	75.48-	4.02+	23.16
Average	0.00	36.86	48.64	31.75	
L.S.D.0.05	Fungi = 11.3782		Pesticides = 15.3782		Interaction = 27.8457

Values are means of 3 replications, (+) Promoting (-) Inhibition, fungi were grown on the liquid culture medium P.D.B. at 25 ± 2 °C, where fungal biomass fresh weight measured 30 days of incubation.

Although the dense or weak growth of fungi may not give a specific idea of the extent of biodegradation of fungal isolates, there are other indicators of the extent of decomposition, such as a change in color and even a change in smell. But in general, the dense growth gives an important picture of the ability of the fungus to biodegrade, especially since increasing the surface area of the fungal hyphae formed by the fungus means increasing the contact between the pesticide molecules and the fungus cells, which accelerates the process of withdrawing compounds into the organism for analysis and also increasing the enzymes that the fungus secretes to the outside cells, which increases the level of biodegradation (April *et al.*, 1999; Bennet *et al.*, 2002; Johnsen *et al.*, 2005; Shaaban and Mallah, 1993; Allwbawi *et al.*, 2019).

This is consistent with several studies that have found a favorable association between enhanced growth and biocracking of hydrocarbon molecules. These

studies include (Okerentugba and Ezeronye, 2003; Al-Lubawi, 2015; Hakwenye, 2018; Samir, 2021; Al-Saadi, 2021; Al-Shafi'i, 2022).

Measure the dry weight of biomass

The results from Table 3 showed that the effects of fungi varied significantly, with the *B.cinerea* treatment showing the highest percentage of dry inhibition and fungal biomass promotion and the *A. flavus* treatment showing the lowest percentage of dry inhibition and biomass promotion. They reached (49.72 and 23.88%), respectively, while the effect of pesticides showed significant differences, as the highest rate of the percentage of inhibition and dry promotion of biomass was found in the treatment of the pesticide Bestan, and the lowest rate of the percentage of inhibition and dry promotion of biomass appeared in the treatment of the pesticide Appland, which amounted to 53.83 and 36.75%, respectively. While in the interaction treatments, significant differences were found, as the highest rate of the percentage of inhibition and dry promotion of biomass appeared in the treatment of the pesticide Spartan + the fungus *A. clavatus*, while the lowest rate of the percentage of inhibition and dry promotion of biomass appeared in the control treatment for all fungi, as it amounted to 87.50 and 0.00%, respectively. Cases of encouragement occurred in treatments, the pesticide Bestan with all fungi and the pesticide Spartan except for the fungus *A. flavus* and the pesticide Appland with the fungi *A. terreus* and *B. cinerea*, which amounted to 24.39, 48.48, 71.21, 73.91, 51.16, 29.54, 42.42, 87.50,72.72,51.56,75.00 %, respectively.

Table 3: *Effect of three insecticides (Spartan EC, Appland WP, and Bestor10EC) used on palm insects on fungal biomass dry weight of fungi isolated from the palm trees soil.*

Fungi	Insecticides				Average
	Control	Spartan	Appland	Bestor	
A.terreus	0.00	29.54+	51.56+	24.39+	26.37
A.flavus	0.00	11.76-	35.29-	48.48+	23.88
A.niger	0.00	42.42+	5.26-	71.21+	29.72
A. clavatus	0.00	87.50+	16.66-	73.91+	44.51
Botrytis cinerea	0.00	72.72+	75.00+	51.16+	49.72
Average	0.00	48.78	36.75	53.83	
L.S.D.0.05	Fungi = 13.3782		Pesticides = 37.812		Interaction = 26.434

Values are means of 3 replications, (+) Promoting (-) Inhibition, fungi were grown on the liquid culture medium P.D.B. at 25 ± 2 °C, where fungal biomass dry weight measured 30 days of incubation.

From the previous results, we notice a sharp decrease in biomass after drying, especially for media containing pesticides, compared to the control treatment for each of the fungi under study. This decrease in mass could be the result of the mycelium's high fluid content, which is caused by the fungal hyphae's increased surface area. This increases contact between the pesticide molecules and the fungal cells, speeding up the process of removing the compounds into the mycelium and storing them in liquid form (Hakwenye, 2018; Samir, 2021; Al-Saadi, 2021).

Additionally, the control treatment's rapid depletion of medium nutrients may have contributed to the development of reproductive structures (bacteria), which are distinguished by their low water content. As a result, the weight change following drying was lower than in treatments with lower bacteraemia (Hakwenye, 2018; Karem and Haidery, 2022).

Table 4: *Effect of three insecticides (Spartan EC, Appland WP, and Bestor10EC) used on palm insects on medium pH on which the isolated fungi grown.*

Fungi	Insecticides				Average
	Control	Spartan	Appland	Bestor	
Control without fungi	6.63	5.80	5.03	3.80	5.31
A. terreus	3.70	3.50	3.63	3.67	3.62
A. flavus	3.63	3.33	4.10	3.30	3.59
A. niger	3.03	3.20	3.19	3.20	3.15
A. clavatus	3.10	3.77	4.97	3.20	3.76
Botrytis cinerea	3.70	4.11	3.12	3.53	3.61
Average	3.43	3.58	3.80	3.38	
L.S.D.0.05	Fungi = 0.2376		Pesticides = 0.2376		Interaction = 0.7326

Values are means of 3 replications, fungi were grown on the liquid culture medium P.D.B. incubated 30 days at 25 ± 2 °C

pH meter measurement

The results of Table 4 demonstrated that the effects of fungi and pesticides differed significantly, with the highest pH of fungi occurring in the control treatment devoid of fungi and the lowest pH occurring in the *A. niger* treatment, reaching 5.31 and 3.15, respectively. Significantly, the pH measurement rates for the Appland and Bestan pesticide treatments were 3.80 and 3.38, respectively, with the greatest and lowest values, respectively. The control treatment without fungus + control without pesticide had the greatest pH rate, while the control treatment + fungus *A.*

niger had the lowest pH rate, reaching 6.63 and 3.03, respectively. These substantial differences were seen in the interaction treatments.

pH is considered the best as it is more accurate and faster. Insecticides tend to be more susceptible to alkaline degradation than fungicides or plant growth regulators. Most insecticides have an ideal pH between 5 and 7, and many insecticides increase their effectiveness at a pH of 7 or higher, and some are not affected by the acidity of water.

It appears from the above that the changes in the pH value were varied, and the values ranged between 5.66-3.43, and that this variation may be due to the activity of these fungi, as fungi have a wide range of pH levels at which they can grow, and the optimal degree for most fungi is towards the acidic range. The effects of pH on the many factors that control growth cannot be represented as an individual effect. Growth at low pH levels is likely due to the possibility of increasing iron readiness, while growth at high pH levels may be due to increased enzymatic activity, which is appropriate for high pH levels (Howard, 1999). Most fungi grow in neutral or slightly acidic media between pH 3-8, and the pH changes in the culture with the growth of the fungus and its metabolic activity for several reasons, including the accumulation of carbon dioxide resulting from the respiration process or the accumulation of ammonia. Also, the presence of chemical pesticides in the medium in which the fungus grows can change the pH of the medium, and the pH that ranges between 4-7.9 is considered favorable for hydrocarbon metabolism processes, with fungi being noted to be more tolerant of acidic media than bacteria (Siron *et al.*, 1995; Al-Fatlawi and Allobawi, 2024).

The impact of pH on fungi growth manifests in multiple ways, one of which is the ability to utilize specific minerals (Fomina *et al.*, 2006). Metal ions may form insoluble complexes at certain pH levels, rendering them unavailable for fungal uptake. For instance, magnesium and phosphate ions remain in their free form at low pH levels but form insoluble complexes at high pH, reducing their bioavailability (Sayer and Gadd, 1997; Jabbar *et al.*, 2023). A similar trend is observed with calcium and zinc ions. Another critical influence of pH is its effect on cell membrane permeability. At low pH levels, the plasma membrane becomes saturated with hydrogen ions, restricting the transport of essential ketones. Conversely, at high pH levels, hydroxyl ion saturation inhibits the entry of vital ions. Additionally, external hydrogen ions alter intracellular pH, directly influencing enzymatic activities. A decrease in pH is often attributed to the accumulation of organic acids, such as gluconic, pyruvic, citric, and succinic acids, which are by products of sugar metabolism. In contrast, an increase in pH is linked to the release of ammonium ions generated during the catabolism of proteins and amino acids. These pH shifts significantly affect fungal metabolic processes and nutrient availability (Lilly and Barnett, 1947; Al-Shafiee *et al.*, 2022).

EC meter measurement

The results shown in Table 5 showed that the effects of the fungus on the medium EC varied. The control treatment without fungus had the highest EC rate, while the Penicillium treatment had the lowest rate, reaching 31.00 and 12.07 dS/m, respectively. As for Pesticides, the highest rate of EC level was found in the control treatment compared to the lowest rate of EC in pesticide Bestan, recording 16.85 and 15.32 dm/m, respectively. While, in case of interaction treatments, significant differences were found, as the highest rate of EC appeared in theinteraction treatment Appland and without fungi and the lowest EC was found in the interaction of Bestor and Penicillium resulting in 35.66 and 10.83 dS/m, respectively.

Table 5: *Effect of three insecticides (Spartan EC, Appland WP, and Bestor10EC) used on palm insects on medium EC on which the isolated fungi grown.*

Fungi	Insecticides				Average
	Control	Spartan	Appland	Bestor	
Control without fungi	30.03	30.56	35.66	27.76	31.00
A.terreus	14.70	12.03	12.20	12.43	12.84
A.flavus	14.03	15.50	12.17	12.10	13.45
A.niger	12.83	12.13	13.20	14.60	13.19
A. clavatus	14.60	11.37	11.50	10.83	12.07
Botrytis cinerea	14.90	15.20	15.00	14.17	14.81
Average	16.85	16.13	16.62	15.32	
L.S.D.0.05	Fungi = 0.955		Pesticides = 0.955		Interaction = 2.135

Values are means of 3 replications, fungi were grown on the liquid culture medium P.D.B. incubated 30 days at 25 ± 2 °C

The reason for the decrease in the EC value of the liquid culture medium PDB. Is the biological activity

of the fungi growing on it. Al-Zubaidi (1989) pointed out that the growth of fungi in a medium leads to a decrease in the EC value. This is because by growing in the medium, the fungi break down some salts and feed. On some components of these salts, such as nitrates and carbonates (MgNO3, CaCO3, NaCO3), which consequently leads to a reduction in the EC value. He also pointed out that an increase in the EC value leads to a decrease or inhibition of fungal growth, as high EC levels lead to an increase in the osmotic pressure in the ocean, which It leads to the cell contents being expelled to the outside according to the phenomenon of osmosis.

Conclusions and Recommendations

The insecticides Spartan EC, Appland WP, and Bestor 10EC significantly influenced the growth of soil-borne, particularly *Aspergillus terreus* and *Botrytis cinerea*. Bestor showed the highest overall stimulation across fungi in both PDA culture medium and Liquid culture medium PSB. These findings suggest potential ecological impacts on soil microbial balance. It is recommended to assess the long-term effects of these insecticides on soil health, develop strategies to minimize non-target effects, and ensure sustainable pesticide use through further research and updated regulations.

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Novelty Statement

This study provides novel insights into the indirect effects of insecticides Spartan EC, Appland WP, and Bestor 10EC on non-target soil-borne, highlighting their role in stimulating the growth of specific fungal species such as *Aspergillus terreus* and *Botrytis cinerea*. By revealing the potential ecological impact of these chemicals on soil microbial dynamics, this research underscores the need for a broader assessment of pesticide effects beyond their target organisms, contributing to sustainable pest management and soil health preservation.

Author's Contribution

Salwan A.Z.J. Allobawi: Supervised and planned the study.
Ali Ajil Al-Haidery: Helped in statistical analysis.
Malik H. Karem: Wrote the manuscript.
Adeeb Kitab Abdul Zaid Al-Shafiee: Executed research.

Conflict of interest
The authors have declared no conflict of interest.

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