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Efficiency of Some Nanoparticle Oxides in Controlling Cotton Seedling Pests

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ABSTRACT

The present work assessed the effect of three nanoparticles materials; Titanium dioxide nanoparticles (TiO_2NP), silicon dioxide nanoparticles (SiO_2NP) and iron oxide nanoparticles (FeO NP) with three different concentrations (500, 250 and 125ppm) on managing Egyptian cotton seedling pests Jassid pest *Empoasca lybica* (De Berg.) (Hemiptera:Cicadellidae), Whiteflies populations *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), Thrips pest *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), Aphid (Aphis gossupii Glover), Whitefly (Bemisia tabaci Gennadius), Red spider pest *Tetranychus telarius* (L.) (Acari: Tetranychidae) and studying their effect on the natural enemies Ladybugs (Coccinellidae ladybug) and *Chrysoperla carnea* (aphid lion). Under field conditions during 2022 and 2023, the nanoparticles suspensions was sprayed at cotton plants (Gossypium) at the three different concentrations compared with untreated cotton plants as control, the results show that SiO_2NP with its three concentrations have the most potent effect in decreasing jassid, aphid, thrips populations count during the two tested years. While TiO_2NP has the second effect, FeO NP has the least effect on decreasing the previous pest count on cotton plants during the two tested years. On the other hand, TiO_2NP has the most potent effect against the red spider population through its three concentrations, then SiO_2 NP and FeONP come in the second and third stage, respectively during the two tested years. The three used nanoparticles and their effect on the ladybug's natural enemy was investigated. The results show there is no negative effect on the ladybug count compared with the untreated cotton plant control. Moreover, at the 250ppm FeONP and 125ppm TiO_2NP concentrations, it was noticed that the count of *Chrysoperla carnea* (aphid lion) and ladybug increased during the two tested years, which led to a decrease in aphid count at this concentration compared with the two other concentrations. Nanoparticles have promising results in pest control as pesticide alternatives.

KEYWORDS: Nanoparticles oxides, Egyptian cotton, Seedling pests, Natural enemies.

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INTRODUCTION

The recurrent use of insecticides causes pest resistance in many insect pests, which requires different pest control methods. Nanotechnology could be an efficient tool for pest control (Abeer et al 2024) moreover; the use of chemical pesticides cause air, water and environmental pollution (Osman et al., 2012; N.N.Lv et al., 2021)The effect of CuO NP and ZnO NP on the survival, biology and enzyme activity of fall army worm was studied data show that the treatments adversely affected the Insect life cycle, indicating their potential as insecticide alternatives. (Abeer et al., 2024) Nanotechnology plays a crucial role in advancing sustainable agriculture by enhancing integrated pest management, enabling precise agrochemical delivery, and facilitating early pest detection. Its targeted applications contribute significantly to modern farming practices (Sharanabasappa et al., 2018). The aphid pest is considered one of the vectors for many viruses that attack plants. Despite of the aphid's natural enemy decreasing its count the chemical control is the major way to control this pest. Aphids feed on more than 320 plant species across 46 families. By feeding on phloem sap, they cause host plant damage, including premature leaf drop, wilting, and dehydration (Blackman et al., 2008)

The whitefly, *Bemisia tabaci* (Genn.) is a highly destructive pest that attack plants as larval development, feeding and oviposition occur on the undersides of the plant leaves (Mohamed et al 2012) Studying the use of sulfoxaflor and flupyradifurone insecticides for managing sucking pests in cucumber cultivation, aiming to minimize adverse effects on beneficial predators (Barrania et al.,2019)The control efficacy of star polycation SPc nanocarrier against Cotton Aphid, *Aphis gossypii* (Hemiptera: Aphididae) when combined with botanical pesticides, 5% eucalyptol, 1% azadirachtin, and 1% matrine. The data revealed that Nano-pesticides could significantly enhance the pest cuticle infiltration. This environmentally friendly approach improves mortality of rate *A. gossypii* with minor use of chemical pesticides (Zi-Han et al., 2024) Synthesized (CuO NP), (ZnO NP), (MgOH NP) and (MgO NP) by green method, the screening of synthesized nanoparticles for pest control revealed that their effectiveness against green peach aphid, Myzu spersicae Sulzer (Homoptera: Aphididae) causing high percentage of aphid mortality (Ghidan et al 2024) Furthermore, field trials conducted over two growing seasons on faba bean and soybean crops evaluated the impact of silica nanoparticles on both insect pests and beneficial organisms. At varying concentrations, silica NPs reduced populations of *Aphis craccivora*, *Liriomyza trifolii*, and *Spodoptera littoralis*. Notably, lower concentrations led to an increase in natural predators, such as rove beetles, particularly in soybean fields, indicating that silica nanoparticles not only suppress pest populations but also enhance the attraction of beneficial predatory insects (Thabet et al., 2021). The aphicidal activity of silver (Ag) and silver-zinc (Ag-Zn) nanoparticles was assessed against the oleander aphid, *Aphis nerii*. The median lethal concentrations (LC_{50}) were determined to be 424.67 mg/mL for Ag NPs and 539.46 mg/mL for Ag-Zn NPs. These findings indicate that both nanoparticles hold promise as effective alternatives to conventional pesticides in aphid management (Rouhani et al., 2016)

Metal nanoparticles attach to S and P in nucleic acids and proteins, which leads to the denaturation of organelles and enzymes, therefore for cell death. Gold nanoparticles cause trypsin inhibitors, which affect cell reproduction (Patil et al., 2016)

MATERIAL AND METHODS

Field trials were conducted over two consecutive summer growing seasons (2022 and 2023) at the Sids Agricultural Research Station, located in the Beni Suef Governorate. The trials were performed on cotton crops. The experimental area was segmented into 16 plots, each measuring 14 meters. A randomized complete block design was employed, with four replicates assigned per treatment, including untreated control plots. Field concentrations were 500 ppm, 250 ppm, and 125 ppm for Titanium dioxide nanoparticles (TiO_2NP), Silicon dioxide nanoparticles (SiO_2NP), and Iron oxide nanoparticles (FeO NP). The nanoparticles were sprayed by a Hand atomizer. For counting the populations of cotton Aphid (Aphis gossupii Glover), Whitefly (Bemisia tabaci Gennadius), Thrips pest *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), Red spider pest *Tetranychus telarius* (L.) (Acari: Tetranychidae), Jassid pest Empoasca *lybica* (De Berg.),(Hemiptera: Cicadellidae) Ladybugs and *Chrysoperla carnea* (aphid lion), 25 leaves were randomly sampled from different canopy levels (top, middle, and bottom) of cotton plants. Sampling was conducted along both diagonals within the central area of each plot during the morning hours to minimize insect activity. Initial population counts were taken shortly before insecticide application (pre-treatment), while subsequent assessments were made three days after treatment (post-treatment). Additionally, 25 whole cotton plants were randomly selected per plot to count predator populations, specifically Chrysoperla carnea and lady beetles, both before and after treatment. All counts were conducted using hand lenses during early morning hours when insect movement was least active, following (Butler et al 1988). Collected data underwent analysis of variance (Allene et al., 1999)

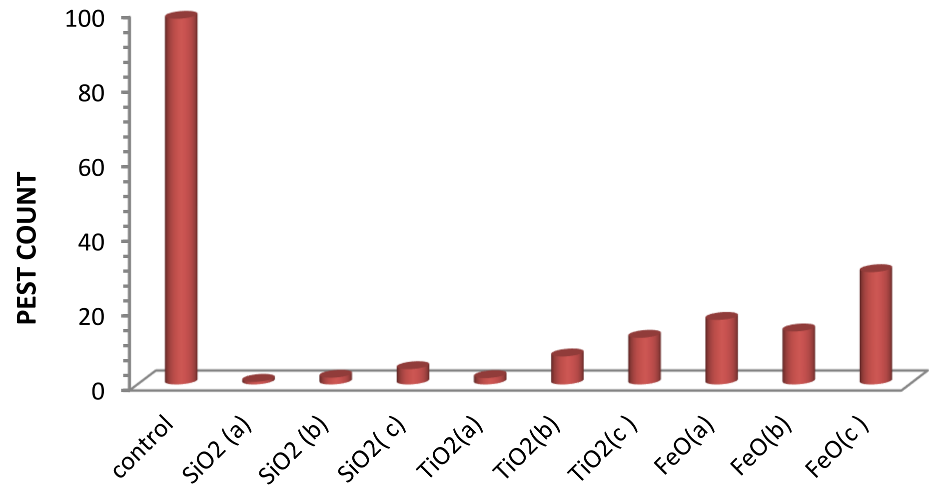
Analytical-grade reagents were employed throughout the experimental procedures without any additional purification. These included titanium tetrachloride, sodium hydroxide pellets, zinc nitrate hexahydrate ($Zn(NO_3)_2\cdot 6H_2O$) as the zinc precursor, KOH as the precipitating agent, and copper(II) chloride dihydrate. Deionized water was used exclusively for the washing steps. The synthesis and characterization of all nanoparticles were conducted based on the methodology detailed in our earlier study (Shaker et al., 2017a,b)

A hand atomizer was used to spray nanoparticle suspension on cotton plants for each concentration. When the cotton plant age 25 days the pest count was measured after 3 days post-treatment by comparing with the untreated control.

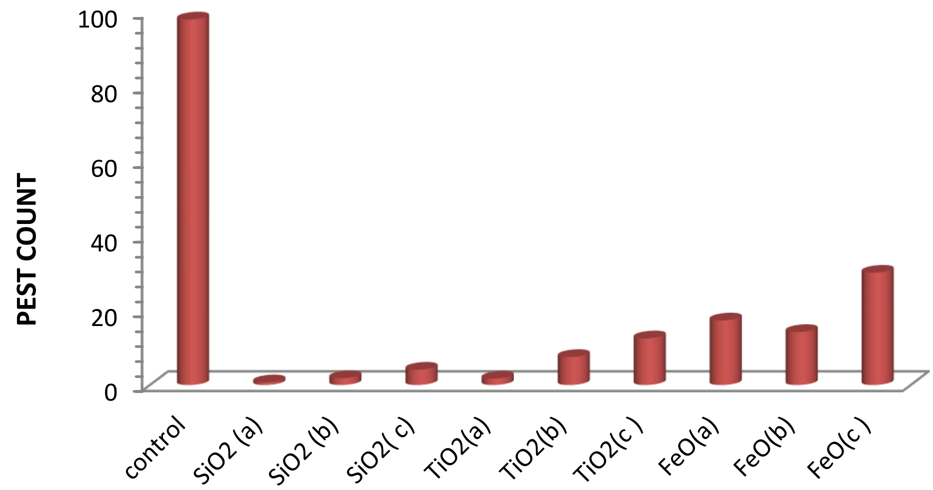
RESULTS AND DISCUSSION

Impact of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on Aphid Population at cotton plants during 2022 and 2023

Figures (1, 2) show the treatment's impact on cotton plants with SiO_2NPs, TiO_2NPs, and FeONPs at three tested concentrations (500, 250, 125 ppm) on aphid count during seasons 2022 and 2023 seasons. Applications of the three tested Nanaoparticles at all concentrations produced a highly significant reduction ($P<0.01$) in aphid populations on cotton plants during 2022 and 2023. SiO_2 NPs treatment exhibited the strongest aphid-suppressing effect, followed by TiO_2NPs. In contrast, FeONPs showed the lowest efficacy in reducing aphid numbers across all tested concentrations in both years.



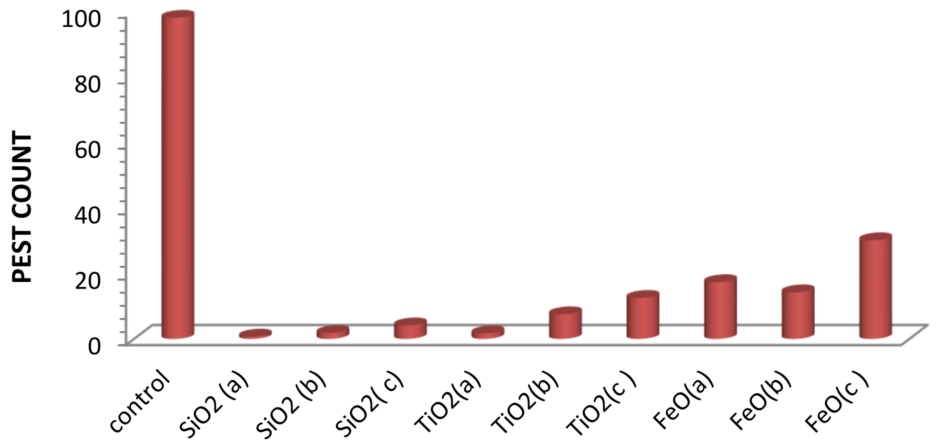
Fig(1) The effect of three different concentrations of Nanoparticles on Aphid Count at Cotton plant(Season2022)



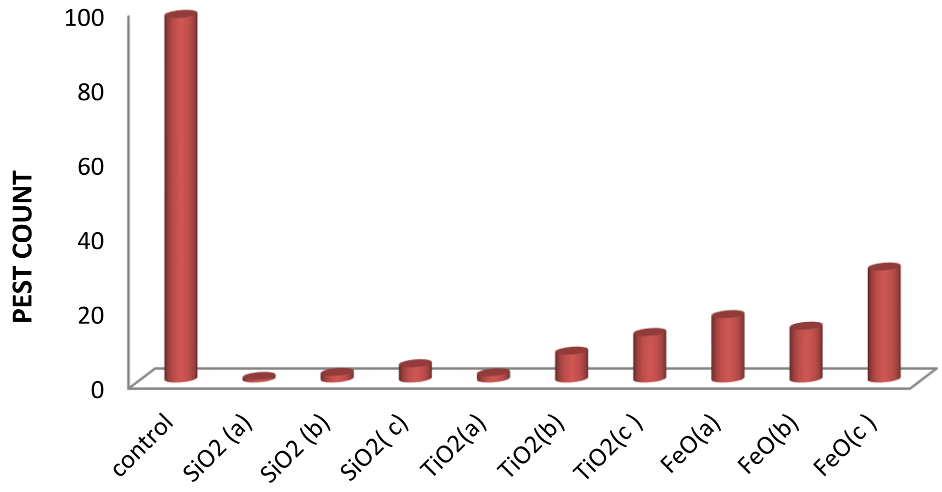
Fig(2) The effect of three different concentrations of Nanoparticles on Aphid Count at Cotton plant(Season2023)

Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on the whitefly on cotton plants during 2022 and 2023:

Figures (3, 4) illustrated the effect of treatments on cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on Whitefly count during the 2022 and 2023 seasons. All applied concentrations of the three tested nanoparticles resulted in a highly significant reduction ($P < 0.01$) in whitefly count on cotton plants during 2022 and 2023. SiO_2NPs demonstrated the most effective suppression of whitefly numbers, followed by TiO_2NPs treatments during the two tested years. In contrast, FeONPs exhibited the least impact on reducing whitefly populations across all three concentrations. These results indicate the efficient role of nanoparticles on control of seedling pest and agree with (Al-habashy 2018) who indicates the efficacy of SiO_2NP to control insect pest of faba bean pests, the cowpe aphid, aphis craccivora and cotton leafworm spodeptra they also Synthesized and characterized CuONP with size of 150-340nm and AgNP 25- 60nm and study their effect on rice brown planthopper BPH results show promising results on control BPH(Abou-El-Ela et al 2022)Synthesized AgNP with size of 70 – 80 nm and use treatments with concentrations of 200, 400 and 600ppm results show mortality of aphid 93.3% at 600ppm.



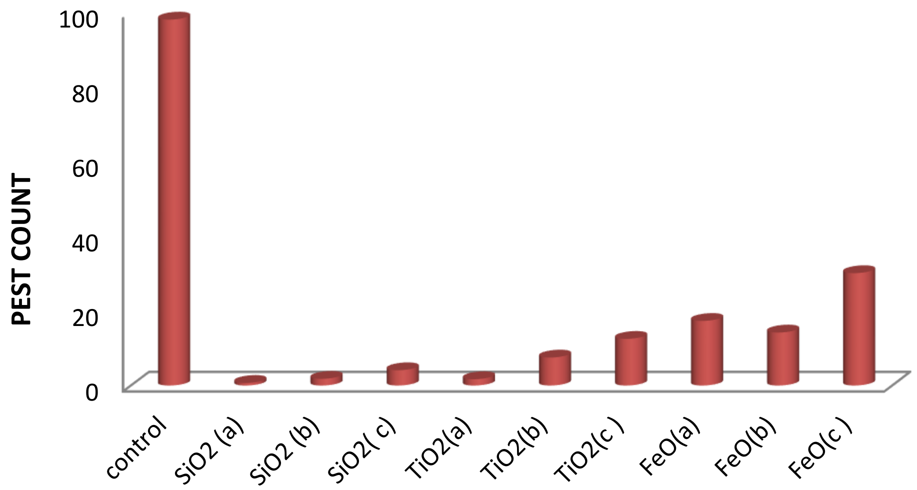
Fig(3) The effect of three different concentrations of Nanoparticles on whitefly Count at Cotton plant(Season2022)



Fig(4) The effect of three different concentrations of Nanoparticles on whitefly Count at Cotton plant(Season2023)

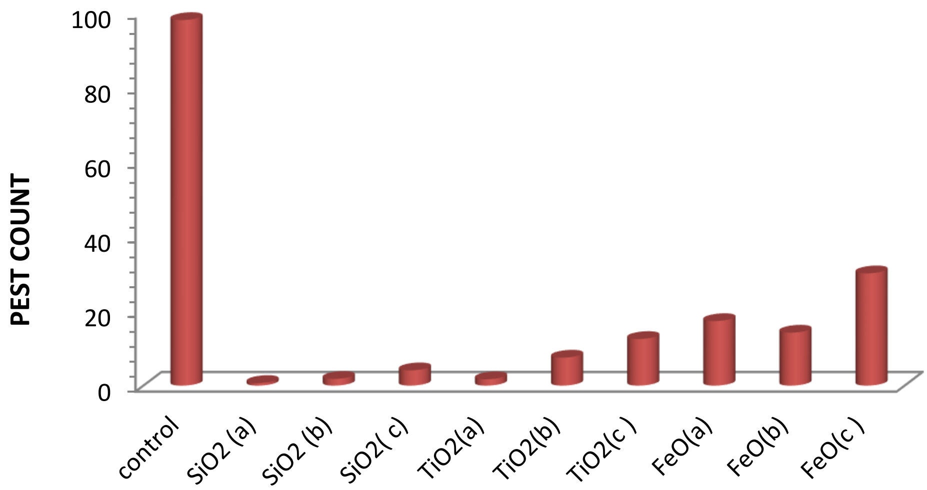
Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on Thrips during 2022 and 2023

Data illustrated in Figures (5,6) showed the effect of treatments on cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on thrips count on cotton plants during the 2022 and 2023 seasons. All applied concentrations of the three tested nanoparticles resulted in a highly significant reduction ($P<0.01$) in thrips count on cotton plants during 2022 and 2023. SiO_2NPs showed the highest efficacy in reducing thrips numbers, followed by TiO_2NP treatments during both years. However, FeONPs-treated plants demonstrated the least reduction in thrips counts across the three concentrations. This results Agree with (Athanassiou.v et al., 2018) revealed that TiO_2 NP and ZnONP act as insecticides on adults of *Tribolium castaneum* results showed that the different concentrations of TiO_2NP and ZnONP have high mortality of the adult insects. Indicating that TiO_2 and ZnO nanoparticles are effective in controlling and in integrated pest management.



Fig(5) The effect of three different concentrations of Nanoparticles on Trhips Count at Cotton plant(Season2022)

TREATMENTS

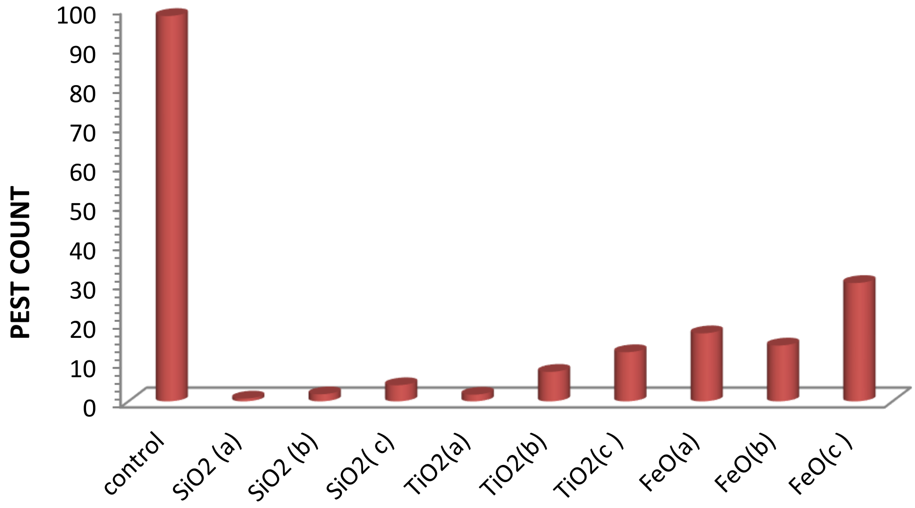


Fig(6) The effect of three different concentrations of Nanoparticles on Thrips Count at Cotton plant(Season2023)

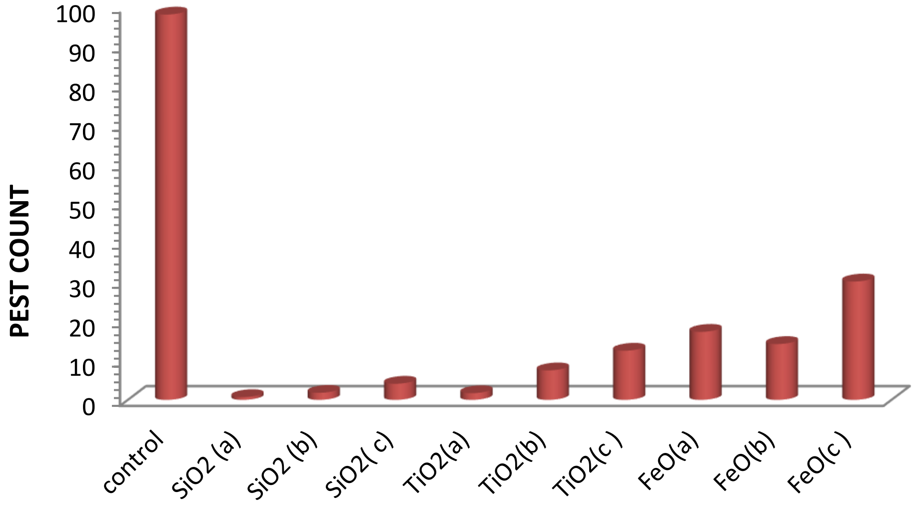
TREATMENTS

Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on treatments on Jassid during 2022 and 2023

Figures (7, 8) showed the effect of treatments on cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on Jassid count on cotton plants during the 2022 and 2023 seasons. Application of the three tested nanoparticles at all concentration levels led to a highly significant reduction ($P<0.01$) in Jassid count on cotton plants during 2022 and 2023. SiO_2 NPs showed the highest efficacy in reducing Jassid populations, followed by TiO_2 NP treatments. Conversely, FeO NPs-treated plants demonstrated the least reduction in Jassid across the three concentrations during the two tested years. (Sivapriyg.v et al., 2018) Study the effect of iron oxide nanoparticles and aqueous extract of *Anthocephalous cadamba* against *S. granarius* . The results revealed that 100% mortality was achieved



Fig(7) The effect of three different concentrations of Nanoparticles on Jassid Count at Cotton plant(Season2022)



Fig(8) The effect of three different concentrations of Nanoparticles on Jassid Count at Cotton plant(Season2023)

Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on Red spider during 2022 and 2023

Figures (9, 10) showed the effect of treatments on cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on red spider count on cotton plants during the 2022 and 2023 seasons. Application of the three tested nanoparticles at all concentration levels led to a highly significant reduction ($P<0.01$) in whitefly count on cotton plants during 2022 and 2023. TiO_2NP treatment showed the highest efficacy in reducing red spider count, followed by SiO_2NPs treatments on cotton crop during both examined years. In contrast, FeONPs hdemonstrated the least reduction in red spider across the three concentrations these results agree with (Mohammed et al 2019) who Investigate the biological aspects of cowpea beetle Callosobruchus aculatus (Fab.) treated with Zinc oxide Nano particles with size of (5nm) and (100nm) and concentrations of (100, 250, 500, 750 and 1000) ppm. The results proved that Zinc oxide nanoparticles significantly inhibited egg hatching, reducing it to 49.4% relative to 86.9% of the control. In addition, high concentrations of Zinc oxide Nanoparticles cause high mortality (98%). Also, the treatments affected the pupal and larval periods. The longest observed duration was 40.60 days at the highest concentration. These results indicate that the treatments cause pest life cycle disturbance.

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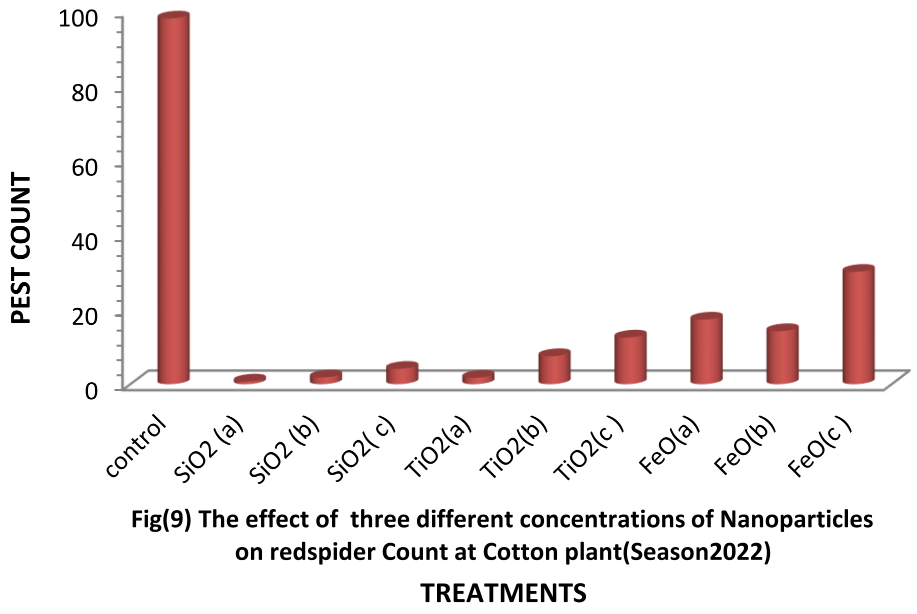
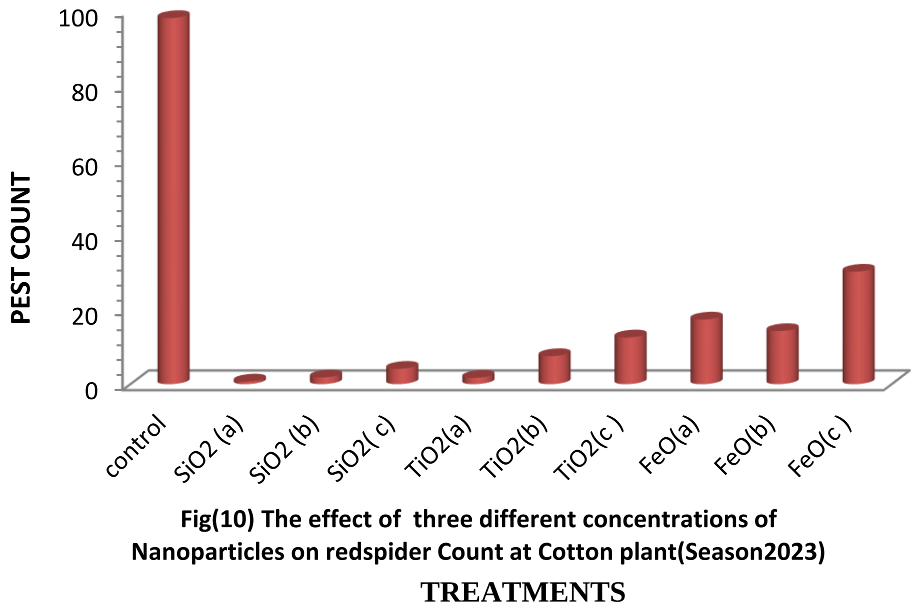


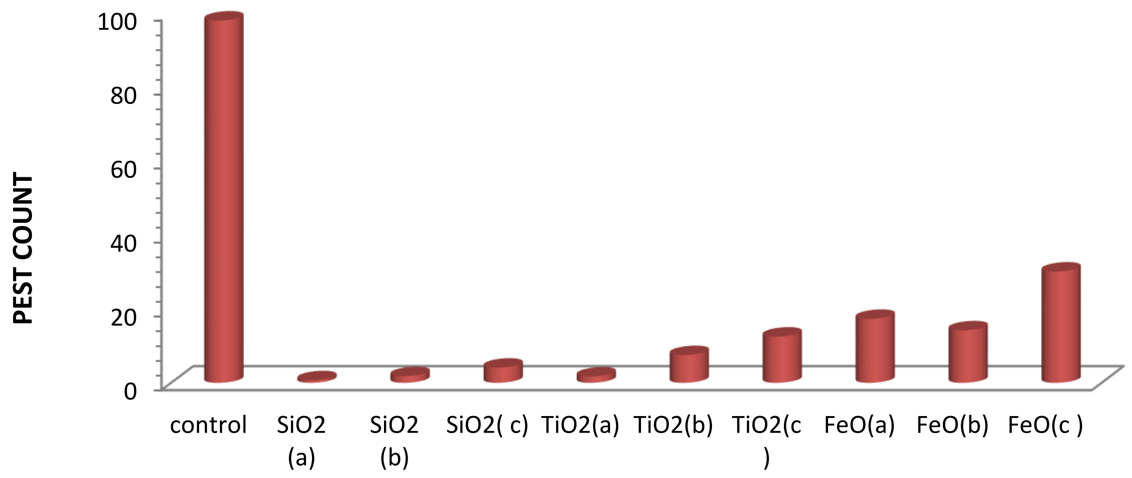
Fig(9) The effect of three different concentrations of Nanoparticles on redspider Count at Cotton plant(Season2022)



Fig(10) The effect of three different concentrations of Nanoparticles on redspider Count at Cotton plant(Season2023)

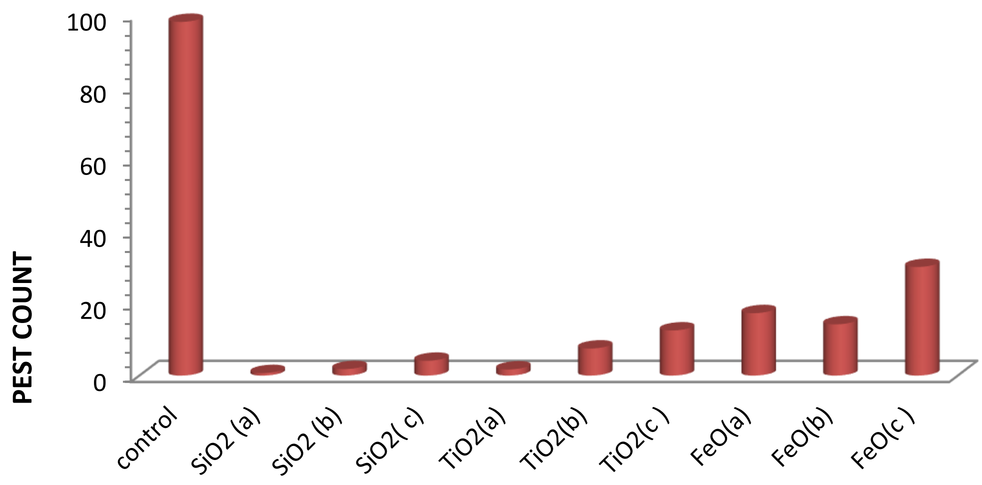
Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on Ladybug *Coccinella spp*, during 2022 and 2023

The application of Nanoparticles is safe for the natural enemy, ladybugs. Figures(11, 12) showed the effect of treatments of cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on ladybug count on cotton plants during the 2022 and 2023 seasons. Treatments with the three tested Nanaoparticles proved that there is no great difference between the treated and untreated plants for the ladybug count it was 4, 3.9, 4.8 and 3.5, 4.0, 4.4 for SiO_2NP, TiO_2NP and FeONP, respectively for the two seasons at high concentrations compared with 5.8 and 4.9 for the control. it was noticed that the FeONP treatment with a concentration of 250 ppm is more preferable for ladybugs, as their count increases more than the control.



Fig(11) The effect of three different concentrations of Nanoparticles on ladybug Count at Cotton plant(Season2022)

TREATMENTS

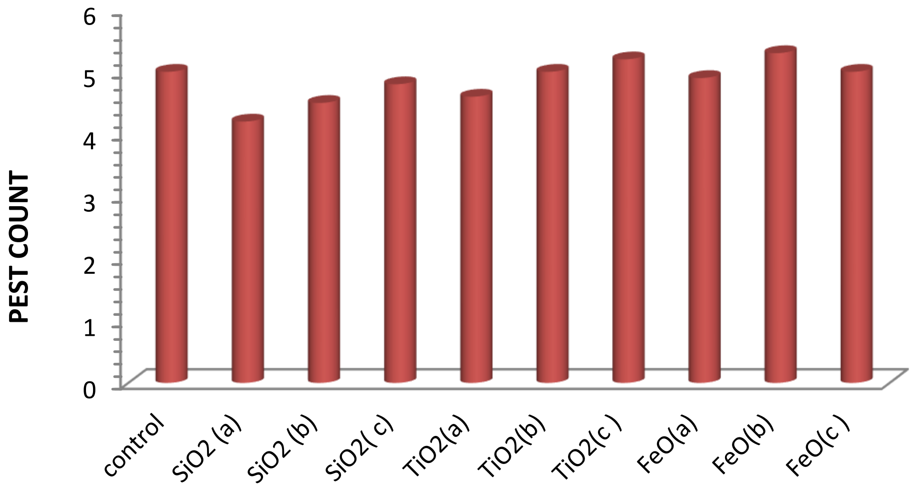


Fig(12) The effect of three different concentrations of Nanoparticles on ladybug Count at Cotton plant(Season2023)

TREATMENTS

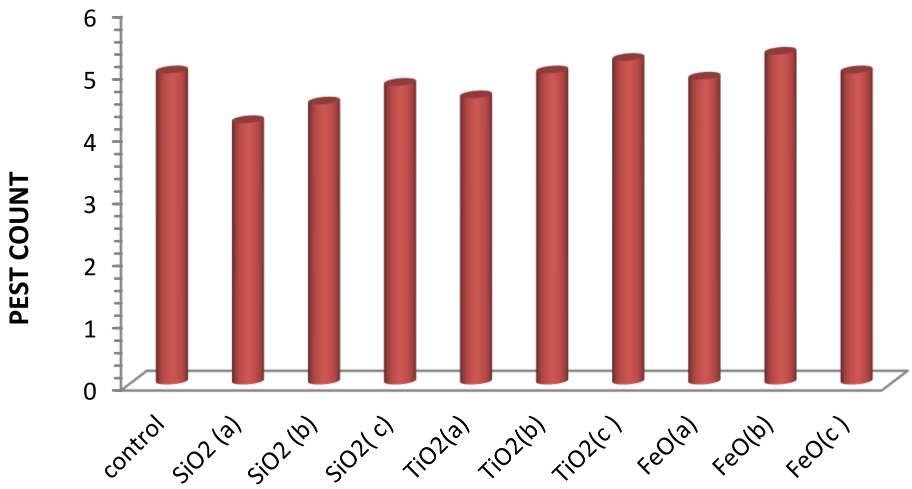
Effect of Titanium dioxide, Silicon dioxide, and Iron oxide Nanoparticles treatments on *Chrysoperla carnea* (aphid lion) during 2022 and 2023

Nanometal oxides have no negative effect on *Chrysoperla carnea* Furthermore, Figures (13,14) showed that iron oxide nanoparticles with the concentration of 250 ppm and TiO_2NP with 125 ppm could attract more *Chrysoperla carnea* than that found on control untreated plants. The effect of treatments of cotton plants with SiO_2NP, TiO_2NP, and FeONP at three tested concentrations (500, 250, 125 ppm) on *Chrysoperla carnea* populations on cotton plants during the 2022 and 2023 seasons. Treatments with the three tested Nanaoparticles. There is no significant difference between the treated and untreated plants for the *Chrysoperla carnea* count it was 4, 3.9, 4.8, and 3.5, 4.0, 4.4 for SiO_2NP, TiO_2NP, and FeONP, respectively, for the two seasons compared with 5.8 and 4.9 for the control. it was noticed that the FeO treatment with a concentration of 250 ppm is more preferable for aphid lion, as the count increased more than the control treatment, it was 6.5 and 5.9 for the untreated plants.



Fig(13) The effect of three different concentrations of Nanoparticles on chrysoperla Count at Cotton plant(Season2022)

TREATMENTS



Fig(14) The effect of three different concentrations of Nanoparticles on chrysoperla Count at Cotton plant(Season2023)

TREATMENTS

CONCLUSION

These data concluded that metal oxides nanoarticles SiO_2NP, TiO_2NP and FeONP can be used as pesticide alternatives for control cotton seedling pest Aphid (Aphis gossupii Glover), Whitefly (Bemisia tabaci Gennadius), Thrips pest *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), Red spider pest *Tetranychus telarius* (L.) (Acari: Tetranychidae), Jassid pest Empoasca *lybica* (De Berg.) when used with different concentrations on cotton plants these treatments cause decrease in the pest populations. It is noticed that the previous nanoparticles are safe for natural enemies,(Hemiptera: Cicadellidae) Ladybugs and *Chrysoperla carnea* (aphid lion). Medium concentration of FeO and low concentration of TiO_2NP cause attraction of natural enemies, and thus we can use metal oxide nanoparticles for seedling pest control.

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