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Impact of Adding Nanomaterials on the Biological Activity of Indoxacarb Pesticide Against *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) Infesting Wheat, *Triticum Aestivum* Plants

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ABSTRACT

Wheat plants are widely cultivated for seed production, a cereal grain that is a worldwide staple food. Wheat crop infested with fall army warm AW) *Spodoptera frugiperda* (JE Smith) which is considered an insect pest belonging to the order Lepidoptera, Fam. Noctuidae. This study highlights the necessity to search for safe alternatives and materials to the environment control FAW at wheat fields. Impact of these materials on wheat plants parameters, estimating the size of the Bentonite and calcium silicate granules using an electronic microscope, study physic-chemical properties and impact of these materials on bio-chemicals analysis to wheat plants. Used Indoxacarb, Calcium silicate and Bentonite spraying on infested wheat plants with Fall Army Worm (FAW) delete using seed of wheat (variety Giza 171), seedling date on 10\11\2021. The results indicated that the statistical analysis showed that there are significant differences between each treatment, between days after twice spraying, and between twice spraying. The results after the first day of application declared that Indoxacarb treatment caused an 88.42 % reduction in FAW larvae followed by adding calcium silicate to Indoxacarb at 62.96 % ± 9%, while the Bentonite treatment record the least effect at 53.70 ± 9 %. Regarding the 5th day of spraying treatments of Bentonite and Indoxacarb record the superior treatments with 100 % reduction against FAW larvae followed by calcium silicate at 41.66 ±20 % but the least reduction was noticed with Indoxacarb in a binary mixture with calcium silicate 37.0 % reduction, respectively. Indoxacarb causes the highest reduction after 1st day from the first and second spraying, but after 5th day from spraying Bentonite and calcium silicate which are used as a nanoparticle were the first superior compared to Indoxacarb insecticide. Especially plant parameters, using calcium silicate, Bentonite separately in mixing with Indoxacarb pesticide were provided botanical measurements of plant height, number of shoots and number of leaves. In case of physic-chemical properties, noticed that surface tension values ranged between 14 to 22, reduced surface tension value help the spraying process successfully due to the increasing wetness of plant surfaces, suspensibility % were higher. PH value of Indoxacarb was 7.15 almost neutral while other treatments' PH values ranged from 8.17 to 8.50. The results showed that analytical results to wheat leaves indicate that Flavonoids, silicate, total phenolic, total protein and carbohydrate were increasing in case of Bentonite and calcium silicate treatment compared with control.

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INTRODUCTION

The wheat *Triticum* sp, is widely grown. The archaeological record suggests that wheat was first cultivated in the world of the Fertile Crescent around 9600 BCE. Botanically, the wheat kernel is a type of fruit called a caryopsis. Wheat is grown on more land area than any other food crop (220.4 million hectares or 545 million acres, 2014). World trade in wheat is greater than for all other crops combined. In 2020, world production of wheat was 761 million tones (839 million short tons; 1.7 trillion pounds). Wheat is a crop infested with fall army warm (FAW) *Spodoptera frugiperd*a (JE Smith) is a devastated insect pest–belonging to the order Lepidoptera, Fam. Noctuidae. It is a polyphagia's insect (Baudron *et al.*, 2019) causing economic damage to cultivated cereal crops such as maize, rice, sorghum, cotton and various vegetable crops and eventually impacts on food security (FAO, 2017; CABI, 2018a; Bateman *et al*., 2018). The FAW feeds on leaves stem maize cone parts of plant species (Tefera *et al*., 2019). These pests live in tropical and subtropical regions of America and were first found in America on maize in South and North America. In Africa, it was first reported in 2016 (Sisay *et al.*, 2018) and has become the first one of the major invasive pests which spread over 30 countries across tropical and southern Africa including Madagascar, (Bateman *et al*., 2018) which later reached over 44 countries (Sisay *et al.*, 2019). Reported there are 353 host plants for this pest (Kansiime *et al*., 2019), larval stage causing symptoms such as different sizes of papery windows in leaves leading to extensive defoliation of plants.

The appearance of fecal materials and in later stage growth and development of plants are affected (Reddy, 2019). This insect has marching behavior similar to that of the army causing large havoc and loss to the crops that come in its path (FAO, 2019) The FAW is devastating in nature and CABI (2017a) has predicted that the pest causes a large loss of 6.1 billion US dollar only in African countries when control measures are not applied. The awareness programmers regarding when the symptoms appear, early detection and control measures of the pest along with the recommendation of effective pesticides and bio-pesticide can be effective and cause minimize the loss. Assessing suitability and selectivity to crop varieties that can tolerate the FAW needs to be initiated and in the longer run national policies should promote lower risk control options through short-period subsidies and rapid evaluation and registration to bio-pesticides and biological control products (CABI, 2017a). The rice strain feeds on rice and other pasture grasses whereas the corn strain feeds on maize, cotton, sorghum and other crops (CABI, 2020). These strains are morphologically similar but can be differentiated at the molecular level or weight. The FAW invaded in Africa has a large diversity than that found in America which contains both strains (Jacobs *et al*., 2018; CABI, 2020). This paper highlights the necessary to search for safe alternatives and friendly to the environment to control FAW in wheat fields, the Impact of these materials on wheat plants parameters, estimate the size of the Bentonite and calcium silicate granules using an electronic microscope, study of physic-chemical properties and impact of these materials on bio-chemicals analysis to wheat plants.

MATERIALS AND METHODS

Materials:

1. Indoxacarb (prent® 15% EC.), it̕s had been sprayed at a rate of 10ml/20 L. water.
2.Calcium silicate (Casio3) (250gm/5L.water).
3. Bentonite used at a rate of 250 gm. / 5 L. water

Chemical analysis for Bentonite and calcium silicate (Table 1):

Chemical analysis of Bentonite and calcium silicate			
Component	**Percentage (%)**	**Component**	**Percentage**
SiO2	55	Calcium silicate alone CaSiO3	100 %
TiO2	0.2	-	-
Al2O3	20	-	-
Fe2O3	7.1	-	-
Mn O	0.01	-	-
MgO	0.6	-	-
CaO	3.7	-	-
Na2O	0.0	-	-
K2O	2.4	-	-
P2O5	0.8	-	-
L.O.I	10.2	-	-

Experimental Design:

The field experiments were conducted at the plant protection research station, Qaha district, Qalioubia Governorate, Egypt, the experimental area was 1512 m^2, and this area was divided into 18 plots, each plot was 42 m^2, distributed in Complete Randomized block design, this area cultivated by using seed of wheat (variety Giza 171), seedling date on 10\11\2021. The treatments were 6^{th} treatments (Calcium silicate, Bentonite, Indoxacarb, Calcium silicate with Indoxacarb, Bentonite with Indoxacarb and control) were sprayed with a Knapsack sprayer, each treatment include three plots. Examination of wheat plants started in the early morning on 1\1 \2022. The sampling size was 10^{th} plants that were randomized selected/plotted and examined at field. The population of fall armyworm (FAW) *Spodoptera frugiperda* (JE Smith) (larvae) was recorded for each treatment before and after 1^{st} day, 3^{rd} day and 5^{th} day from the application, wheat plants were twice sprayed against larvae of FAW twice spray 5^{th} day. The larvae were counted on plants in the field directly. Cultural practices were carried out according to the Ministry of Agriculture recommendation. The reduction percent in pest population resulting from the application was calculated according to (Henderson and Tilton equation 1955)

Phyic-Chemical Properties:

Physic-chemical properties of these materials were studied, and the emulsion stability, suspension, foam, surface tension and DA, these measurements were estimated according to (WHO methods 1973).

Measurement of Particle Size to Bentonite and Calcium Silicate:

Weight 0.02 gm of Bentonite or calcium silicate in the glass tube and added 5 ml ethanol, thenceforth shaker for 5 minutes period. Taken 5 micros from solution and unique on a glass slice, leave until completely dry, thenceforth take several photos using an electronic microscope to count particles.

Plant Measurements:

Ten plants were randomized and selected/plotted, to study plant heights (Cm.) were measured by the meter, number of stems emerged per one seed and number of leaves/plant.

Biochemical Analysis:

A. Total Flavonoids:

Biochemical analyses were determined at the central lab. at Plant Protection Research Institute, Nadi el said street, Doki, Giza, Egypt. Total Flavonoids were measured by the aluminum chloride colorimetric method (Zhishen *et al.*,1999). Ten microliters of sample were added to 1 ml of distilled water, also added of 100 ul of sodium nitrite (5%, W/V), thenceforth stand for 5 min, then 100 ul $Alcl_3$ (10 %) were added and incubated for a min, followed by the addition of Na OH (1M) and volume was complete to 5ml with distilled water. After 15 min the solution was mixed completely and the absorbance was measured against a blank at 510 nm. Total Flavonoids were expressed as mg catechin (CE) as standard per gm sample.

B. Silicate:

For the determination of Si content in wheat plant tissues: Plant biomass samples were taken randomly by cutting the entire aboveground section into one wheat plant. These sections were put in oven dried at 70°C until they reached a constant dried weight. Their individual weight was then obtained, after which they were finely ground using a Cyclone Sample® Mill. Samples were first digested, the samples following the Oven-Induced Digestion (OID) procedure according to (Kraska and Breitenbeck, 2010). The Silicon content of the digested plant samples was evaluation quantified based on the Molybdenum Blue Colorimetric procedure as described by (Hallmark *et al.,* 1982) using a UV visible spectrophotometer at 630 nm.

C. Total Phenolic Content:

Extractions and Quantification of Phenolic:

Leaves of wheat plant as samples were weighed (0.25 g), then put into 50 ml tubes to which 7.5 ml of 13.4 g L^{-1} ascorbic acid in 13.4 m.mol L^{-1} of EDTA solution was added and then vortexed, and 2.5 ml of 8 mol L^{-1} Na OH was added. The samples were vortexed and incubated in a water bath at 50 °C for 30 min, the incubation period was 5 min vortexed. The samples were acidified with the addition of 1.65 ml of 10.2 mol L^{-1} HCl and incubated in a water bath at 50 °C for a period of 30 min. Thenceforth 12.5 ml of ethyl acetate per sample and mixed in an end-over-end rotator for 5 min. Samples were centrifuged at 3220 for 10 min. The organic phase was then pipetted into a 50 ml centrifuge tube. The separation process was repeated and both organic phases were mixed and evaporated until dryness at 60 °C using a dry block heater under a stream of nitrogen gas. The dried residue was dissolved in 2 ml of methanol solution (1:1 mixture of methanol: water). The residues were re-dissolved and thenceforth filtered using syringe filters. The phenolic compounds were quantified using a Waters UPLC system equipped with an Acquity photodiode array (PDA) detector over a range of 210 nm to 400 nm for 3D analysis and 280 nm for 2D analysis, using Empower 3 software. Separation was carried out using UPLC BEH C18 column (2.1 × 50 mm, 1.8 µm) at 45 °C. The mobile phase includes acetonitrile with 0.1% acetic acid (solvent A) and MilliQ water with 0.1% acetic acid (solvent B). The injection volume was 2.0 µL per sample and the flow rate was kept constant at 0.8 ml min^{-1} over a total run time of 8 min. The solvent gradients were run as followed (mm:ss): 00:00–0:30 min: isocratic flow of 1% solvent A and 99% solvent B, 00:30–04:00 min: linear gradient to 30% solvent A and 70% solvent B, 04:00–05:30 min: linear gradient to 95% solvent A and 5% solvent B, 05:30–06:30 min: linear gradient to 1% solvent A and 99% solvent B, 06:30–08:00 min: isocratic flow of 1% solvent A and 99% solvent B. The peaks were validated using mass spectroscopy with a Waters QDa mass detector. The total phenolic content was determined according to the Folin- Ciocalteu procedure as mentioned by (Hagerman *et al.,* 2000). As gallic acid equivalent (mg/g)

D. Determination of Total Protein Contents:

Total protein was determined using Coomassie Brilliant blue G-250 reagent and bovine albumin as standard in frozen grinded plant materials at 595 nm, using by spectrophotometer (JENWAY, 6705 UV-Vis, Staffordshire, UK), according to the described method of (Bradford 1976). The total protein is expressed as mg/g larval fresh weight.

E. **Total carbohydrates Assay:**

Total carbohydrate was extracted, prepared for assay and estimated phenol-sulfuric acid in samples by the reaction according to the procedure of (Dubois *et al.* 1956) and (Crompton and Birt1967). Total carbohydrate is expressed as mg glucose/gm. larval fresh weight.

RESULTS AND DISCUSSION

Fall armyworms infested a lot of crops in the world, from these crops' wheat crop, crop yield is a strategic crop, so you must reduce pesticide used to prevent the pollution to yield. We used alternative materials from its calcium silicate as a nanomaterial, Bentonite single or mixing with Indoxacarb as spraying against fall armyworm, *Spodoptera frugiperda*. Data in Tables (2 &3) show that the statistical analysis showed that there are significant differences between each treatment, between days after twice spraying, and between twice spraying. The results are in the same Table (3). On the first day of application declared that Indoxacarb treatment caused an 88.42 % reduction in FAW larvae followed by adding calcium silicate to Indoxacarb 62.96 % ± 9% while the Bentonite treatment record the least effect 53.70 ± 9 %. Regarding the 5th day of spraying treatments of Bentonite and Indoxacarb record the superior treatments with 100 % reduction to FAW larvae followed by calcium silicate 41.66 ±20 % but the least reduction noticed with Indoxacarb in a binary mixture with calcium silicate 37.0 % reduction, respectively. The same trend occurs in the second spray where Indoxacarb record a 100 % reduction percentage which came in the first record, while other treatments registered equally 83.33±16 % reduction, these treatments are calcium silicate, Bentonite, calcium silicate mixing with Indoxacarb and Bentonite with Indoxacarb, respectively. And on the third day of spraying, it was noted that adding calcium silicate to Indoxacarb recorded the highest transactions, but after 5th day of spraying, the alternative materials will be recorded as the best 100 % in case of calcium silicate alone and Bentonite alone compared with the creatures (Indoxacarb) 79.16±20 % reduction, while Bentonite with Indoxacarb come to final order recorded 58.33±20 % reduction to FAW larvae. We extract from the table that Indoxacarb causes the highest reduction after 1st day from the first and second spraying, but after 5th day from spraying Bentonite and calcium silicate which were used as a nanoparticle were the first superior compared to Indoxacarb insecticide.

Table 2: Impact of some nanomaterials alone and in mixtures with Indoxacarb on reduction percentages to fall armyworm (FAW) larvae infested wheat under field conditions.

Materials	**% Reduction on plants damaged ± SE***					
No. of spray	**First spray**			**Second spray**		
Days after treatments	1 days	3 days	5 days	1 days	3 days	5 days
Control	0.00±0c	0.00±0c	6.66±6d	0.00±0b	0.00±0c	0.00±0c
calcium silicate	62.96±9ab	83.33±16ab	41.66±20bc	83.33±16a	83.33±16ab	100.00±0a
Bentonite	53.70±9ab	66.66±16b	100.00±0a	83.33±16a	66.66±16b	100.00±0a
Indoxicarb	88.42±11ab	100.00±0a	100.00±0a	100.00±0a	100.00±0a	79.16±20ab
Calcium silicate + indoxicarb	62.96±9ab	100.00±0a	37.5±0cd	83.33±16a	100.00±0a	79.16±20ab
Bentonite + indoxicarb	81.48±9b	66.66±16b	75.00±12ab	83.33±16a	66.66±16b	58.33±20b

Means within columns followed by different letters are significantly different LSD test($p \leq 0.05$).D day, M Materials, S Spray.

Table 3: statistical analysis value between (treatments), (spray), (time), (time & pray), (spray & treatment), (time & treatment) and (treatment & spray and time).

Statistical analysis	**F value**	**df**	**P value**	**LSD $_{0.05}$**
Treatment	43.68	5	0.0173*	12.38
Spray	59.49	1	0.0000***	6.97
Time	166.78	2	0.000***	4.51
time*spray	25.78	2	0.000***	11.96
spray * treatment	4.24	5	0.0040**	11.72
time*treatment	10.07	10	0.000***	25.37
treatment*spray*time	2.11	10	0.0498*	29.303

2. Impact of Certain Nanomaterials Alone and In Binary Mixtures with Indoxacarb on Wheat Plants Parameters:

The materials used in the control of FAW larvae infesting wheat during winter season 2021/2022, an effect on plant growth parameters was obvious in Table (4), where adding calcium silicate to Indoxacarb treatment come to first order as effect on plant height followed by adding Bentonite to Indoxacarb, Indoxacarb alone, calcium silicate, Bentonite and control, where caused by the length of plants to 83±1.73 cm, 80±00 cm, 76±1.73 cm, 70±1.15 cm, 67±0.57 cm and 55±2.88 cm, respectively. Completely to efficiency certain nanomaterials and Indoxacarb on plant parameters, in case of a number of steams per seed, the results indicate that adding nanomaterials to Indoxacarb or nanomaterials alone causes increase in the number of steams/seed, where adding calcium silicate to Indoxacarb recorded 18±1.15 steams / seed, 16±057 steams when mixing Bentonite with Indoxacarb, Indoxacarb treatment alone cause 9±1.15 steams per seed, Bentonite 8±0.0, calcium silicate 8±0.57 and control which recorded lowest number 5±0.57 steams per seed, respectively. Thenceforth in the case of number of leaves/plant, noticed that mixing calcium silicate with Indoxacarb in a spray tank to knapsack sprayer caused an increasing number of leaves per plant to 65±2.88 leaves while checking the treatment record of 26±2.31 leaves per plant, the rest of the treatments fall between them. It is noticed from table (4) That using calcium silicate, Bentonite individuals or in mixing with Indoxacarb pesticide were provided botanical measurements, these results were due to the component of these nanomaterials.

Table 4: Plant growth parameters of wheat after being treated with certain nanomaterials in the field.

Materials	Growth Parameters ± SE*		
	Plant Height (cm)	No. of Stems/ seed	Number of Leaves
Control	55±2.88d	5±0.57c	26±2.31d
calcium silicate	70±1.15c	8±0.57b	32±1.15cd
Bentonite	67±0.57c	8±0.0b	31±0.57cd
Indoxacarb	76±1.73b	9±1.15b	36±3.46c
calcium silicate + Indoxacarb	83±1.73a	18±1.15a	65±2.88a
Bentonite + Indoxacarb	80±0.00ab	16±0.57a	49±0.25b
$LSD_{0.05}$	5.03	2.40	6.61

*Means within columns followed by different letters are significantly different LSD test ($p \leq 0.05$).

3. Physic-Chemical Properties of Certain Nanomaterials Alone and In Mixtures with Indoxacarb Insecticide:

Regarding the physic-chemical properties (emulsion stability, suspensibility percentage, surface tension and acidity degree to calcium silicate, Bentonite as nanomaterials alone and in a binary mixture with Indoxacarb as shown in Table (5), an emulsion stability test was carried out on Indoxacarb alone and in mixing, the results indicate that emulsion to Indoxacarb record 100 % stability followed by mixtures calcium silicate and Bentonite with Indoxacarb 95 % stability while Bentonite alone and calcium silicate alone this test does not apply to him. The second column in this Table (4), Indicate suspensibility percentage, where are 98±0.04, 96±0.04, 95.2±0.16, 89.5±0.14 and 0.0 in case of Bentonite, calcium silicate, calcium silicate with Indoxacarb, Bentonite with Indoxacarb and Indoxacarb, respectively. The foam increased on the acceptable limit by 1.26 while foam volume decreased to other treatments until zero cm in the case of Bentonite, each treatment passed the foam test except for Indoxacarb. In the same table noticed that surface tension values ranged between 22 to 14, and reduced surface tension values help the spraying process successfully due to the increasing wetness of plants. Surfaces. PH value of Indoxacarb was 7.15 almost neutral while other treatments' PH values ranged from 8.17 to 8.50.

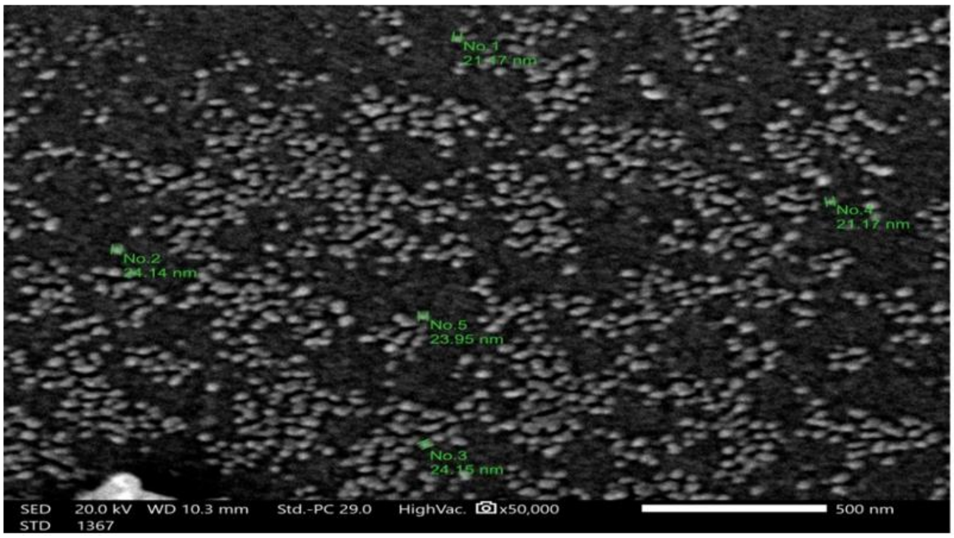
Table 5: Physic-chemical properties of tested materials.

Materials	Parameters ± SE*				
	1.Emulsion stability	2.Suspensibility %	3.foam/cm	4.Surface tension	5.PH
calcium silicate	0.0	96 ± 0.04 b	2.00±0.05c	14.00±0.57c	8.50±0.05a
Bentonite	0.0	98 ± 0.04 a	0.00±0.00e	18.00±0.57b	8.25±0.02b
Indoxacarb	100 % a	0.00±0.00 e	6.26±0.14a	20.66±0.66ab	7.15±0.02c
calcium silicate + Indoxacarb	95 % b	95.2±0.16 c	4.00±0.28b	22.00±0.57a	8.17±0.01b
Bentonite + Indoxacarb	95 % b	89.5±0.14 d	1.00±0.14d	18.00±0.57b	8.41±0.01a
$LSD_{0.05}$	0.64	0.52	0.50	1.87	0.10

*Means within columns followed by different letters are significantly different LSD_{05} test ($p \leq 0.05$

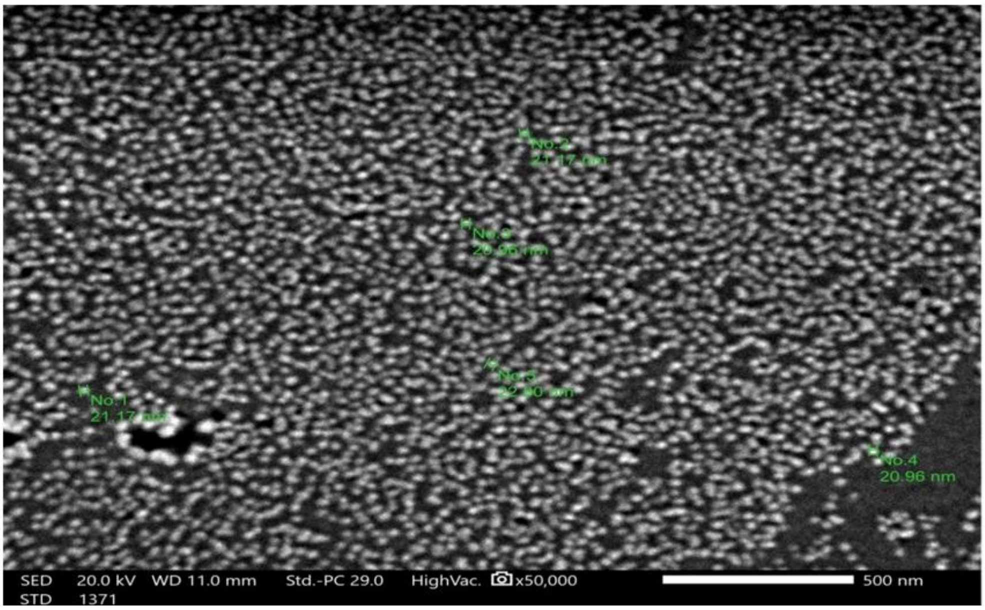
3. Photo of an Electronic Microscope to Bentonite and Calcium Silicate:

Data in (Figs.1 and 2), show the particle size of Bentonite and calcium silicate, the results indicate that particle size to 5 samples for both Bentonite and calcium silicate ranged between 21.17 to 24.15 nanometers, that is, the mean of the particle size is 22.97 nanometers in case of Bentonite, and in case of calcium silicate ranged between 21.17 to 22.40 nanometer as particle size, mean to particle size is 21.33 nanometer. The smaller the particle size its causes a rapid decrease in the pest population. Also, by decreasing the particle size Bentonite and calcium silicate cause increasing treated surfaces to nanomaterials, which further reduces the number of FAW larvae.



bentonite

Fig .1. Photo electronic to Bentonite.



calcium silicate

Fig. 2: Photo electronic to calcium silicate.

4. Chemical Component of Wheat Plants:

Table (5), show analytical results for wheat leaves, the results indicate that Flavonoids, silicate, total phenolic, total protein and carbohydrate were increased in case of Bentonite and calcium silicate compared with the control. Calcium silicate cause increasing Flavonoids in laves 3.9±0. 1 compared with 3.3 ±0.2 mg Ce/gm and 3.0±0.1 mg CE/gm in case of Bentonite and control treatment. Flavonoids have many functions like regulating cell growth, attracting pollinators and insects and protecting against biotic and biotic stresses, (Maria *et al* 2021). In the case of silicate, the data illustrate that Bentonite increased silicate compared to calcium silicate and control, also, total phenolic increased to 1.7 and 1.4 compared with 0.9 in the case of Bentonite, calcium silicate and control treatment, respectively. Generally, total protein increased with calcium silicate to 91.7 while the results were obvious that the control record was 80.0mg/gm. when estimating carbohydrates, it was noted that the same trend Bentonite comes at first order followed by calcium silicate and control. These results agree with (El- Gabiery and Ata Allah 2017). (Divya; J. *et al* 2021) evaluate the efficacy of mixing Sand with chlorantraniliprole 18.5SC @0.4 ml/ kg as a whorl application insecticide in river sand. Emamectin benzoate 5SG@ 0.4 g/ kg and spinosad 45SC @ 0.4 ml/ kg sand were found to be effective, with a significant reduction in leaf damage. The quantity of insecticide required/ unit area was 50% less than the spray while obtaining maximum grain yield/ cost benefit.

Table 5: Chemical components of planting shoots to wheat.

Treatments	Chemical components/ samples				
	Flavonoids Mg CE /gm	**Silicate** (Si mg / Kg-1)	**Total phenolics** (T.P.mg / gm. F. wt)	**T. Protein** (mg / gm dry weight)	**Carbohydrate**
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Control	*3.0 ± 0.1*	113.3 ± 4.2	0.9±0.1	80.0±2.6	335.18±**3.2**
Calcium silicate	3.9 ± 0.1	174.0 ± 7.2	1.4±0.1	91.7±1.5	375.54±**2.1**
Bentonite	3.3 ± 0.2	226.0 ± 5.6	1.7±0.0	81.7±1.5	390.25±**2.0**

Conclusions

Using Indoxacarb as an insecticide, Calcium silicate and Bentonite as nanomaterials is a new trend to control infested wheat plants with Fall Army Worm (FAW) were studied. After the first day of application from the first and second spraying. Indoxacarb treatment cause a higher reduction in FAW larvae, on the other hand, the higher reduction after the 5th day from spraying was in the case of Bentonite and calcium silicate nanoparticles. Due to plant parameters, using calcium silicate, Bentonite individuals or in mixing with Indoxacarb pesticide were provided botanical measurements of plant height, number of shoots and number of leaves. In the case of physic-chemical properties, noticed a reduction in surface tension value which led to increasing wetness of plants' surfaces, also Flavonoids, silicate, total phenolic, total protein and carbohydrate were increased in wheat leaves in case of Bentonite and calcium silicate treatment compared with control. More searches for safe alternatives and friendly to the environment for controlling-FAW at wheat fields.

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ARABIC SUMMARY

تأثير إضافة المواد النانوية على النشاط البيولوجي لمبيد الاندوكساكاربIndoxacarb على دوده الحشد الخريفيه *Spodoptera frugiperda* (JE Smith)(Lepidoptera: Noctuidae) التي تصيب القمح*Triticum Aestivum* .

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القمح هو عشب يزرع على نطاق واسع، وهو من الحبوب التي تعتبر غذاءً أساسياً في جميع أنحاء العالم. يصاب القمح بدودة الحشد الخريفيه وهى واحدة من الآفات الحشرية المدمرة التي تنتمي إلى رتبة حرشفية الاجنحة، يسلط هذا البحث الضوء على ضرورة البحث عن بدائل آمنة وصديقة للبيئة للتحكم في دودة الحشد الخريفية في حقول القمح، وتقدير حجم حبيبات البنتونيت وسيليكات الكالسيوم باستخدام المجهر الإلكتروني، ودراسة الخواص الفيزيائية الكيميائية، ودراسة تأثير هذه المواد على التحليل للمواد الكيميائية الحيوية لنباتات القمح. استخدام رش إندوكساكارب وسيليكات الكالسيوم والبنتونيت على نباتات القمح (صنف جيزة 171) والمنزرعه فى 10 اكتوبر 2021 والمصابة بدودة الخريف. أشارت النتائج إلى أن التحليل الإحصائي أظهر وجود فروق معنوية بين كل معاملة، وبين الأيام بعد الرشتين. أظهرت النتائج بعد اليوم الأول من التطبيق أن إندوكساكارب تسبب في انخفاض 88.42٪ من يرقات دودة الحشد الخريفية تليها إضافة سيليكات الكالسيوم إلى إندوكساكارب 62.96٪ ± 9٪ بينما سجلت معاملة البنتونيت أقل تأثير 53.70 ± 9٪. فيما يتعلق باليوم الخامس من معاملات الرش للبنتونيت والإندوكساكارب، سجل المعاملتان ا انخفاضًا بنسبة 100٪ ضد يرقات دودة الحشد الخريفية تليها سيليكات الكالسيوم 41.66 ± 20٪ ولكن أقل انخفاض ملحوظ مع إندوكساكارب في الخليط الثنائي مع سيليكات الكالسيوم 37.0٪. تسبب الإندوكساكارب في أكبر خفض للتعداد بعد اليوم الأول من الرش الأول والثاني، ولكن بعد اليوم الخامس كان اكبر انخفاض لرش البنتونايت وسيليكات الكالسيوم التي تستخدم كجسيمات نانوية مقارنة بمبيد حشري الإندوكساكارب. تم عمل القياسات النباتية لارتفاع النبات، وعدد البراعم وعدد الأوراق بعد الرش باستخدام سيليكات الكالسيوم و البنتونيت منرده أو في الخلط مع مبيد إندوكساكارب، وفي حالة الخواص الفيزيائية والكيميائية، لوحظ أن قيم التوتر السطحي تراوحت بين 22 إلى 14 ، كما ان قيمة التوتر السطحي المنخفضة سببت نجاح عملية الرش بسبب زيادة بلل أسطح النباتات ،. كما كانت قيمة **PH** لإندوكساكارب 7.15 متعادلة تقريبًا بينما تراوحت قيم **PH** المعالجات الأخرى من 8.17 إلى 8.50. ايضا أظهرت نتائج التحليل لأوراق القمح إلى زيادة مركبات الفلافونويد والسيليكات والفينول الكلي والبروتين الكلي والكربوهيدرات في حالة معاملة البنتونيت وسيليكات الكالسيوم مقارنة مع القطعه التجريبية المرشوشة بالماء.