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# Effect of Diatomaceous Earth on Certain Pests as well as Yield Quality of Cucumber Plants Under Greenhouse Conditions

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## Abstract

Two field experiments were carried out during the two successive seasons of 2020/2021 and 2021/2022 at Kaha Vegetable Research Farm, Qaluobia Governorate, Horticulture Research Institute (HRI), Agriculture Research Center (ARC), Egypt. The study aimed to investigate the response of diatomaceous earth applications on yield, quality and pests of cucumber plants were grown under greenhouses conditions. The experimental farm's soil type was clay loam in texture with a pH of 7.98. The cucumber hybrid Sina 1 F1 was used in this study. This experiment included six concentrations of Diatomaceous earth (75% ,50% and 25% as a foliar spray or addition to soil) in addition to control (without foliar spray or addition to soil). During the growth season, plants were sprayed three times, the first time being twenty days after transplanting, the second and third time repeat every two weeks. Results indicate that, the different concentrations application of Diatomaceous earth at the foliar spraying at 75%, addition to soil at 75% and foliar spraying at 50% gave the highest values of plant height and leaf area, highest values of chlorophyll content and increased average fruit weight, early and total yield in both seasons. The same result was observed in the means number of pests associated with vegetative and fruit growth, which recorded the highest decrease throughout the research period.

**Keywords:** Cucumber, Diatomaceous earth, Productivity, Quality, Pests control

## Introduction

Cucumber (*Cucumis sativus* L.) is one of most major economically important vegetables in Egypt for local and export markets, vegetable crops. It is cultivated all year round in open fields and under tunnels or greenhouses. According to the statistics of Ministry of Agriculture in Egypt (2022), the total cultivated area was 17931 fed., by an average of 10.42 tons/fed. Cucumber plants are subjected to infestation by many pests such as. Sap-sucking insect whitefly; *Bemisia tabaci* (Genn); and The western flower thrips *Franklaniella occidentalis* (Pergande), the lesser pumpkin fly *Dacus ciliatus* Loew and two spotted spider mite *Tetranychus urticae* Koch are economically important pests on many economic plants such as cucumber in different parts of the world under greenhouses, these pests are frequently found to be major agricultural pests .Due to their ability to spread plant viruses, these insects are also regarded as serious pests. There are two kinds of harm caused by these pests: direct damage and indirect harm. Direct injury is caused by removing plant sap from the leaf of the plant. However, indirect harm brought on by the buildup of honeydew, which is thought to be an excellent medium for the formation of sooty mold. Due to their ability to spread plant viruses, these insects are also regarded as serious pests **((Hanafy et al., 2014, Ammar and Abolmaaty, 2016 and Ammar et al., 2022a).** As a result, even a small population of these pests can cause significant harm to crop. Chemical pesticides have been widely and foolishly applied for many years to manage agricultural pests. Other agents being used in integrated control programs are encouraged by the growing insect resistance to chemical pesticides, ecosystem pollution, and other harmful side effects on non-target species. To prevent health issues for humans and to produce a cost-effective product, it is now imperative to produce fruits and vegetables free of pesticides. For this reason, the current work was done to explore and suggest some aspects of Integrated Pest Management (IPM) in the fight against the cucumber plant pest. The increasing environmental and health concerns associated with conventional pesticides have catalyzed a significant shift toward the development and application of eco-friendly pesticides within the agricultural sector.

Diatomaceous earth is very rich in silica and has been investigated as a possible pest management technique since they are composed of 85% amorphous silica ($SiO_2$) **(Laing et al., 2006).** Diatomaceous earth is the powdered remnant of diatoms, which have distinct effects on insects' exoskeletons when used as pesticides. It has tiny, sharp protrusions that stab insects to death as they crawl over them, and it is coated in fossilized Diatomaceous earth **(Sarwar, 2016).** Due to its ability to provide crops stiffness, strength, and resistance to pests and diseases, reduce the pace of transportation, improve the water economy, and mitigate the negative effects of increased crop yields under abiotic stress circumstances, silicon is a significant ally for agronomists **(Vasanthi et al., 2014)**. In addition, **Soubeih et al. (2017)** found that the Diatomaceous earth as foliar spraying was the superior effect at 5% concentration on cumulative leaf miner and aphid infestations. The highest reduction of soil additive treatment against leaf miner insects was obtained from diatom sediments (DS) at 5ton/fed, followed by diatom sediments (DS) at 2.5 ton/fed. In case of aphid leaves infestations as soil additives, the highest reduction was (DS) at 5ton/fed on potato plants. **Coman et al., (2021)** indicated that diatomite was selected as an ecological insecticide, in which a model of eco-sustainable technology for reducing and preventing diseases and pests was developed. Fertilizer is necessary for successful yield and high fruit quality and is a major production cost. Although silicon is not considered an essential element for plant nutrition, Si fertilizers are routinely applied to a variety of plant species including horticultural crops to increase crop yield and quality **(Ma 2004 and Hodson et al., 2005).**Applying diatomite has been demonstrated to increase the growth and yield of a number of plant species, including antirrhinum majus **(Zahan et al., 2015 and El-Sayed 2018)**, rice **(Angin et al., 2011 and Basha et al., 2013)**, strawberries **(Abdallah 2011),** wheat **(Sandhya 2013)**. Furthermore, **Gokavi et al. (2020)** found that the Arabica coffee (cv. Chandragiri) quality characteristics, yield, and leaf nutrient content significantly improved when DE were used as a source of silica material. Additionally, **Kuzina et al. (2021)** demonstrated that the use of diatomite resulted in an increase in winter garlic yield. On potato **Soubeih et al. (2017)** showed that diatom at 5% as foliar spraying or/and (DS) at rate of 5ton/fed as soil additive, which had significant positive response to plant growth, leaves area, chlorophyll content as well as yield and its component. **El-Sherif et al. (2018)** obtained that diatomite had the highest rate of improvement in plant height and chlorophyll content compared to the control in the two tested seasons on moringa plants.

This study aims to evaluate the efficiency of using Diatomaceous earth to improve the productive and quality characteristics of cucumbers and reduce the population density of pests that infestation cucumber plants grown under greenhouses conditions.

## MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 2020/2021 and 2021/2022 at Kaha Vegetable Research Experimental Farm, El-Qaluobia Governorate, Horticulture Research Institute (HRI), Agriculture Research Center (ARC), Egypt.

### Sampling method for the plant

A random complete block design with three replicates was adopted. The soil of this experimental farm was clay loam in texture with a pH of 7.98. Soil mechanical and chemical analyses are shown in Table (A).

**Table (A):** Soil mechanical and chemical analyses of the soil

| **Physical analysis** | | **Chemical analysis** | | | |
|---|---|---|---|---|---|
| | | Cationsmeq/l | | Anions meq/l | |
| **Coarse sand** | 8.25% | $Ca^{++}$ | 9.65 | $CO_3^{--}$ | Zero |
| **Fine sand** | 16.15% | $Mg^{++}$ | 3.16 | $HCO_3^{-}$ | 5.38 |
| **Silt** | 24.60% | $Na^{+}$ | 6.53 | $Cl^{-}$ | 5.93 |
| **Clay** | 51% | $K^{+}$ | 1.16 | $SO_4^{--}$ | 9.19 |
| **Texture class:** | **clay loam** | | | | |
| **Soil Ph** | 7.9 | Available N | 22.5 mg/kg | | |
| **E.C dS/m** | 2.16 | Available P | 9.1 mg/kg | | |
| **Organic matter** | 3.1% | Available K | 120 mg/kg | | |

DDM diatomite is a naturally occurring diatomaceous earth that was formed from the fossilized remnants of silica-impregnated freshwater Diatomaceous earth. It has a neutral pH and is mostly made up of SiO (86–89%) in a soluble form that is useful to plants. It has been purchased from the company "Growth promoters world". Table (B). The experiment included seven concentrations with diatomaceous earth and control as shown in Table (C).

**Table (B):** Major chemical elements of diatomaceous earth

| **Major Chemical Elements** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **$SiO_2$** | $Al_2O_3$ | $Fe_2O_3$ | CaO | $K_2O$ | MgO | $Na_2O$ | $TiO_2$ | $H_2O$ |
| **89.00%** | 5.95 % | 0.88 % | 0.10 % | 0.63 % | 0.20 % | 0.32 % | 0.29 % | 3.00 % |

**Table (C):** The experiment included seven concentrations with diatomaceous earth and control

| No. | Concentration | Rate of Application (gm/L) |
|---|---|---|
| **T1** | Foliar spray with Diatomaceous earth 75% | 37.5gm/ L |
| **T2** | Soil addition with Diatomaceous earth 75% | 37.5gm/ L |
| **T3** | Foliar spray with Diatomaceous earth 50% | 25gm/L |
| **T4** | Soil addition with Diatomaceous earth 50% | 25gm/L |
| **T5** | Foliar spray with Diatomaceous earth 25% | 12.5 gm /L |
| **T6** | Soil addition with Diatomaceous earth 25% | 12.5gm/L |
| **T7** | Control (spray with distilled water) | ---------- |

Seeds of cucumber (the hybrid Sina 1F1) cultivar was sown in 84 cell trays (cell diameter 9 mm) containing 26.5 cm3 of peat-based commercial substrate. Seeds were planted on the 25th and 28th of September during the 2020/2021 and 2021/2022 seasons respectively. After 15 days, the seedlings, which were at the two true-leaf growth, were transplanted at the greenhouse on the 10thand 14th of October in the first and second seasons, respectively. Each experimental plot was 18 m in length and 1.20 cm in width. Transplants were spaced 0.5 m apart, on the two sides of the ridge. All agriculture practices were done according to the recommendation by the Ministry of Agriculture for the cucumber crop.

**Sampling method for the pests**

The inspection started 15 days after snowing on the 25$^{th}$ and 29$^{th}$ of October in the first and second seasons, respectively. Direct samples were taken by taking 15 leaves/ plots from the three levels of the plants (low, mid, and upper) for each treatment under test randomly before sun rise and examined primarily by a pocket lens in the greenhouse, then transferred to the laboratory in paper bags to examine by the aid of stereomicroscope. The collected pests and mites from each method were counted and preserved in vials containing 70% ethanol alcohol, then identified in the Taxonomic Pests Department at Plant Protection. The targeted pests during vegetative growth were *Bemisia tabaci* (Genn) (Nymph); *Liriomyza trifolii* Burgess (Larvae) and *Tetranychus urticae* Koch (Movable stage). These Samples were kept in paper bags and transferred to examination in the laboratory on the same day for inspection by the stereomicroscope to count and record the numbers of investigated pests. The sampling was taken for 7 day intervals and continued until 12 weeks for all concentrations. After 50 days from transplanting, flowers were taken and fruits were harvested from fifteen plants to examined, counted and recorded the numbers of investigated pests (*Franklaniella occidentalis* (Pergande) nymphs& adults and *Dacus ciliates* (Loew) infestation inside each fruit's appearance). The percentage of reduction in infestation was calculated according to the formula **(Topps and Wain, 1957)** as follows:

$$R\% = \frac{C-T}{C} \text{x } 100$$

Where:

C: Number of insects recorded in the control samples.

T: Number of insects recorded in treatment samples.

**Studied characteristics**

Vegetative growth characteristics: Vegetative growth characteristics were recorded after 50 days from transplanting, in samples of five plants randomly chosen from each plot, and the following data were recorded:

Plant height (cm): It was measured as the average length in centimeters of five random plants. The measurement started from the surface of the ground to the plant stem apex.

Leaf area (cm2): It was expressed as the mean leaf area in cm2 using the dry weight method. The mature leaf was cleaned from dust and then weighed 0.001 g. Therefore 20 disks of known area were separated as weight.

Leaf area (cm2) = Dry weight of mature ×20× the area of disk…

Dry weight of 20 disk

Where, the area of a disk is about 1.0 cm.

Chlorophyll content: The youngest fully expanded mature ten leaves were used per plant as mentioned by Westerman (1990). It was measured in SPAD unit, where SPAD= 10mg chlorophyll / gm fresh weight using digital chlorophyll meter (model Minolta chlorophyll Meter SPAD- 501).

Yield and its components

Early fruit yield /plant: It was determined as weight of first four harvested fruits.

Total fruit yield /plant: It was calculated using plot yield and plot area all over the season then fruit yield per plant was calculated.

Average fruit weight: Ten fruits from each experimental plot were weighted and average fruit weight was then calculated.

Physical characteristics of fruits: A random sample of 10 fruits from each experimental plot was taken to determine fruit firmness (was measured using a hand penetrometer (2 mm) on opposite cheeks at the center of each fruit), length and diameter.

Chemical characteristics: Total soluble solids (TSS %) were measured in fruit juice using a hand refractometer. Five fruits were taken at random from each treatment for this test.

Mineral content of leaves: Half a gram of dried samples was digested using the $H_2SO_4$ and $H_2O_2$ As described by Cottenie (1982). The extracted samples were used to determine the following minerals: N, P, and K were analyzed using the modified micro kjeldahl method described by Nelson and Sommers (1980), Phosphorus was calorimetrically determined at the wavelength of 680 nm Jackson, (1967). According to Black (1965), potassium was determined using a flame photometer. For the silicon plant tissue analysis, each treatment was analyzed in triplicate and included leaf and fruit samples from each treatment plus the untreated control at 70 DAS using an autoclave-induced digestion method (Elliott and Snyder, 1991).

## Statistical analysis

For horticultural characteristic data were statistically analyzed using the one- way analysis of variance (ANOVA) to test for effects among treatment using **(SAS ,1999)** followed by Duncan's multiple range test to compare means between the different treatment.The significance of differences among means was carried out using the Least Significant Test (LSD) at p=0.05

For entomological Analysis of variance (ANOVA) was performed on infesting pests variables **(SAS, 1999)** and appropriate error terms for the F tests of interactions were calculated separately.The significance of differences among means was carried out using the Least Significant Test (LSD) at p=0.05.Data also procs Correlation and Regression coefficient were used to determine the relation between different factors affected the pests number and their relation to obtained yield.

## RESULTS

### Effect of diatomaceous earth concentration on vegetative growth parameters of cucumber plants

Data in Table (1) mentioned that the application of diatomaceous earth at concentrations of 75% with foliar spraying or addition to soil and 50% with foliar spraying on cucumber plants gave the highest values of plant height, leaf area and chlorophyll content in the two tested seasons compared to the control.

**Table (1): Effect of diatomaceous earth concentration on plant height, leaf area and chlorophyll content of cucumber plants**

| Datomaceous earth concentration % | Plant height (cm) | | Leaf area ($cm^2$) | | Chlorophyll content (SPAD) | |
|---|---|---|---|---|---|---|
| | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 |
| **Control** | 210.00 d | 218.33 d | 275.70 d | 277.03 d | 33.20 d | 39.46 d |
| **Spray with 75%** | 275.00 a | 276.67 ab | 315.54 ab | 317.56 a | 41.40 ab | 44.13 a |
| **Soil addition 75%** | 273.33 a | 283.33 a | 319.08 a | 319.41 a | 42.30 a | 44.06 a |
| **Spray with 50%** | 270.33 a | 280.00 ab | 315.49 ab | 316.49 a | 39.83 bc | 42.60 ab |
| **Soil addition 50%** | 243.67 b | 271.67 b | 313.63 b | 309.35 b | 39.53 bc | 41.43 bc |
| **Spray with 25%** | 228.33 c | 240.67 c | 294.14 c | 297.50 c | 38.33 c | 41.43 bc |
| **Soil addition 25%** | 212.03 d | 228.00 d | 296.83 c | 295.84 c | 38.70 c | 40.73 cd |

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

## Effect of diatomaceous earth concentration on general weekly number of pests infesting cucumber leaves

### *Bemisia tabaci*

Data in Table (2) revealed that, comparing the mean weekly number in population of *B. tabaci* nymphs after applications of six concentrations , the data clear that the concentration can be arranged in descending orders as follows: Foliar spray 75% was the best application used, afterward soil addition 75%, foliar spray 50%, soil addition 50%, foliar spray 25% and soil addition 25%, with means numbers (621, 689, 712, 959, 1115, 1299 individual / 180 leaves), respectively throughout the first season. In the corresponding second season, there was significant interference between the different six concentrations that used the same effects with means numbers (782, 823, 879,890, 908 and 1154 individual / 180 leaves**).** As follows foliar spray 75%, soil addition 75%, soil addition 50%, foliar spray 50%, foliar spray 25% and soil addition 25% respectively, compared to with means numbers1800 individual / 180 leaves (control).

### *Liriomyza trifolii*

Data showed that, following applications of six concentrations, the mean weekly number in the population of *L. trifolii* larvae was compared in Table (5),the data clear that the concentration can be arranged in descending orders as follows: Foliar spray 75% was the best application used, afterwards soil addition 75%, foliar spray 50%, soil addition 50%, foliar spray 25% and soil addition 25%, with means numbers (621, 689, 712, 959, 1115, 1299 individual / 180 leaves), respectively. In the second season, there was significant interference between the parameters used, the same effects were in the second season with means numbers (782, 823, 879,890, 908 and 1154 individual / 180 leaves**)** as follows foliar spray 75%, soil addition 75%, soil addition 50%, foliar spray 50%, foliar spray 25% and soil addition 25% respectively, compared to control.

**Table (2): Effect of diatomaceous earth concentration on the general weekly means number of pests infesting cucumber leaves (vegetative growth) var. (Sina 1F1) under greenhouse at Qaluobia Governorate during two seasons**

| | **2021** | | | **2022** | | |
|---|---|---|---|---|---|---|
| **Pests** | ***Bemisia tabaci*** | ***Liriomyza trifolii*** | ***Tetranychus urticae*** | ***Bemisia tabaci*** | ***Liriomyza trifolii*** | ***Tetranychus urticae*** |
| **Diatomaceous earth concentration %** | **Nymph** | **Miner** | **Movable stage** | **Nymph** | **Miner** | **Movable stage** |
| **Control** | 1715 a | 324 a | 1089 b | 1800 a | 289 a | 1178 a |
| **Foliar spray 75%** | 621 g | 86 d | 655 f | 782 e | 72 f | 573 e |
| **Soil addition 75%** | 689 f | 94 c | 732 e | 823 cde | 83 e | 632 d |
| **Foliar spray 50%** | 712 e | 102 c | 1032 c | 890 cd | 94 d | 1001 c |
| **Soil addition 50%** | 959 d | 98 c | 1011 d | 879 cd | 108 c | 978 c |
| **Foliar spray 25%** | 1115 c | 117 b | 1089 b | 908 c | 98 d | 1151 b |
| **Soil addition 25%** | 1299 b | 119 b | 1244 a | 1154 b | 117 d | 1210 a |
| **F value** | 53.33*** | 933.2*** | 203.2*** | 3.47* | **50.77*** ** | 180.91*** |
| **L.S.D** | 16.65 | 8.32 | 14.22 | 346.35 | 156.7 | 5.49 |

Values in the same column followed by the same letter do not significantly differ from each other according to Least Significant Test at 5% level

### *Tetranychus urticae*

Data indicated significant differences between the six treatments whereas (F value = 203.2***and L.S.D = 14.22), the first and second concentrations (foliar spray 75% and soil addition 75%) were indicated highly significant reduction with means numbers (655 and 732 individual/ 180 leaves), respectively. Next comes each three concentrations (foliar spray 50%, soil addition 50%, foliar spray 25%) and with means numbers (1032, 1011, and 1089 individual / 180 leaves), respectively compared to control. The lower reduction showed the intertreatment soil addition of 25% with means numbers (1244 individual / 180 leaves). Data in the second season showed that foliar spray 75% and soil addition 75% indicated a highly significant reduction with means numbers (573 and 632 individual / 180 leaves), respectively and found that a difference from the first season in some concentration (soil addition 50%, foliar spray 50%, foliar spray 25%) and with means numbers (978, 1001 and 1151individual / 180 leaves) respectively, compared to control. The lower reduction showed an additional 25% with means numbers (1210 individual/ 180 leaves). These results are summarized in the fact that the most influential coefficient concentration (foliar spray 75 and soil addition 75%) during the two seasons of the study and the treatment was the least influential soil addition 25%.

### Effect of diatomaceous earth concentration on fruit firmness, fruit length and fruit diameter of cucumber plants

Data in Table (3) show clearly that all applied diatomaceous earth concentrations as a foliar spray or soil addition have positive effects on fruit firmness of cucumber plants in two seasons. Furthermore, the highest values of fruit length were recorded by foliar spraying of diatomaceous earth concentration 75% or 50% as well as soil addition with 75 % in the two seasons. As for fruit diameter, results illustrated that all applied diatomaceous earth concentrations as a foliar spray or soil addition have positive effects on fruit diameter in the first season. Meanwhile in the second season, the highest values of fruit diameter were obtained from using foliar spraying of diatomaceous earth concentration 75% or 50% as well as soil addition with 75% without significant differences between them.

**Table (3): Effect of diatomaceous earth concentration on fruit firmness, fruit length and fruit diameter of cucumber plants**

| Diatomaceous earth concentration % | Fruit firmness ( g/cm$^2$ ) | | Fruit length (cm) | | Fruit diameter (cm) | |
|---|---|---|---|---|---|---|
| | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 |
| **Control** | 293.0 b | 286.1 b | 14.66 d | 15.23 c | 3.20 b | 3.17 b |
| **Foliar spray 75%** | 327.3 ab | 351.4 a | 16.00 ab | 16.56 ab | 3.45 a | 3.50 a |
| **Soil addition 75%** | 346.2 a | 350.3 a | 16.12 ab | 16.13 abc | 3.46 a | 3.40 a |
| **Foliar spray 50%** | 325.4 ab | 336.0 ab | 16.43 a | 17.00 a | 3.43 a | 3.45 a |
| **Soil addition 50%** | 323.2 ab | 332.0 ab | 15.56 bc | 15.00 c | 3.34 ab | 3.23 b |
| **Foliar spray 25%** | 315.4 ab | 335.0 ab | 15.13 cd | 15.53 bc | 3.33 ab | 3.20 b |
| **Soil addition 25%** | 313.2 ab | 330.3 ab | 15.76 b | 14.90 c | 3.32 ab | 3.18 b |

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

**Effect of diatomaceous earth concentration on the general weekly number of pests infesting cucumber (flowering and fruiting growth)**

Data in Table (4) showed the gradual reduction of pests, Franklaniella occidentalis and Dacus ciliates, numbers as a result of different concentrations as different applications (foliar spray and soil addition) on cucumber plants in both seasons. Data showed highly significant differences among the six compounds with different concentrations.

***Franklaniella occidentalis***

Data in Table (4) revealed that, comparing the mean weekly number in a population of *F. occidentalis* nymphs and adults after applications of six concentrations , the data clear that the concentration can be arranged in descending orders as follows: (foliar spray 75% and soil addition 75%), were the best application used, afterward foliar spray 50%, soil addition 50%, and the lowest application was (foliar spray 25% soil addition 25%), with means number (46, 61, 83, 80, 97, 102 individual / 180 leaves), respectively throughout the first season. During the second season, there was significant interference among the six different concentrations used. The same effects were in the second season with means numbers (55, 49, 73,69, 86, and 95 individual / 180 leaves) as follows foliar spray 75%, soil addition 75%, soil addition 50%, foliar spray 50%, foliar spray 25% and soil addition 25%, respectively compared to control.

***Dacus ciliates***

Data showed that in Table (4) there are significant differences among the different six concentrations. The concentrations of foliar spray 75% and soil addition 75% highly significant reduction in the mean means number (of 23 and 31 individual/ 180 leaves), respectively. Next comes moderate reduction concentration (foliar spray 50%, soil addition 50%, with means number (of 35 and 41individual/ 180 leaves) respectively, compared to control. The lower reduction showed in (foliar spray 25% and soil addition 25%) treatments with means number (of 54 and 61individual/ 180 leaves). Data in the second season, the first and second concentrations (foliar spray 75% and soil addition 75%) indicated a highly significant reduction in the mean means number(16 and 22 individual/ 180 leaves), respectively, and found that a difference from the first season in some concentrations (soil addition 50%, foliar spray 50%, soil addition 25%) and with means number (29, 32 and 55 individual/ 180 leaves),respectively compared to control without any fertilizer. The lower reduction showed intreatment foliar spray 25% with means number (68 individual/ 180 leaves).

These results are summarized in the fact that the most influential coefficient concentration (foliar spray 75 and soil addition 75%) during the two seasons of the study and the treatment was the least influential foliar spray 25% and soil addition 25%.

**Table (4): Effect of diatomaceous earth concentration on the general weekly means number of pests infesting cucumber (flowering and fruiting growth) var. (Sina1 F1) under greenhouse at Qaluobia Governorate during two seasons**

| | **2021** | | | **2022** | | |
|---|---|---|---|---|---|---|
| **Pests** | ***Franklaniella occidentalis*** | ***Dacus ciliatus*** | ***Means*** | ***Franklaniella occidentalis*** | ***Dacus ciliates*** | ***Means*** |
| **Diatomaceous earth concentration %** | **Nymph &Adult** | **Larvae** | | **Nymph &Adult** | **Larvae** | |
| **Control** | 198 a | 110 a | 154 a | 154 a | 90 a | 122 a |
| **Foliar spray 75%** | 46 e | 23 e | 34.5 c | 55 f | 16 f | 35.5 d |
| **Soil addition 75%** | 61 d | 31 d | 46 bc | 49 g | 22 e | 35.5 d |
| **Foliar spray 50%** | 83 c | 35 cd | 59 bc | 73 e | 29 de | 51 cd |
| **Soil addition 50%** | 80 c | 41 c | 60.5 bc | 69 d | 32 d | 50.5 cd |
| **Foliar spray 25%** | 97 b | 54 b | 75.5 b | 86 c | 68 b | 77 b |
| **Soil addition 25%** | 102 b | 61 b | 81.5 b | 95 b | 55 c | 75 bc |
| **F value** | 329.42*** | 120.83*** | 14.04** | 63.18*** | 149.75*** | 18.19** |
| **E.V** | 8.58 | 7.58 | 36.16 | 1.38 | 7.13 | 24.85 |

Values in the same column followed by the same letter do not significantly differ from each other according to Least Significant Test at 5% level

## Effect of diatomaceous earth concentration on yield and its components of cucumber plants

Data presented in Table (5) showed that using diatomaceous earth at concentrations of 75% with foliar spraying or addition to soil and 50% with foliar spraying on cucumber plants increased fruit weight average, early yield, and total yield of cucumber plants in the two seasons of study compared with the other without significant differences among them. The fruit yield was positively correlated with the vegetative characters such as plant height, leaf area and chlorophyll content as shown in Tables (1).

**Table (5): Effect of diatomaceous earth concentration on average fruit weight, early yield and total yield of cucumber plants**

| **Diatomaceous earth concentration %** | **Average fruit weight (g)** | | **Early yield (g / plant)** | | **Total yield (kg / plant)** | |
|---|---|---|---|---|---|---|
| | **2020/2021** | **2021/2022** | **2020/2021** | **2021/2022** | **2020/2021** | **2021/2022** |
| **Control** | 85.47 e | 87.46 c | 570.00 d | 586.67 d | 1.590 d | 1.723 d |
| **Foliar spray 75%** | 105.08 a | 106.45 a | 936.89 a | 954.67 a | 2.816 a | 2.862 a |
| **Soil addition 75%** | 106.46 a | 108.46 a | 928.00 a | 952.44 a | 2.700 a | 2.831 a |
| **Foliar spray 50%** | 108.35 a | 110.45 a | 930.00 a | 949.33 a | 2.787 a | 2.853 a |
| **Soil addition 50%** | 98.98 b | 96.32 b | 839.33 b | 884.33 b | 2.511 b | 2.663 b |
| **Foliar spray 25%** | 93.06 cd | 95.40 bc | 675.33 c | 675.00 c | 1.968 c | 1.997 c |
| **Soil addition 25%** | 89.30 de | 90.30 bc | 660.33 c | 575.00 c | 1.966 c | 1.985 c |

Values in the same column followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5% level

## The infestation-yield relationship

The effect of different diatomaceous earth concentration on cucumber total yield was presented in Table (6) for two successive seasons. Referring to the effects of using different diatomaceous earth concentrations was significant between pest population and weight yield. These values indicated that the five factors (pests), whitefly, *Bemisia tabaci*( Genn. ), leaf miner, *Liriomyza trifolii* (Burgess), The western flower thrips, *Franklaniella occidentalis* (Pergande) and cucurbit fruit fly, *Dacus ciliates* (Loew) and spider mite, *Tetranychus urticae* ( Koch) were responsible percentage for 86% and 91%, respectively. Total Explained Variance ("E.V.") of variability in the average weight of crop yield in both seasons 2020/2021and 2021/2022, respectively. Data revealed that foliar spray 75%, foliar spray 50% and soil addition 75% were the most concentrations application caused increasing weight of cucumber yield with low mean weekly number of the pests during the two seasons, whereas recording (2.816, 2.787,2.700,2.862, 2.853 and 2.831 Kg), respectively by the concentrations application followed by soil addition 50%, foliar spray 50%, soil addition 25% which record the highest mean number of pests in both seasons the results showed (2.511, 1.968, 1.966, 2.663, 1.997 and 1.985 Kg), respectively. Data showed that the relationship among different concentrations application on the population density of pests in vegetative growth and crop yield of cucumber was negative and highly significant whereas "r" values were -0.910 and -0.820, while "b" values were -0.004 Kg and -0.017 Kg for two successive seasons 2020/2021 and 2021/2022, respectively. The coefficient of determination was 0.828 and 0.672 throughout two successive seasons. As well the means number of pests infesting lowering growth and fruiting growth was negative and highly significant whereas "r" values were (-0.884 and -0.924), while "b" values were (-0.002 and -0.028) Kg and coefficient of determination were (0.781 and 0.853) for two successive seasons.

**Table (6): Effect of different diatomaceous earth concentrations on weekly means number of pests infesting cucumber plant and total yield.**

| Diatomaceous earth concentration % | 2020/2021 | | | 2021/2022 | | |
|---|---|---|---|---|---|---|
| | The number of pests infesting vegetative growth | The number of pests infesting flowering growth and fruiting growth | Total yield (kg / plant) | The number of pests infesting vegetative stag | The number of pests infesting flowering growth and fruiting growth | Total yield (kg / plant) |
| **Control** | 1166.2 A | 154 A | **1.590 d** | 1044.6 A | 122 A | **1.723 d** |
| **Foliar spray 75%** | 385.6 D | 34.5 C | **2.816 a** | 418.6 C | 35.5 D | **2.862 a** |
| **Soil addition 75%** | 443.8 CD | 46 BC | **2.700 a** | 467.8 C | 35.5 D | **2.831 a** |
| **Foliar spray 50%** | 498.2 BCD | 59 BC | **2.787 a** | 545.6 BC | 51 CD | **2.853 a** |
| **Soil addition 50%** | 570.4 BCD | 60.5 BC | **2.511 b** | 565.4 BC | 50.5 CD | **2.663 b** |
| **Foliar spray 25%** | 638.6 BC | 75.5 B | **1.968 c** | 582.2 BC | 77 B | **1.997 c** |
| **Soil addition 25%** | 749.6 B | 81.5 B | **1.966 c** | 682 B | 75 BC | **1.985 c** |
| **Correlation (r )** | **-0.910**** | **-0.884**** | **-----** | **-0.820*** | **-0.924**** | **----** |
| **Partial regression (b)** | **-0.004** | **-0.017** | | **-0.002** | **-0.028** | |
| **Coefficient of determination "$r^2$"** | **0.828** | **0.781** | **----** | **0.6724** | **0.853** | **----** |
| **F value** | **11.99*** | | | **21.15** | | |
| **(E.V%)** | **86%** | | | **91%** | | |

Values in the same column followed by the same letter do not significantly differ from each other according to Least Significant Test at 5% level

**Effect of diatomaceous earth concentration % on N P K and Si contents of cucumber plants**

Table (7) shows the effect of diatomaceous earth concentration % on N and P contents of cucumber plants. As for N % content, results found that using diatomaceous earth at the concentration of 50 % with foliar spraying increased the content of N% in both seasons without significant differences with the concentration of 75% with foliar spraying or soil addition in the second season. As for P % content, results indicated that using diatomaceous earth at the concentration of 75 % with foliar spraying or soil addition and using diatomite at the concentration of 50 % with foliar spraying increased the content of P % in the two tested seasons. Data clearly that, using diatomaceous earth at the concentration of 50 % with foliar spraying increased the content of K % in the two seasons followed by 50% with soil addition with significant differences between them. For concerning Si % content, all applied diatomaceous earth concentrations as a foliar spray or soil addition have positive effects on silicon (Si) contents of cucumber plants in both two seasons study compared with the concentration of 25 % with foliar spraying or soil addition and control treatment.

**Table (7): Effect of diatomaceous earth concentration % on N, P, K and silicon (Si) contents of cucumber plants**

| Diatomaceous earth concentration % | N % | | P % | | K % | | Si % | |
|---|---|---|---|---|---|---|---|---|
| | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 | 2020/2021 | 2021/2022 |
| **Control** | 2.18 e | 2.21 e | 0.21 d | 0.20 c | 3.73 d | 3.52 d | 17.40 c | 17.30 c |
| **Spray with 75%** | 2.71 b | 2.66 ab | 0.26 ab | 0.24 ab | 4.08 bc | 4.12 bc | 19.77 a | 19.60 a |
| **Soil addition 75%** | 2.67 b | 2.67 ab | 0.26 ab | 0.25 a | 3.96 c | 4.04 bc | 19.73 a | 19.70 a |
| **Spray with 50%** | 2.78 a | 2.69 a | 0.28 a | 0.26 a | 4.70 a | 4.60 a | 19.70 a | 19.53 a |
| **Soil addition 50%** | 2.62 c | 2.48 bcd | 0.25 b | 0.23 b | 4.19 b | 4.16 b | 19.70 a | 19.63 a |
| **Spray with 25%** | 2.67 b | 2.39 de | 0.23 c | 0.20 c | 3.96 c | 4.02 bc | 18.60 b | 18.57 b |
| **Soil addition 25%** | 2.49 d | 2.46 cd | 0.21 c | 0.20 c | 3.99 c | 3.96 c | 18.60 b | 18.40 b |

Values in the same column followed by the same letter.do not significantly differ from each other according to Duncan's multiple range tests at 5% level

## Discussion

Future sustainable agriculture should focus on producing sufficient yield to satisfy changing human needs by conserving natural resources, maintaining the quality of the environment. In the present study, results are summarized in the fact that the most influential coefficient concentration (foliar spray 75 and soil addition 75%) and foliar spraying at 50%during the two seasons of the study and the treatment was the least influential soil addition 25% in plant growth (plant height, leaf area and chlorophyll content).These results are similar to those obtained by **El-Sherif et al. (2018) Soubeih et al. (2017)** This may be because silicon plays a part in preventing an imbalance of nutrients during the growth and production of plants.**(Ma and Takahashi 2002).** Leaf miner, aphid infestations, and prevalence are the areas where concentration is most beneficial. This finding agrees with **Vasanthi et al. (2014); Soubeih et al. (2017) and Coman et *al.* (2021)**. Diatomite mode of action may occur through its physical properties by scratching the cuticle (wax layer) of the insect enhancing the insect's dehydration or desiccation effect. In addition, it has. low mammalian toxicity, long active, stable and easy to eliminate from the bulk density of the grain **(Losic and Korunic 2018; Romei and Schilman 2024). Significant** positive relationships between plant growth and yield were also discovered by the study. Whereas, using foliar spray 75 and soil addition 75%) and foliar spraying at 50% increase average fruit weight, early yield, and total yield of cucumber plants in the two seasons. These results are going with those obtained by **(Abdalla 2011)** on *Vicia faba*, **(Angin *et al*., 2011**) on strawberry, **(Basha *et al*., 2013**) on rice, **(Sandhya 2013)** on wheat and (**Zahan *et al*., 2015 and El-Sayed 2018)** on *Antirrhinum majus*, **Kuzina et al. (2021)** on garlic and carrots and **Gokavi et al. (2021)** on Arabica coffee. The previous results demonstrate the beneficial effects of diatomite treatment on the balanced growth of plants and the decrease of pests. It may be connected to the fact that silicon actively participates in plant metabolism, structural activity, physiological and biochemical activity, improvement of plant mechanical strength, appropriate use of light interception, and development of plant strength when exposed to various forms of biotic and abiotic stress **(Etesami and Jeong 2020).** Moreover, The physical structure of the soil is improved by diatomite, which also helps light or sandy soils retain moisture longer and breaks up heavy clay-based soils. It also facilitates water transport to the root zone and releases nutrients gradually, acting as a carrier of fertilizer **(Hellal et al., 2012).** Diatomic can be a beneficial fertilizer since it can raise the soil's electric conductivity as well as its potassium and phosphorus concentrations **(Hellal et al., 2012, Zahan et al., 2015 and El-Sayed et al.,2018).** Moreover, **Eneji et al. (2008)** also discovered favorable connections between Si and P absorption and concluded that Si has an impact on soil, suggesting that Si is crucial for P uptake. The use of Si reduced N leaching, which may have been caused by Si's strengthening of soil aggregation, which allowed for more plant N. This is consistent with **(Lalithya et al. 2014)** on tomato. In addition, Si based fertilizer application reduces the leaching of $NO_3$ phosphate and K **(Matichenkov and Bocharnikova 2010).**

## Conclusion

Application of diatomaceous earth with foliar spraying or soil addition at 75% and foliar spraying at 50% gave the highest values of plant height, leaf area, and chlorophyll content as well as, increased average fruit weight, early and total yield in the two tested seasons. Moreover, the means number of pests associated with vegetative and fruit growth, which recorded the highest decrease throughout the research period. The results of this investigation, we suggest diatomite treatment as an environmentally beneficial approach to the culture and is an environmentally friendly approach.

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**Ethical statement**: Ethical Approval is not applicable.

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