Effects of Neem and Diatomaceous Earth Against *Myzus Persicae* and Associated Predators in Addition to Indirect Effects on Artichoke Growth and Yield Parameters

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**Abstract:** An important pest on artichoke is green peach aphid, *Myzus persicae* (Sulzer). The associated predators of *M. persicae*, such as the coccinelids, Chrysopid and Anthocorids were recorded. In the present study, effects of the biological insecticide NeemAzal-T/S or diatomaceous earth alone or in combination against *M. persicae* and on the associated predators were evaluated. Experiments were conducted in the Production and Research Station of National Research Centre, El-Nobaria (northern Egypt) during the season of 2005/2006. Four treatments were applied on artichoke plants to control the aphids. Commercial NeemAzal-T/S significantly reduced the number of *M. persicae*. NeemAzal-T/S and diatomaceous earth in combination produced the best control of *M. persicae* and were safe on the associated predators. The indirect effects of the tested compounds on artichoke growth and yield parameters were studied. Neem in combination with diatomaceous earth ranked first to alleviate the adverse effects of aphids on artichoke plants and to improve the vegetative growth and bud yield, followed by neem alone, while diatomaceous earth alone came almost at the last.

**Keywords:** Aphids, artichoke, diatomaceous earth, neem, predators, vegetative growth, yield parameters

**INTRODUCTION**

Globe artichoke (*Cynara cardunculus* var. *scolymus* (L.) Fiori) is a large immature flower rich in medicinal substances. It is considered one of the most important vegetable crops in the countries bordering the Mediterranean basin including Egypt. Artichoke is a species of great pharmacological interest, and has important nutritional values[1,2]. Increasing the used both of chemical fertilizers and pesticide led to an environmental pollution. In view of the negative impact of synthetic insecticides on human health as well as the environment, new techniques for controlling pests are needed. Therefore, it is advisable to pay a special attention to use safe agriculture system for artichoke production according to its nutritional and medicinal values[3]. Now consumers are extremely health conscious. Consumer's preference is high quality and chemical residue-free products[4]. As result, green or ecologically friendly agriculture is increasingly being adapted around the world. Thus, it is of the most important to use natural resources even for pest control. Green peach aphid *Myzus persicae* (Sulzer) feeds on hundreds of host plants in over 40 plant families, including Composite family (artichoke)[5,6]. *M. persicae* is caused serious problems on artichoke plants during early summer (March and April) when the average humidity and air temperature are in the high range. Large numbers of the aphids cause plant leaves to curl and turn yellow and the plants to show retarded growth, resulting in the formation of undersize or deformed edible parts[7]. High populations of aphids can reduce the vigor of the plant making it susceptible to other pests[8]. Other aphid species infest artichoke plants, including the bean aphid *Aphis fabae* (Scopoli) and artichoke aphid *Capirophorous elacagni* (del Guercio), can be caused a problem at certain times of the year. Several studies have been carried out on the effect of natural insecticides such as neem products to control aphids. Neem can provide adequate control of aphid species under greenhouse conditions[9], and under field circumstances[10,11]. Neem has a broad spectrum of activity against *M. persicae*[12,13,14]. Similar results were obtained by Nisbet et al.[13,16,17] and Lo et al.[18], who mentioned that neem products have acceptable control to *M. persicae*. Karagounis et al.[19] reported that alternative-control products are promising for peach aphid control, and have also low side-effects on predators and it could be used in safe organic farming system.

Another natural insecticide is diatomaceous earth, which has until recent period been used mainly against stored product pests[20,21]. It is an inert, residue-free dust with long-term effects[22], and it is selective against arthropods. Diatomaceous earth acts by destroying the cuticle through fatty absorption[23]. Grahn[24] has also

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verified the possibility of using diatomaceous earth against aphids. Natural enemies are important in the control and regulation of aphids\(^{[21]}\). Several predators attack aphids in artichoke, most notably species in the genera *Coccinella*, *Scymnus*, *Chrysoperla* and *Orius*. Preserve populations of beneficial insects by avoiding unnecessary insecticide applications and by providing acceptable habitat for these predators. The use of selective insecticides together with natural enemies could help to reduce the amount of insecticide necessary for control\(^{[24,7]}\). The present study was conducted to investigate the effects of NeemAzal-T/S or diatomaceous earth alone or in combination on *M. persicae* and the associated predators; (*Coccinellids, Chrysoperla*, and *Orius*), and also to study the indirect effect of these compounds on artichoke growth and yield parameters.

**MATERIALS AND METHODS**

**Experimental Site:** A field experiment was carried out on globe artichoke, cv. Green Globe. The field was located in the Production and Research Station of National Research Centre, El-Nobaria, El-Behira Governorate (northern Egypt). The soil texture is sandy with 90.08% sand, 0.66% silt and 9.26% clay. The pH was 7.9 and EC was 1.8 dS/m. Green Globe, a seed-propagated artichoke cultivar (Juliwa, Heidelberg, Germany), was used in this investigation during the growing season of 2005/2006. Planting was on September fifth, with 100 cm apart between each two plants on the ridge and 100 cm between the ridges. The experiment was carried out in a randomized complete block design (RCBD) with three replicates. The plot area was 30 m\(^2\) containing 30 artichoke plants. Drip irrigation system with good quality water was used. All other agricultural practices such as irrigation and fertilization management were followed according to Instructions lectures\(^{[27]}\) by the Ministry of Agriculture, Egypt, and Saleh\(^{[29]}\).

**Materials:** NeemAzal-T/S, a commercial formulation produced by Trifolio-M GmbH (Lahnau, Germany) was used. NeemAzal-T/S consists of 4% NeemAzal (1% azadirachtin A and 3% other neem ingredients), vegetable oil and tensides. Concentration of 1% of NeemAzal-T/S was evaluated for effectiveness against *M. persicae* and its effect on predators and indirect effects on artichoke growth and yield parameter. The diatomaceous earth was carried out with Fossil Shield (Bein GmbH, Eiterfeld, Germany). Fossil Shield contains 73% amorphous SiO\(_2\) with an average particle size of 5-30 µm and a water content of approximately 2%\(^{[21]}\). A solution of diatomaceous earth in water with a concentration of 2 g/L was used.

**Diatomaceous Earth in Combination with Neem:** Neem acts as an anti-feedant\(^{[29]}\). Food consumption results in a reduction in the efficacy of diatomaceous earth because of the uptake of water\(^{[23]}\). Therefore these two biological insecticides should complement each other. Diatomaceous earth was applied at concentrations of 2g/ L water. The solution of diatomaceous earth in water was enriched with 10 ml Neem/L.

**Field Treatments Were as Follows:**

- Control (300L water/ha)
- NeemAzal-T/S (3L in 300L /ha (1%))
- diatomaceous earth (600g in 300L/ha)
- combination of (2+3) (2g/L of diatomaceous, enriched with 10 ml Neem/ L)

The treated plots were sprayed twice; the first spray was at early of March 2006 and the second was after two weeks from the first one. 

**Measurements:**

**Aphid and Predator’s Populations:** Aphids were recorded in square inch on underside of artichoke leaf in middle of ten plants randomly in each treatment and control shortly before spraying and at 1, 7 and 15 days after each spray. The predators were counted by direct count method on ten plants in the same regime as aphids. Percent reduction in infestation of aphids for each treatment was calculated according to Henderson and Tilton equation\(^{[30]}\), and also percent reduction of predator’s populations was evaluated.

**Aphid Numbers on Different Leaves on Artichoke Plant:** Aphid numbers were counted on artichoke leaves of ten plants only in control plots during the infestation period, as model for distributing the aphid populations on different leaves of artichoke plants.

**Vegetative Growth Characters:** Growth characters represented by plant height (cm), number of leaves per plant and leaf chlorophyll content (SPAD) were done 2 weeks after treatments start. The content of total chlorophyll was measured using a Minolta Chlorophyll Meter (SPAD-501).

**Bud Characters:** Buds were harvested at one-week intervals, total yield was determined for weight and number of buds per plant. The marketable yield was calculated after exclusion of buds that have black spot or aphids (non-marketable). The data collected was being randomized from 10 plants per plot.

**Statistical Analysis:** The obtained data was statistically analyzed using CoStat software package (CoHort...
RESULTS AND DISCUSSIONS

Percent Reduction in Populations of Aphid *M. Persicae*: NeemAzal-T/S increased the mortality of *M. persicae* populations compared with the control and with aphid’s population before treatment (ca. 11 aphids/square inch). Results indicate that 88.8% initial kill of aphids was achieved by NeemAzal-T/S one day after the first spray, and it was 96.4% in combination treatment, while it was 68.6% in diatomaceous earth treatment (Fig. 1 & Table 1). At 7th day, the reduction percentages were 70.6, 56.0 and 83.3% in NeemAzal-T/S, diatomaceous earth and combination, respectively. After 15 days, reduction percent was 56.0, 43.4 and 63.5% in the considered treatments, respectively. The second spray started after 15 days of the first one. The results show that the same trend of efficiency of the tested compounds was obtained. After one day, combination led the tested compounds causing 97.0% reduction followed by NeemAzal-T/S (90.0%), while it was 78.0% in diatomaceous earth treatment. After 7 days, percent reduction was 80.0, 69.0 and 89.0% in NeemAzal-T/S, diatomaceous earth and combination, respectively. At 15th day, the reduction percent was 62.0, 48.0 and 69.0% in the measured treatments, respectively (Fig. 1 & Table 1).

As regards the general mean of reduction percent in aphids for the two sprays, it is evident that combination effect was the most effective causing 83.1% reduction followed by NeemAzal-T/S (74.5%), while diatomaceous earth came lastly with average 60.9%. Statistical analysis revealed that there were significant differences (P< 0.034) and (LSD: 13.9) between NeemAzal-T/S or combination and diatomaceous earth (Table 1). The results presented here with *M. persicae* clearly confirm reports from Nisbet *et al.*,[15,16,17] and Lowery & Isman[20] who said that neem extracts could be used in the field to control peach aphid, *M. persicae*. Also, our results are in good agreement with those of Schauer[23] who controlled the pea aphid, *Acythosiphon pisum* (Scopoli), and the black bean aphid, *Aphis fabae*, which also infest artichoke plants, with various neem extracts. The potential of NeemAzal-T/S to control *M. persicae* populations supports the reports from Hummel *et al.*,[14], who used NeemAzal-T/S to control the vetch aphid *Megoura vicina* (Buckton) in contrast to synthetic pesticides, who found that NeemAzal-T/S is considered safer and more eco-friendly. Similar results were also reported by Lo *et al.*,[18], Edelson *et al.*,[31], and Karagounis *et al.*,[19] who mentioned that neem products have satisfactory control to *M. persicae*.

To increase the efficacy of NeemAzal-T/S against *M. persicae*, a combination with diatomaceous earth was tried. All tested mixtures significantly reduced the number of *M. persicae* (Fig. 1). The best treatment of aphids control was a treatment with NeemAzal-T/S in combination with diatomaceous earth which had a significant effect to reduce the number of *M. persicae* compared with other treatments. However, this can change dramatically under wet conditions because of the mode of action of diatomaceous earth as reported by Mewis[21].

Increasing of mortality percents of *M. persicae* in artichoke field experiments after treatment compared with the control can be caused by (A) a lethal effect through the application or (B) by reduced numbers of *M. persicae* available as possible diet. Therefore the influence of NeemAzal-T/S and diatomaceous earth directly applied to *M. persicae* and predators were tested for their impact.

Percent Reduction in Populations of Associated Predators: The effects of applied compounds on predator’s populations in artichoke field were also studied. The following species of predators were recognized, and were present in reasonable numbers: *Chrysoperla carnea* (Steph) (larvae), *Orius* spp. (nymphs & adults), *Coccinella* spp. (larvae & adults) and *Scymnus* sp. (adults).

Data presented in Figs. (2A, B, C and D) and Table (1) show that the tested compounds were not so harmful on abundance of predators. In term of figures, reduction percentages in population density of *C. carnea* were: 17.7, 16.6 and 19.2% in NeemAzal T/S, diatomaceous earth and combination, respectively at
first day after the first application. The corresponding values for *Orius* spp. were 17.5, 16.4 and 19.0% with the same mentioned materials, respectively. For Coccinellids; reduction percent on *Coccinella* spp. were: 15.3, 14.2 and 16.8%, while it was on *Scymnus* spp, 16.2, 15.1 and 17.8% in the considered treatments, respectively after one day post the first spray. The reduction percents in predator’s populations were lower at 7th and 15th day than at 1st day, these percents ranged from 7.5 to 9.9% in NeemAzal –T/S treatment, ranged from 6.1 to 8.5% in diatomaceous earth treatment, and ranged from 7.9 to 10.3% in combination treatment at 7th day post 1st spray. At 15th day, the reduction percents ranged from 1.2 to 6.9% in all treatments.

Regarding the second spray, the same trend on the four predators was observed with the tested compounds as in the first spray. Based on the mean of percent reduction in population density of the predators, results show that there were no significant differences (P< 0.074) between each of the three tested compounds. The side effect of diatomaceous earth was slighter than NeemAzal-T/S and combination on the associated predators found (Figs. 2A, B, C, and D & Table 1). The side effects of these compounds on the associated predators were presented in (Fig. 2 & Table 1), which showed that this side effect was higher on *C. carnea* and *Orius* spp. than on Coccinellids (*Coccinella* and *Scymnus*) for the tested compounds (NeemAzal-T/S, diatomaceous earth and combination), this result was corresponded with results obtained by Ulrichs *et al.*[35], who demonstrated lower susceptibility of Coccinellids predators to the neem oil and diatomaceous earth, also as reported by Tedeschi *et al.*, al., Ahmad *et al.*[9] and Gupta[11], who mentioned that azadirachtin can be noxious to some predators, but the short persistence makes this active ingredient a promising solution in IPM programs.

### Table 1: Percent reduction in populations of *M. persicae* and the associated predators at 1, 7, and 15days post two sprays

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sprays</th>
<th>days</th>
<th>Aphids</th>
<th>The associated predators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>M. persicae</em></td>
</tr>
<tr>
<td>NeemAzal-T/S</td>
<td>1st</td>
<td>1st</td>
<td>88.8</td>
<td>17.7</td>
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<td></td>
<td>7th</td>
<td></td>
<td>70.6</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>15th</td>
<td></td>
<td>56.0</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>1st</td>
<td>90.0</td>
<td>16.8</td>
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<tr>
<td></td>
<td>7th</td>
<td></td>
<td>80.0</td>
<td>9.5</td>
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<tr>
<td></td>
<td>15th</td>
<td></td>
<td>62.0</td>
<td>2.8</td>
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<tr>
<td>Combination</td>
<td>1st</td>
<td>1st</td>
<td>88.6</td>
<td>16.6</td>
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<tr>
<td></td>
<td>7th</td>
<td></td>
<td>56.0</td>
<td>8.3</td>
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<tr>
<td></td>
<td>15th</td>
<td></td>
<td>43.4</td>
<td>3.4</td>
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<tr>
<td></td>
<td>2nd</td>
<td>1st</td>
<td>78.0</td>
<td>16.2</td>
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<td></td>
<td>7th</td>
<td></td>
<td>69.0</td>
<td>8.6</td>
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<tr>
<td></td>
<td>15th</td>
<td></td>
<td>48.0</td>
<td>2.6</td>
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<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>74.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Diatomaceous earth</td>
<td>1st</td>
<td>1st</td>
<td>68.6</td>
<td>16.6</td>
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<tr>
<td></td>
<td>7th</td>
<td></td>
<td>56.0</td>
<td>8.3</td>
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<tr>
<td></td>
<td>15th</td>
<td></td>
<td>43.4</td>
<td>3.4</td>
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<tr>
<td></td>
<td>2nd</td>
<td>1st</td>
<td>78.0</td>
<td>16.2</td>
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<td>7th</td>
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<td>69.0</td>
<td>8.6</td>
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<td>2.6</td>
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<td>60.5</td>
<td>9.4</td>
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<tr>
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<td>1st</td>
<td>96.4</td>
<td>19.2</td>
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<td></td>
<td>7th</td>
<td></td>
<td>83.0</td>
<td>10.3</td>
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<tr>
<td></td>
<td>15th</td>
<td></td>
<td>63.5</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>1st</td>
<td>97.0</td>
<td>17.7</td>
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<td></td>
<td>7th</td>
<td></td>
<td>89.0</td>
<td>10.0</td>
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<td></td>
<td>15th</td>
<td></td>
<td>69.0</td>
<td>3.1</td>
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<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>83.1</td>
<td>11.2</td>
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<tr>
<td>LSD</td>
<td></td>
<td></td>
<td>13.9</td>
<td>6.29</td>
</tr>
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</table>
Fig 2: Effect of mean or diatomaceous earth alone or combined on mean ± SE of the associated predators numbers on artichoke plant post the indicated days in each spray.

The evaluation of the action of natural insecticides (such as neem or diatomaceous earth) on predator's efficiency is a very important parameter. After the second spray, these predators could keep the aphids population less than the economic threshold till end of season as appeared in Fig (3), where found many predators on one artichoke plant.

Distribution of Aphids on Different Artichoke Leaves: Distribution of aphids on different artichoke leaves were only studied in control plots during infestation period as model for distributing *M. persicae* on plant leaves. The aphid numbers were lower on older leaves than on younger leaves as illustrated in Fig. (4) and presented in Fig (5), because the older leaves had no sufficient food for aphids. While the younger leaves had more sap and nutritive contents which help to attract the aphids to infest these leaves. This result was corresponded with White *et al.*,[@35] who stated that aphids would usually outbreak after a mild winter, on part of plants containing both high nitrogen...
Table 2: Indirect effects of NeemAzal-T/S and Diatomaceous earth alone and in combination on artichoke growth and yield parameters

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height, cm</th>
<th>Leaves No./plant</th>
<th>Chlorophyll, SPAD</th>
<th>Total yield, g/plant</th>
<th>Total yield, No./plant</th>
<th>Marketable yield, g/plant</th>
<th>Marketable yield, No./plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (1)</td>
<td>120.7</td>
<td>20</td>
<td>49.3</td>
<td>2387</td>
<td>14.7</td>
<td>1790</td>
<td>9.7</td>
</tr>
<tr>
<td>NeemAzal-T/S (2)</td>
<td>124.3</td>
<td>21</td>
<td>52.7</td>
<td>2690</td>
<td>15.7</td>
<td>2242</td>
<td>11.7</td>
</tr>
<tr>
<td>Diatomaceous earth (3)</td>
<td>121.3</td>
<td>20.3</td>
<td>50</td>
<td>2565</td>
<td>15.3</td>
<td>1973</td>
<td>12.3</td>
</tr>
<tr>
<td>Combination (2+3)</td>
<td>125</td>
<td>22.7</td>
<td>55.3</td>
<td>2773</td>
<td>16</td>
<td>2402</td>
<td>10.7</td>
</tr>
<tr>
<td>LSD</td>
<td>2.6</td>
<td></td>
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</tbody>
</table>

Fig 3: Predator’s population at the end of season.

Fig 4: 4 Aphid number on different leaves on artichoke plant.

Fig 5: Mean ± SE of aphid number on different leaves on artichoke plant.

Fig 6: Economic value of yield in treatment of Neem Azel-T/S and Diatomaceous earth alone and in combination compared to control (%)

Indirect Effects of the Tested Compounds on Artichoke Growth and Yield Parameters: Data presented in Table (2) exhibit the indirect effect of neem and diatomaceous earth alone or in combination on vegetative growth characters, e.g., plant height, number of leaves per plant, and chlorophyll content as well as total and marketable yield during the growing season. Addition of neem alone or in combination with diatomaceous earth decreased the adverse effect of aphids by significant improving (P< 0.031) of vegetative growth characters especially plant height and total chlorophyll content in artichoke leaves. The positive effect of diatomaceous earth alone on growth characters was not significantly (P< 0.072) compared to control. While, no significant difference was
detected (P< 0.065) among all treatments in their effects on leaves number per plant. With regard to the effect of foliar application of the tested compounds on artichoke yield, the obtained results show superiority in all yield parameters, e.g., weight and number of total yield and marketable yield compared to the unsprayed treatment (Table 2). Foliar application of neem and diatomaceous earth alone or in combination significantly improved the productivity (weight of buds), but did not significantly affect the number of buds per plant of total yield compared to unsprayed treatment. The marketable yield of buds (weight and number) increased by all sprayed treatments compared to unsprayed treatment. The combination treatment of neem with diatomaceous earth was most effective to increase the marketable yield of artichoke buds, followed by neem alone, then diatomaceous earth alone. For instance, the marketable yield of treated plants by neem alone or combined with diatomaceous earth were 125 and 134%, respectively, compared to unsprayed control treatment (Fig. 6). It means that, there is an economic value to use such these products as bio-control compounds to increase the bud yield of artichoke, because aphids infestation secrete copious amounts of honeydew, that covered a big distance of artichoke leaves which was deleterious to vegetative growth by negative effects on chlorophyll content and photosynthesis rate, subsequently caused a decrease in the net assimilation rate and loss bud yield. These results are corresponded with Gupta[11], who mentioned that mean grain yield of mustard was higher in treatment of Neem compared to control. Also the same results were obtained by Alabi & Olununjù[39], who stated that groundnut plants sprayed with neem seed extract gave yields higher than the plants that received other treatments (black soap and cow dung), apart from the un-treated plants.

The final conclusion for the present work confirmed that NeemAzal-T/S has a great potential in controlling M. persicae populations in the field. The efficacy increases by adding diatomaceous earth with NeemAzal-T/S in field experiments against M. persicae, and increasing the artichoke’s marketable yield, since they were safer to predators and also on human and farm animals. It is a good situation to increase the role of the natural enemies to control M. persicae biologically in artichoke field and keep the environment clean and to produce a safe product.

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REFERENCES


