DEVELOPMENT OF ON-SITE EMULSIFYING DEVICE FOR PRODUCTION OF COOKING-OIL-BASED PESTICIDES

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ABSTRACT World standards have become less tolerant regarding toxic pesticide residues, especially on fruits and vegetables. In the present study botanical cooking oils were selected as the basic constituents, since they are nontoxic to humans and not harmful to the environment. On-site pesticide-production devices were developed to facilitate technology that would be efficient and economical for manufacturing pest-control emulsions. Factors influencing the quality of the pesticide emulsion were tested to maximize its stability. A compact, inexpensive, energy-efficient mechanical homogenizer was developed to enable on-site emulsification and immediate application of the pesticides on greenhouse vegetables. Preliminary efficiency tests showed that cooking-oil-based pesticides in water emulsion can provide good control against aphids, mealy bugs, powdery mildew, and downy mildew on peppers and tomatoes. Homogenizer performances were ranked according to the average oil-droplet sizes in the water emulsion: smaller droplets have lower tendency for the cohesion that is a main cause of spoiled emulsions. The oil droplet sizes were estimated according to the average diameter and STD of the results in the water-based emulsion, at an oil—in-water concentration of 10%. The average diameter of cotton-oil droplets was reduced to 3 µm by increasing the speed of the homogenizer to 6000 RPM at a power consumption of 2 hp. Cooking-oil-based pesticides achieved the greatest control. For example, the infection levels of powdery mildew on leaves of pepper seedlings, 55 days after infection reached 50% leaf coverage whereas severity of disease on pepper plants treated by the oils ranged from 16 to 33%. The lowest infection level, obtained with cotton oil, reduced the severity of disease by more than 66% relative to an untreated field.
**Keywords:** pest control, predatory mite, edible oils, emulsifier, sprayer.

**INTRODUCTION**

Pesticides that are safe for humans and the environment are essential to satisfy the increasing demand for clean products and an uncontaminated environment. Cooking oils obtained from botanical sources degrade rapidly, therefore they are environmentally friendly and, since they are used as food, they are clearly safe for humans. There are reports that indicate that edible oils perform well as pesticides: Fenigstein et al. (2001) found that botanical oils that were emulsified and applied to a cotton field after storage provided good control against whitefly (*Bemisia tabaci*). Such pesticide constituents are of low toxicity and, therefore, not aggressive to the pest, so they generally require very uniform deposition on the plant canopy, which can be achieved with the best available commercial sprayers (Gan-Mor et al., 1996, 2004). Although these oils provide good control, and are relatively inexpensive when purchased as crude oil, they are expensive to growers, because of packing, handling, stabilizing, and overheads costs. Significant product-cost reduction can be achieved through a new approach that involves use of a device for on-site preparation of an emulsion for greenhouse sprayers (Gan-Mor and Ronen, 2009; Gan-Mor et al., 2010). The fact that the materials are completely non-toxic enables substantial change in the production process, i.e., on-site production by farm workers with a relatively inexpensive facility and minimal overhead costs.

The objective of the present study was to construct and test a compact, inexpensive, energy efficient homogenizer that enables on-site pesticide emulsifying for greenhouse spraying, and to monitor the factors that influence oil-droplet sizes, which, in turn, affect the emulsion stability.

**MATERIALS AND METHODS.** A multi-stage pesticide-production emulsifier was developed to enable on-site emulsifying and immediate application of the pesticides on greenhouse vegetables (Fig. 1).

![Figure 1. General view of the on-site emulsifier for greenhouse spraying.](image_url)

An oil pump feeds the oil into the emulsifier into which water is fed under constant pressure at a constant flow rate. The emulsifier is constructed with stationary and rotating blades that can be adjusted to speeds from 2000 to 6000 RPM (Fig. 2).
Figure 2. Stationary and rotating blades for reducing the oil-droplet diameter inside the emulsifier.

The oil sheering and mixing into the water reduce the oil droplets to very small diameters, so that the resulting emulsion flowing out of the emulsifier contains very fine oil droplets. Several botanical cooking oils, i.e., cotton, peanut, and canola, were selected as the basic constituents, since they are nontoxic to humans and not harmful to the environment. The emulsion stability depends on the size of the oil droplets in the water, and the amounts of surfactant and other stabilizing chemicals used. In trying to minimize the presence of chemicals, after preparation of the product the mixture was checked for droplet size, which was regarded as the primary stabilizing parameter. This was done by measurement of the droplet diameters and size distribution in the emulsions, for various emulsifier rotor speeds and oil types.

The test seedlings were located next to highly infected pepper seedlings, and were sprayed weekly for 6 weeks. The percentage coverage of the sprayed leaves was evaluated six times over a period of 60 days from planting.

**RESULTS AND DISCUSSION.** Laboratory tests of the homogenizer and its ability to stir and produce tiny droplets were performed. The capability to reduce droplet size by changing the rotational speed was examined for five speeds - 2000, 3000, 4000, 5000, and 6000 RPM - with constant flow rate and pressure: 1 L/min and 15 psi, respectively. The droplet diameters in the emulsions were measured with a microscope. The average, maximum, and minimum diameters of 100 droplets of cotton oil, measured for each rotor speed and the STD values of the average were calculated by simple statistical program (Table 1).

Table 1. Dimensions of cotton oil droplets accepted by five homogenizer speeds.

<table>
<thead>
<tr>
<th>Speed (RPM)</th>
<th>AVG (µm)</th>
<th>D max (µm)</th>
<th>D min (µm)</th>
<th>STD (µm)</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>4.82</td>
<td>13.52</td>
<td>1.40</td>
<td>2.51</td>
<td>0.49</td>
</tr>
<tr>
<td>3000</td>
<td>6.29</td>
<td>9.73</td>
<td>2.25</td>
<td>1.69</td>
<td>0.33</td>
</tr>
<tr>
<td>4000</td>
<td>5.46</td>
<td>9.15</td>
<td>2.02</td>
<td>1.52</td>
<td>0.30</td>
</tr>
<tr>
<td>5000</td>
<td>3.42</td>
<td>6.51</td>
<td>1.71</td>
<td>1.10</td>
<td>0.22</td>
</tr>
<tr>
<td>6000</td>
<td>2.67</td>
<td>9.68</td>
<td>0.79</td>
<td>1.65</td>
<td>0.33</td>
</tr>
</tbody>
</table>
The diameters of droplets produced at 2000 RPM showed relatively large D max (13.5 µm) and high STD (2.5 µm). This suggested that the homogenizing process at that speed was incomplete and that the emulsion was not ready for application. However, at the other, higher speeds, the STD and confidence intervals were found to be relatively low, with similar values. This means that the homogenization process had started successfully. The average droplet diameters were reduced from 6.3 to 2.7 µm as the speed increased from 3000 to 6000 RPM. At 6000 RPM the droplet size had fallen to the required diameter of less than 3 µm, and the homogenizer motor was running at its maximum power of 2 HP.

Experiments were performed with the emulsion produced at 6000 RPM, to assess the control efficacy of botanical cooking-oil-based pesticides sprayed onto pepper potted plants. The control efficacy of pepper powdery mildew (*Leveillula taurica*) by control agents based primarily on cooking oils was tested in six treatments: canola oil, two types of cotton oil, two types of peanut oil, and a control comprising water with no additional chemicals. Each treatment comprised of five replicates of a single two-three months old plants. The oil-in-water concentration was set to 3%. To reduce possible phytotoxicity and emulsion costs, only a small amount of surfactant -less than 0.3% - was used. Typical results of powdery mildew suppression on pepper leaves by these pesticides are given in Fig. 3.

![Figure 3. Control of powdery mildew (*Leveillula taurica*) on pepper seedlings by cooking-oil-based pesticides.](image)

The infection levels of powdery mildew on leaves of pepper seedlings, 55 days after infection reached ca 50% leaf coverage whereas severity of disease on pepper plants treated by the oils ranged from 16 to 33%. The lowest infection level, obtained with cotton oil, reduced the severity of disease by more than 66% relative to an untreated field.
**CONCLUSION.** A compact, inexpensive, energy-efficient homogenizer was developed, that enables on-line emulsifying for large field sprayers and on-site emulsifying for greenhouse spraying, for immediate application. The performance of the homogenizer was successfully optimized to provide 1 L/min of 30% oil-in-water emulsion with an oil-droplet size of 3 µm.

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