



## Integrated Pest Management for Sustainable Mango Production

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Accepted on: 10-10-2014; Finalized on: 30-11-2014.

### ABSTRACT

Mango (*Mangifera indica* L.) suffers from several diseases, insects and mites at all stages of its life. They cause several kinds of rot, dieback, anthracnose, malformation, necrosis, spots, mildew, mites and insects. Crop diseases and pests management, is based on several important principles as chemical pesticides and agricultural practicals. Now, a day, integrated pest management is the most effective use. Three foliar application of bioagents, natural compounds alone or in combination to mango trees markedly decreased infection with malformation, anthracnose, powdery mildew, dieback diseases, mites, insect in leaves, blossom clusters as well as increased fruit set and yield in two cultivars (Ewais and Seddek) and regions (Behera and Ismailia Governorates). The best way to ensure success of a disease-management program is to use integrated disease-control measures. A successful disease-control program could involve just a single practice, but the long term reduction of disease losses generally requires the application of several control measures.

**Keywords:** Integrated Pest Management, Mango Production.

### INTRODUCTION

Statistics provided by the Egyptian Ministry of Agriculture and Land Mangoes are an important fruit crop in Egypt and all over the world Statistics provided by the Egyptian Ministry of Agriculture and Land Reclamation indicate that a total of 151,000 Fadden are planted with mango trees, with a total production of 0.596 million ton in Egypt alone.<sup>8</sup> Mango is considered one of the most popular fruits among millions of people in the tropical area and increasingly in the developed countries, because of its delicious taste and high caloric value, it is ranked as one of the good fruits in the international market.

Mango suffers from several diseases at all stages of its life. All the parts of the plant, namely, trunk, branch, twig, leaf, petiole, flower and fruit are attacked by a number of pathogens including fungi, bacteria and algae. They cause several kinds of rot, dieback, anthracnose, malformation, scab, necrosis, blotch, spots, mildew, etc. This fact sheet concentrates on the symptoms of the important mango diseases, the weather conditions conducive to disease development, and methods for control.<sup>11,30</sup>

Powdery mildew is caused by the fungus *Oidium*. The disease is reported to cause approximately 20 -80% per cent crop loss. Powdery mildew is common in all over Egypt as El-Behera, El-Fayum, El-Monefia forword by El Ismailia Governorates. Powdery mildew is one of the most serious diseases of mango affecting almost all the varieties.<sup>29</sup>

Malformation disease, caused by the fungus *Fusarium subglutinans*, is a serious constraint reducing

production.<sup>30</sup> The disease is sometimes termed "blossom malformation," and this term is accurate when the flowering panicle is involved, but the symptoms can also appear on seedlings in the nursery that are too young to flower.<sup>25, 14-17</sup> Although the etiology of the disease has been well established, its cause has not been fully accepted in Egypt, and control measures proved effective elsewhere are not yet widely practiced. They are, however, used by some growers and are promoted by a few enlightened extension agents. When these relatively low-tech procedures come to be applied extensively in Egypt, a dramatic rise in mango production may be expected.

Anthracnose is a fungal disease caused by *Colletotrichum gloeosporioides* Penz. It is the most common disease of mangoes on the Egypt, devastating young leaves and often causing defoliation of flush growth and postharvest.<sup>11, 2</sup> If wet weather occurs during flowering, anthracnose causes severe blossom blight which can destroy inflorescences (flower panicles) and prevent fruit set. Fruit can be infected up to harvest but visual symptoms usually do not develop until the fruit begins to ripen. Anthracnose is usually only a problem in fruit that is ripening, as the fungus remains dormant in green fruit during the growing season. Small dark spots form at first and then enlarge rapidly under favorable conditions. Pink spore masses grow on the infected tissue. Such fruit has no market value. At the same time, fruit sensitivity to decay, low temperature and general fruit perish ability due to the rapid ripening and softening limits the storage, handling and transport potential.



Mango is a major horticultural crop and are susceptible to many insect pests. These include swarming beetles, fruit flies, termites and mango seed weevil. There are agnates available on the last three of this list. Mango scale insects, *Aulacaspis tubercularis* Newstead, become a major pest in Egypt mango orchards. *Aulacaspis tubercularis* attacks hosts in at least seven plant families.<sup>22</sup> In South Africa, *A. tubercularis* was first recorded on one cultivar of mango in 1947 and has since become a pest throughout all mango producing areas of South Africa.<sup>24</sup> Only the crawler stage can move to a new host (adult males can fly but cannot establish a colony), but scale insects can move to new hosts as a result of wind, birds, and insects. Crawlers are capable of moving distances of tens of kilometers on wind currents to infect clean crops.<sup>9</sup> *Aulacaspis tubercularis* attacks mango leaves, branches and fruit, where it causes superficial pink or yellow blemishes to develop, making the fruit unmarketable.<sup>24</sup> Scales are found on the upper or lower surfaces of leaves and also on fruits. Halteren<sup>21</sup> studied the development of *A. tubercularis*, and concluded that development is completed in 35–40 days for females and 23–28 days for males.

Egypt, and South Africa, it has become the most important citrus pest in Upper Egypt.<sup>6</sup> However, there is little information on the specific economic losses caused by this scale.<sup>7</sup> This insect is mainly a problem as a contaminant on fruit, which can cause rejection in most fresh fruit markets. It also causes dieback of twigs, premature drop of fruit and leaves, and deformation of fruit. Large populations cause chlorosis and premature drop of leaves, dieback of twigs and branches, stunting and distortion of the fruit, and premature fruit drop.<sup>5</sup>

The Acari constitute a large and economic group of arthropods. Some of them are photophagous feeding on leaves, buds and fruits, causing direct injury to plants while others may transmit plant diseases, causing great damage to agriculture crops, Others are predaceous and play an important role in the biological control of pests such as injurious mite, scale insects and white flies.

The genus *Eniophyes* includes many species of which *E-mangifera*<sup>32</sup> cause considerable damage to mango this species is a persistent pest of mango in Egypt. It attacks the terminal buds, causing malformation and stunting of inflorescences and finally results in great loss of yield. Association of mites with malformed panicles came into picture in 1944 when Sayed reported the mite *Aceria mangiferae* (Sayed) syn.<sup>32</sup>

Contamination of the environment by pesticides is increasing due to their usage for attempted eradication of various pests and protection of agricultural crops. Integrated pest management (IPM) systems are generally considered to be keys to promoting sustainable agricultural land use systems, particularly, with increasing recognition of environmental problems which are associated with synthetic pesticide applications.<sup>8</sup>

More attention in the last decade has focused on replacing synthetic fungicides with new strategies, such as changes in cultural practices, the use of biological control agents and natural compounds. The desired effects of the use of natural compounds and biological control agents in crop protection have drawn attention to integrated disease management. An integrated approach for their management is needed for sustainable mango production. One of the potential methods of reducing the severity of diseases in an environmentally safe manner is the use of natural compounds. Natural compounds are those products which are not produced by synthesis but which occur in nature in mineral salts, and biological agents. Generally, IPM is regarded as the use of environmentally safe practices to reduce the disease incidence and development or use of multiple control tactics integrated into a single pest control strategy.<sup>29</sup> Since economic thresholds have not been established for most plant pathogens, an IPM takes a somewhat different approach in plant disease control. Biological control using antagonistic microbes to reduce the use of chemical fungicides in a system of integrated plant disease management, offers a powerful alternative to control plant diseases as *Streptomyces Aureofaciens* and *Pseudomonas*<sup>20,18,13</sup> and *Bacillus*.<sup>19</sup> The involvement of *Tilletiopsis* spp, a frequently recovered from leaves with powdery mildew infection, as biological control agents of powdery mildew disease on mango<sup>29</sup> was estimated.

These findings encouraged us to evaluate the potential use and the efficacy of foliar sprays of single or integrates of natural compounds as biological control and antioxidant (ascorbic acid) on field-grown mango trees to provide acceptable level of diseases incidence.

## MATERIALS AND METHODS

### • Microorganisms

The preliminary data are accessible to the PI including isolation and identification of local potential biological control agents (BCAs) against pathogens. The isolates were identified NRC. It is intended to stimulate the development of a biotechnological identification of microorganisms by identifying these bio-fungicides that control effectively pathogens of dieback, powdery mildew, malformation and anthracnose as following:

- *Streptomyces* sp. (St)
- *Pseudomonas fluorescens* (Fl)
- *Bacillus brevis* (Bb)
- *Tilletiopsis minor*(™)

### Natural components

The following natural components will be Fertilizer Co., Hanover, PA), Methyl Jasmonat and antioxidant (Ascorbic acid, 1mM).<sup>10</sup>



## Field application

Single and different combinations of formulation of microorganisms and natural compounds will be applied to the field to validate their potential activity against mango trees diseases under natural infection conditions of different field locations. To determine the efficacy of the natural compounds against mango diseases, a field experiment was conducted, using the susceptible cultivars Ewais (8 yr-old) and Seddek (10 yr-old) at Noubaria region, Behera Governorate in two seasons. Natural compounds are:

- *Streptomyces sp. (St)*
- *Pseudomonas fluorescens(FI)*
- *St X FI*
- *Bacillus brevis (Bb)*
- *Tilletiopsis minor*(™)
- Bb X TM
- Methyl jasmonate
- Ascorbic acid
- Mixture

Disease severity was determined as percentage of infection trees. To determine the efficacy of the microorganisms and natural compounds against powdery mildew, malformation, anthracnose and dieback, field experiments were conducted using the susceptible cultivars. Three foliar applications were applied at 30 -d intervals starting from Feb. 1<sup>th</sup> on mango trees in one-year. The microorganisms and natural compounds were being by using a knapsack sprayer. Trees were sprayed till run-off. Treatments were assigned in a randomized complete block design. Trees sprayed with water served as a check treatment. Plots consisting of 3 mango trees were replicated three times. Irrigation, fertilization and other cultural practices were carried out as recommended. In February, March and April, blossom clusters and fruit set which were naturally infected with powdery mildew was rated for disease severity on a 0-7 scale.<sup>31</sup> Malformation incidence on the blossom clusters was assessed. Four branches at the four cardinal points were labeled per tree canopy. During each assessment, the total number of healthy and diseased shoots (vegetative and floral) were counted on each branch and averaged over the four branches per tree. Evaluations were carried out monthly in the vegetative stage of mango growth and weekly during fruiting development (February to April). For dieback disease severity was determined as percentage of infected flowers and fruits per meter at 30 days interval during the growing season (May to November). Mean while branch disease severity was expressed as the diameter or lesion length of infected tissue (cm/m) at 30 days interval during the growing periods (May to December).

**For insect:** to evaluate the efficacy of products against *A. tubercularis* stages. Five leaves from each treated and untreated trees were taken at random each month begin Jan 5<sup>th</sup> till Jun 5<sup>th</sup> 2011 at El-Noubaria, El-Behera governorate. The number of living nymphs and adults were recorded with each sample under binocular microscope each month. The percentage reduction in living individuals was calculated by Henderson and Tillton equation.<sup>23</sup>

**Yield:** The average yield per tree in kg per treatment was determined in August and September at harvest.

## Statistical analysis

Tukey test for multiple comparisons among means was utilized.<sup>28</sup>

## RESULTS

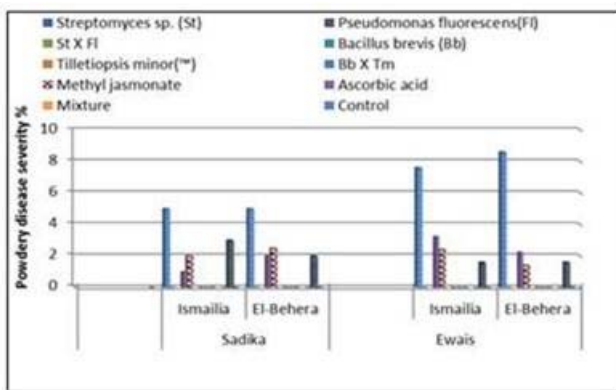
### Field Experiments

The efficacies of the microorganisms and natural products against malformation, powdery mildew, anthracnose and dieback diseases of mango under natural conditions were determined in season of 2011-2012 using Ewais and Sadika cultivars. The percentage of diseases incidence on mango vegetative buds and flowers blossom clusters obtained by bioproducts treatments compared to the control is shown in Figures. (1-4 ). The diseases incidence of all diseases substantially higher on leaves and flowers blossom clusters than in vegetative and flower buds in both cultivars and regions. Data revealed that vegetative and flower blossom clusters infection was high in untreated control in both cultivars and regions. Significant suppression of all diseases incidence was achieved by applying of bioproducts compared to the untreated control in two cultivars (Ewais and Seddek), regions (Behera and Ismailia Governorates) and seasons (Figures 1-4). Significant reduction of mango malformation, anthracnose and dieback diseases severity was achieved by applying of *Streptomyces* compared to the other treatment and untreated control. Meanwhile, powdery mildew disease was reduced by *Tilletiopsis sp* in two cultivars (Ewais and Seddek), regions (Behera and Ismailia Governorates) and seasons. As for as, mites, at the same time, all treatment reduced the mites numbers per blossom (Figure 5). Significant reduction of mites numbers was achieved by applying of *Streptomyces* compared to the other treatment and untreated control. In addition, the integrated pest management program which using in the pests control.

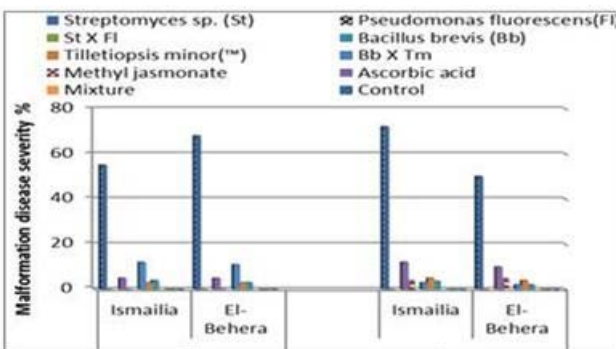
As for as, *A. tubercularis* stages, the integrated pest management program which using in the pests control. The results were confirmed to success all the biopesticides used. The results illustrated in Fig. (6) showed that *Streptomyces sp. (St)*, Methyl jasmonate, Mixture and *St X FI* were achieved highly efficiency against *A. tubercularis* stages recording 100% reduction in living individual numbers . Treatments of Ascorbic acid, Bb X TM, *Tilletiopsis minor* (™) , *Bacillus brevis (Bb)* and

*Pseudomonas fluorescens*(F1) were the lowest efficiency against *A. tubercularis* stages on Ewais or Sedek mango varieties . The results showed that population of *A. tubercularis* stages on Ewais mango trees untreated were recorded 45, 53,79,66,54 and 32 individuals /5 leaves during Jan.5<sup>th</sup> till Jun.5<sup>th</sup>, respectively. In case of Sedek mango trees untreated, 33,49,67,55,50 and 28 individuals/ 5 leaves were recorded during the inspection months, respectively (Fig.6 ). The results indicated in Figs 7&9 that the numbers of *A. tubercularis* stages were decreased after spraying the biopesticides recording 100% reduction. The results showed to success some biopesticides in controlling the insect pest (*Streptomyces sp. (St)*, Methyl jasmonate, Mixture and *St X F1*) while Ascorbic acid, Bb X TM, *Tilletiopsis minor*(<sup>TM</sup>) , *Bacillus brevis (Bb)*and *Pseudomonas fluorescens*(F1) did not effective against the insect pest . These product showed to success against the pathogen diseases.

compared to control in both cultivars and regions. Application of bioagent mixtures on two cultivars gave completely reduced in all diseases, insect, mites and increased fruit sets (Figure 7) and yield of all cultivars (Figure 8 and Table 1). Also, the results illustrated showed that *Streptomyces sp. (St)*, Methyl jasmonate, Mixture were achieved highly efficiency in increasing fruit sets and yield in two cultivars (Ewais and Seddek), regions (Behera and Ismailia Governorates) and seasons.

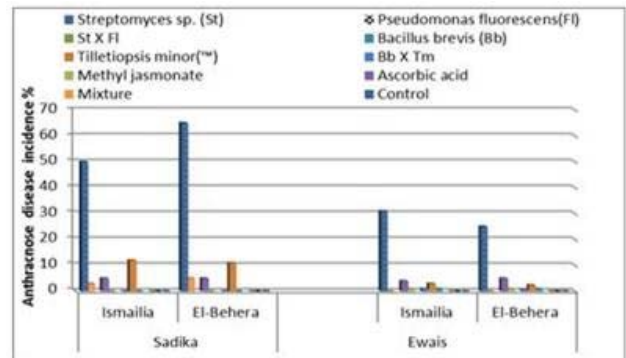


**Figure 1:** Efficacy of foliar sprays of different natural compounds alone and in combinations on the incidence of powdery mildew of Awais and Sadika cultivars in El-Behera and Ismailia governorate's.

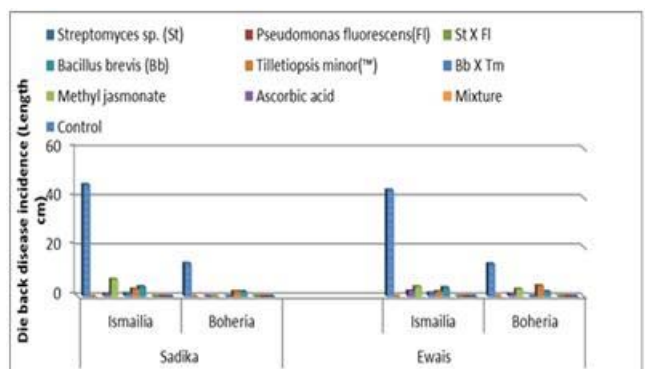


**Figure 2:** Efficacy of foliar sprays of different natural compounds alone and in combinations on the incidence of malformation disease of Awais and Sadika cultivars in El-Behera and Ismailia governorate's.

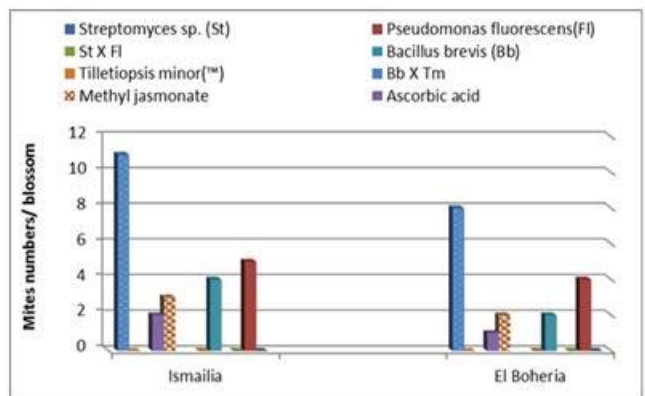
The results illustrated showed that *Streptomyces sp. (St)*, Methyl jasmonate, Mixture were achieved highly efficiency against diseases and pests recording 100% reduction in some cases. Treatments of Ascorbic acid, Bb X TM, *Bacillus brevis* and *Pseudomonas fluorescens* were the lowest efficiency. It is clear that, foliar spray of mango with bioproducts has significantly increased the fruit yield



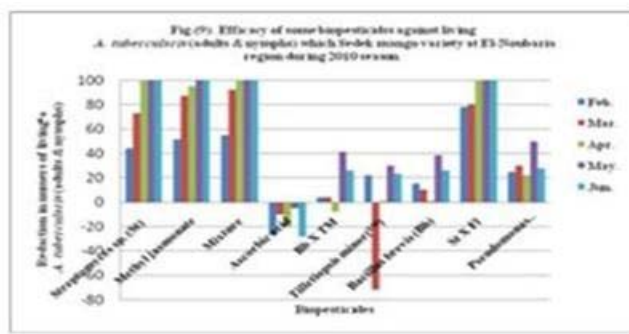
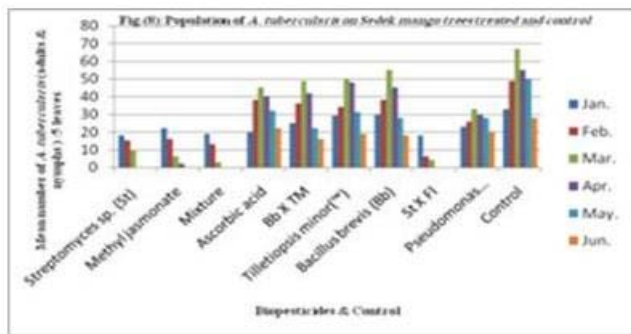
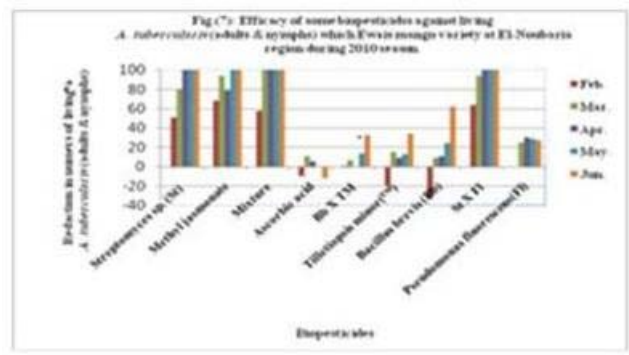
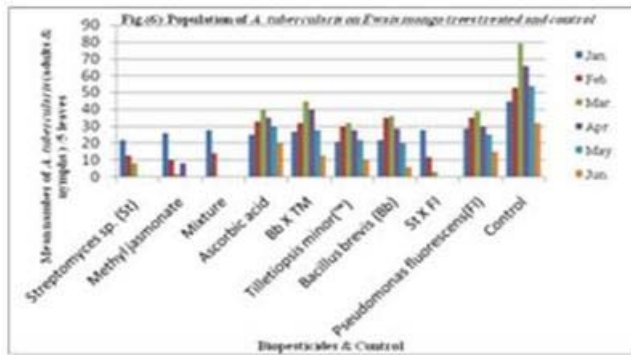
**Figure 3:** Efficacy of foliar sprays of different natural compounds alone and in combinations on the incidence of anthracnose disease of Awais and Sadika cultivars in El-Behera and Ismailia governorates.



**Figure 4:** Efficacy of foliar sprays of different natural compounds alone and in combinations on the incidence of dieback disease of Awais and Sadika cultivars in El-Behera and Ismailia governorate's.



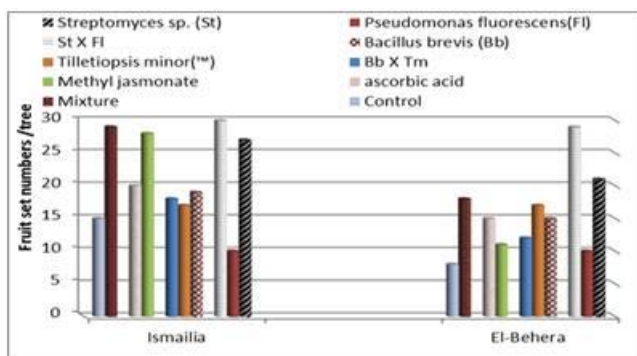
**Figure 5:** Efficacy of foliar sprays of different natural compounds alone and in combinations on mites numbers of Ewais mango cultivar in El-Behera and Ismailia governorates.



**Figure 6:** Efficacy of foliar sprays of different natural compounds alone and in combinations on Population of *Aulacaspis tubercularis* in El-Behera governorate.

**Table 1:** Efficacy of foliar sprays of different natural compounds alone and in combinations on fruit yield of Eweis and Sadika mango cultivars in El-Behera and Ismailia governorates.

Treatments	Yield (Kg / tree)			
	Sedekia		Eweis	
	El-Behera	Ismailia	El-Behera	Ismailia
<i>Streptomyces aureofaciens</i>	41.6	51.4	34.1	38.5
<i>Pseudomonas fluorescens</i>	35.2	38.6	25.0	31.4
<i>Bacillus brevis</i>	30.3	37.5	27.0	30.1
<i>Pseudomonas putida</i>	28.6	30.6	26.1	29.5
<i>Trichoderma harzianum</i>	41.0	44.4	29.7	33.5
<i>Penicillium oxalicum</i>	22.0	25.4	26.6	28.7
Methyl jasmonate	28.1	30.1	21.7	27.5
Ascorbic acid	20.2	22.4	18.2	23.5
Control	16.8	17.1	13.5	16.7
LSD	1.3	2.5	1.7	2.4



**Figure 7:** Efficacy of foliar sprays of different natural compounds alone and in combinations on fruit set numbers of Eweis and Sadika mango cultivars in El-Behera and Ismailia governorate's.

**Figure 8:** Efficacy of foliar sprays of mixed bio products compounds as IPM on controlling of mango diseases incidence and yield of mango cultivars in Ismailia governorate.

## DISCUSSION

Mango considered being one of the most important fruit crop grown in Egypt, which is ranked third after citrus, grapes and mango have importance both in the domestic market or export. Because of the high potential for loss, crops should be monitored for these diseases and controls should be implemented as disease risk increases. General, diseases caused exaggerates loss of agriculture crops. Yields of mango crop can be drastically reduced or entirely lost by the attack of soil diseases as root rot, wilt and aerial diseases, e.g., powdery mildew, dieback, anthracnose and malformation.<sup>11</sup> Evaluation of foliar diseases infection on some important mango cultivars in different Governorates in Egypt confirmed that there was a relationship between Governorate and cultivars. The conventional mango growers currently rely on chemical insecticides to control diseases and insect pests. The heavy use of fungicides, insecticides has resulted in increased costs, environmental pollution, and the reduction in natural enemies of insect pests and pollinators. Organic growers generally have few resources to deal with insect pests, resulting in reduced yield and fruit quality. To reduce dependency on insecticides, a suitable integrated pest management (IPM) program is needed.

The main goal of this research is to reduce fungicide input while maintaining commercially acceptable levels of mango diseases and insect control. The relative humidity, temperature and light intensity all affect symptomatology. More attention in the last decade has focused on replacing synthetic fungicides with new strategies, such as changes in cultural practices, the use of biological control agents and natural compounds. The desired effects of the use of natural compounds and biological control agents in crop protection have drawn attention to integrated disease management. This study demonstrated that different natural compounds i.e., biological control agents (BCAs), Methyl jasmonate and antioxidant (1mM, ascorbic acid) can be considered as an environmentally friendly option for the control of foliar on blossom clusters of field mango trees. When used singly, compounds were less effective than when they used in mixtures.<sup>29</sup>

Three foliar application of natural compounds to mango trees markedly decreased infection with diseases. Mixtures of all natural compounds were more effective in significantly reducing diseases severity in leaves, blossom clusters and increasing fruit set and yield in two cultivars (Ewais and Seddek), regions (Behera and Ismailia Governorates) and seasons / Meanwhile, the number of mites and scale insects (nymph and adults) on trees were reduced by spraying with bioproducts and natural compounds.<sup>1,3</sup> Effect of *Streptomyces* on insects was studied by Arasu et al.,<sup>4</sup> found many effect of *Streptomyces* as antifeedant, larvicidal, pupicidal and growth inhibitory as resulting polyketide metabolite

isolated from *Streptomyces* sp. AP-123 against *H. armigera* and *S. litura*.

Mixtures of these compounds are used in order to widen the spectrum and ensure a longer duration of antifungal activity or to exploit synergistic interactions between the compounds by which their overall activity can be increased and integrated disease management be achieved.<sup>29,18</sup> Methyl jasmonate (MJ) is widespread natural regulators involved in many processes during plant development.<sup>26</sup> The results presented here clearly demonstrate that treatment of wheat with MJ leads to protection from leaf rust disease infection. Antioxidants as ascorbic acid (vitamin C) is a multifunctional compound in both plants and animals. This vitamin is an important buffer against the high oxidative load that accompanies rapid metabolism that plays a more active role in which tissue contents affect development via hormonal signaling pathways and modulation of defense networks.

The advantage of using BCAs is that biochemistry and physiology of production of antibiotic antimicrobial substances is well documented. Thus, the research aiming to produce active biological substance as antimicrobial agent from Egyptian *Streptomyces* isolates instate of chemical substance to participate in decreasing environmental pollution. Regardless of the production system, IPM will have an important role to play, and the use of biological controls can be an integral part of IPM. Integration of BCAs with other disease and pests management tools often provides broader crop adaptation and both more efficacious and consistent levels of disease control. The IPM programs can significantly benefit mango growers, including the potential for the production of 'organic' produce. These IPM programs are also friendly to the environment. These communities may visualize a reduction in the use of fungicides and pesticide leading to reduction in pest losses, lower production cost, improved human, environment and animal health and a more stable production system. This system will reduce the incidence of pest and disease increasing the production and productivity of the crop. This study demonstrated that different natural compounds i.e., biological control agents (BCAs) and antioxidant (1mM, ascorbic acid) can be considered as an environmentally friendly option for the control of diseases of field mango trees.

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**Source of Support:** Nil, **Conflict of Interest:** None.

