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Evaluation of Some Biocontrol Agents to Control Mango Powdery Mildew Disease and their Effect on Productivity

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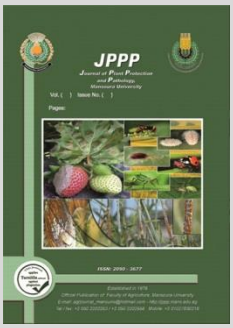

ABSTRACT

This investigation was conducted in a private organic farm in Wadi El-Malak district, Ismailia Governorate, Egypt, to evaluate some biocontrol agents i.e. Trichoderma album, T. harzianum, T. viride , biocides i.e. Blight stop (T. harzianum), Bio Zeid (T. album) and natural compound i.e. humic acid and micronic sulfur treatments in the controlling powdery mildew disease of mango cv. Keitt during the two successive seasons in 2021 and 2022. All treatments proved effective in decreasing the Incidence and severity of powdery mildew disease caused by Oidium mangiferae and increased productivity, yield components, quality, chemical components, and enzyme activity of mango cv. Keitt compared to untreated plants. Mango cv. Keitt which was treated with blight stop at the rate of 1: 50 caused the highest decrease in disease incidence, severity (71.01 and 92.10%) and recorded also, the highest increase in yield being 35.5 Kg/tree; fruit quality "total soluble solids (TSS), being 19.50 and 20.46%, total acidity, being 0.71 and 0.73%, ascorbic acid being 54.68 and 54.77 mg/100g FW and total sugar, being 14.60 and 14.70%"; biochemical analysis i.e. total chlorophyll (4.71 mg/100 g FW), total carotenoids (6.77 mg/100 g FW and total protein (3.38%); total phenol content and the enzyme activities of peroxidase (PO) and polyphenol oxidase (PPO) during both growing seasons, followed by T. harzianum isolate. On the contrary, humic acid showed the least effective treatment. No clear significant differences were noticed between the other treatments in comparison with untreated plants.

***Keywords*:** Mango, Oidium mangiferae, powdery mildew, Biocontrol agent, biocide, and Micronic sulfur

INTRODUCTION

Mango (*Mangifera indica* L.) is the most important fruit and is called the king of all fruits and has attracted the attention of millions of people all over the world, especially in Egypt in recent times due to its attractive appearance and delicious taste. The total area planted with mango in Egypt has increased to cover 289,020 feddan with a total productivity of 2,800,000 tons (Anonymous, 2020).

Mango powdery mildew caused by *Oidium mangiferae* Berthet is one of the most common and dangerous diseases worldwide (Nofal and Haggag, 2006; Muhammad *et al.*, 2014 and Reuveni *et al.*, 2018) and attacks mango clusters, young fruits, and leaves of highly sensitive mango cultivars (Tiwari *et al.*, 2006; Galli *et al.*, 2008; Muhammad *et al.*, 2014; Mamta and Singh, 2015), causes significant economic losses in yield especially when flowering flow and growth are affected during the 5-20% cooler and dry weather conditions (Mehta *et al.*, 2018). It can cause injuries that, subsequently, will favor anthracnose (Junqueira *et al.*, 2001 and Sinha *et al.*, 2002). High temperatures to 25°C and humidity to 40-60% lead to the rapid spread of conidia germs in the air and the appearance of symptoms 58 days after infection (Rawal and Saxana, 1997; Akhtar *et al.*, 1999; Chanana *et al.*, 2005 and Naqvi *et al.*, 2014).

In Egypt, The highest disease incidence and severity of mango powdery mildew was recorded the Behera Governorate (Nofal and Haggag, 2006) and in Ismailia (Abo Rehab *et al.*, 2014). The results proved that the use of sulfur and its derivatives in the form of liquid or powder as a spray twice on the affected leaves at a rate of 2000 parts per million as a source of natural products is very effective in the prevention and control of powdery mildew of mango (Reza and Mortuza, 1997 and Torre *et al.*, 2004). In addition, (Abo Rehab *et al.*, 2014 and Mehta *et al.*, 2018) confirmed the efficacy of five fungicides, led by Punch and biocide AQ 10, as they recorded the highest efficiency in controlling *O. mangiferae*, the cause of mango powdery mildew.

The use of biological control factors (*Verticillium Lecanyii*, *Bacillus Subtilis*, and *Tilletiopsis minor*) as environmentally friendly natural compounds and alternatives to chemical fungi pesticides have proven significantly effective in controlling the mango powdery mildew disease under the field condition during the 2003 and 2004 growing seasons in Nubaria compared to the control treatment (Nofal and Haggag, 2006).

Application of biological control effects on powdery mildew of mango plants in addition to increasing its chemical content (Kaur *et. al.*, 2018). Treating mango plants with sulfur as environmentally friendly compounds led to the control of powdery mildew disease and increased

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the metabolic activity of mango plants and recorded the highest content of total phenols, proteins, proline, and oxidative enzyme activity compared to the other treatments (Sinha *et al.*, 2002 and El-Mslmany *et al*., 2020).

This investigation aims to evaluate the effectiveness of some biological compounds as one of the safe, non-toxic factors in the production chain in controlling mango powdery mildew disease and increasing the productivity and quality of the mango fruit crop as a healthy, safe food.

MATERIALS AND METHODS

Material which used during the investigation:

Biocontrol agents:

Different biocontrol agents *i.e. Trichoderma album, T. harzianum,* and *T. viride* were kindly obtained from the Central Lab. of Organic Agriculture (CLOA), Agricultural Research Center (ARC), Giza, Egypt.

Bio-preparation compounds which used as a comparison with other treatments:

1-Blight stop:

Commercial bio fungicide which consists of (*Trichoderma* spp. 30×106), obtained from CLOA and used at the rate of 1L/50 L water/fed.

2- Bio Zeid:

Commercial bio-preparations which consist of (*T.album* 10×10^6 CFU/ ml), obtained from Kz and used at the rate of 1L/50 L water/fed.

Micronized soreil-Kz 70%WP:

The recommended fungicide which consists of 70% micronic sulfur was used at the rate of 250 gm/100 lit water/ fed.

Survey of Mango Powdery Mildew Disease:

Survey of mango powdery mildew disease incidence and severity of susceptible mango cultivar Keitt has been carried out in four districts of Ismailia Governorates *i.e.* Al-Qasasin, Al Tal Al-Kabeer, Fayed and Wadi Al-Malak in Egypt from February until May of both successive growing seasons 2021 and 2022.

Diseased plants were graded on a scale of 0–5 for disease severity using the following scale described by **Reuveni and Reuveni (1995)** and **Naqvi *et al.* (2014)** where, 0 = no symptoms; 1 = 1-20%; 2 = 21-40%; 3 = 41-60%; 4 = 61-80% and 5 = 81-100% infected leaf area. The percentage of each foliar disease severity was scored by the following formula:

$$\textbf{D.S.I \%} = \frac{\Sigma(n\times c)}{N\times C} \times 100$$

where,

D.S.I = disease severity index, n = number of leaves in each category, c = numerical value of each category, N= numerical value of highest category, and N = total number of leaves in the sample.

Disease incidence and efficacy percentages are calculated using the following equations:

$$\text{Disease Incidence (DI)\%} = \frac{No.of\ diseased\ plants}{Total\ No.of\ examined\ plants} \times 100$$

$$\textbf{\% Efficacy of disease} = \frac{\text{Treatment} - \text{Control}}{\text{Control}} \times 100$$

Infected symptoms were collected from infected mango leaves carefully and placed in paper bags. The bags were carefully tied, labeled, and transported to the Central Laboratory of Organic Agriculture (CLOA), Agricultural Research Center (ARC), Egypt. The excess skin removal technique was performed using colorless sticky tape on infected leaf spots which is pasted over the mold spots and pressed with fingers.

After a few seconds, the slider bands were removed away from the infected leaf containing an enameled epidermis with conidiophores bearing conidiospore chains of the fungus. The strip containing the cuticle containing conidiophores which invert after that onto a microscope slide with lactophenol and then counterstained (Moreira *et al*., 2014).

Preparations of the biocontrol agents:

Different biocontrol agents i.e. *Trichoderma album, T. harzianum,* and *T. viride* were grown for 10 days at 25±2ºC on a liquid Gliotoxin fermentation (GF) medium under complete darkness conditions (Ahmed, 2018). All cultures were individually blended in an electric blender for 2 min, used as a suspension at a concentration of (30×106spores/ml) with a dilution of 1:50 which was mixed with 5% Arabic gum and 5% potassium soap and wetting the leaves, using a sprayer to increase adhesive capacity and improve the distribution of bioagent on the surface of treated plants.

Field experiments:

A field investigation has been carried out to determine the efficacy of biocontrol agents against powdery mildew on mango cv. Keitt at the private organic orchard, Wadi Al-Malak district, Ismailia Governorate, Egypt of both successive growing seasons 2021 and 2022. The field cultivated with susceptible mango cultivar Keitt (10 years old) according to the survey study which was grown in an area of 6x6 square meters, was inspected (El-Mslmany *et al.*, 2020). Treatment of different bioagents or micronic sulfur mixed with 5% Arabic gum, and 5% potassium soap and used as foliar spray individually were applied on the 15th of March before normal flowering and the 15th of April after flowering at the rate of 1 L/50 lit water/fed. of different biocontrol agents and 250gm/100 lit water/fed of micronic sulfur. Trees sprayed with water served as a control treatment. Plots consisting of three mango trees were replicated three times and used for each investigated treatment. The experiment was designed with a completely randomized block. The organic orchard was managed by drip irrigation and fertilization with recommended doses.

Powdery mildew assessment:

Disease incidence and severity percent of powdery mildew were assessed randomly one week after each spray and averaged as mentioned above by Reuveni and Reuveni (1995) and Naqvi *et al.* (2014).

Yield quality:

Nine samples of mango fruits were taken from each experimental plot after four to five months from the last spray at harvest time to determine the fruit quality parameters *i.e.* yield (tree/Kg), total soluble solids (TSS) using a Carl Zeiss hand Refractometer and Titratable Acidity (TA) according to (A.O.A.C., 2005), the quantification of ascorbic acid (mg/100g FW) as described by (Offor et al., 2015 and Nielsen, 2017) and total sugar content was determined by Smith *et al.* (1956) and Shanmugavelan *et al.* (2013).

Biochemical changes of Mango leaves:

All the following chemical assays for the mango plants were carried out in CLOA, ARC, Giza, Egypt.

Determination of total phenol:

The amount of total phenol (mg/100gfwt) in extracts was determined by Folin – Denis method as modified by Singleton *et al*. (1999).

Determination of total chlorophyll and carotenoids:

Total chlorophyll and carotenoid content (mg/100 g pulp fresh weight), was colorimetrically determined according to Wellburn (1994).

Determination of protein content:

Nine leaves were randomly collected from plants of each replicate (3 replicates for each treatment). They were taken from the fourth upper of the mango stem, washed with distilled water, dried with sterile filter papers, then dried at 70°C and wet digested for the determination of total protein according to the methods followed by (Bradford, 1976 and Wolf, 1982).

Determination of antioxidant enzyme activities:

a. Determination of peroxidase (PO) activity:

The activity of the peroxidase enzyme was estimated according to the procedure given by Kochba *et al.* (1977).

b. Determination of polyphenol oxidase (PPO) activity:

The activity of polyphenol oxidase was estimated according to Erzengin (2009).

Statistical Analysis:

Data were subjected to statistical analysis and compared according to the least significant difference (LSD) as mentioned by Snedecor and Cochran (1990). Averages were compared using the new LSD values at the 5% level.

RESULTS AND DISCUSSIONS

Disease survey:

Presented data in Table (1) illustrated that mango cv Keitt showed the highest infection of powdery mildew at the four districts investigation of Ismailia Governorates *i.e.* Al-Qasasin, Al Tal Al Kabeer, Fayed, and Wadi Al-Malak in Egypt from February until May of both successive growing seasons 2021 and 2022. Mango cv. Keitt has recorded the highest infection in the Wadi Al Malak district and showed 46.23 and 24.00%, followed by the Al-Qasasin district which recorded 41.69 and 22.05 in disease incidence and severity percentage, respectively during two seasons. Fayed district showed the lowest location infected with mango powdery mildew compared with the Al Tal Al-Kabeer district in Ismailia Governorate.

These results are in harmony with many studies which insured mango powdery mildew caused by *O. mangiferae* Berthet is one of the most common and dangerous diseases worldwide (Nofal and Haggag, 2006; Muhammad *et al.,* 2014 and Reuveni *et al.,* 2018) and attacks mango clusters, young fruits and leaves of highly sensitive mango cultivars (Tiwari *et al.,* 2006; Galli *et al.,* 2008; Muhammad *et al.,* 2014; Mamta and Singh, 2015), causes significant economic losses in yield especially when flowering flow and growth are affected during the 5-20% cooler and dry weather conditions (Moreira *et al*., 2014 and Mehta *et al.,* 2018).

Table 1. Disease parameters of powdery mildew on mango cv. Keitt grown in naturally infested fields in Ismailia Governorate, Egypt.

Locations	Disease incidence %			Disease severity %		
	2021	2022	Mean	2021	2022	Mean
Al-Qasasin	42.77	40.60	41.69	22.5	21.6	22.05
Al Tal Al-Kabeer	37.87	36.22	37.05	20.3	19.4	19.85
Fayed	35.67	33.44	34.56	18.3	17.9	18.10
Wadi Al-Malak	47.33	45.13	46.23	24.4	23.6	24.00
LSD at 0.05	1.14	1.12		2.12	2.21	

The effect of different biological control and natural compounds treatment to mango cv. Kiett powdery mildew under field conditions during 2020 and 2021 two seasons:

Disease parameters (incidence and severity):

The results in Table (2) indicate that, all tested biological control treatments (*T. Album*, *T. harzianum*, *T. viride*, the two commercial preparations, Blight stop (*T. harzianum*), Bio Zeid (*T. album*) and natural compounds (Micronic sulfur and humic acid) led to a significant reduction in the incidence and severity of powdery mildew disease on kit mango treatments in the 2020 and 2021 seasons compared to the control treatment.

Table 2. The effect of different treatments on disease incidence and severity of Keitt mango powdery mildew under field conditions during the 2020 and 2021 seasons

Different treatments	Disease incidence %				Disease severity %			
	2020	2021	Mean	Efficacy*	2020	2021	Mean	Efficacy*
T. album	17.5	17.2	17.35	62.47	6.5	6.4	6.45	86.05
T. harzianum	15.7	15.3	15.50	66.47	4.6	4.3	4.45	90.37
T. viride	18.3	18.1	18.20	60.63	8.8	8.5	8.65	81.29
Micronic sulfur	20.6	20.4	20.50	55.66	10.1	9.9	10.00	78.37
Humic acid	22.1	21.9	22.00	52.41	11.5	11.3	11.40	75.34
Blight stop (T. harzianum)	13.6	13.2	13.40	71.01	3.5	3.8	3.65	92.10
Bio Zeid (T. album)	16.9	16.7	16.80	63.66	5.7	5.5	5.60	87.89
Control (Untreated)	47.33	45.13	46.23		24.4	23.6	46.23	
L S D at 0.05	1.33	1.22			0.16	0.14		

Blight stop biocide recorded the highest efficacy (71.01 and 92.10%), followed by T. harzianum isolate (66.47 and 90.37%) in controlling disease incidence and severity during the two seasons 2020 and 2021, respectively. On the contrary, humic acid showed the least efficacy (52.41 and 75.43%) in controlling the disease. The field results can be interpreted according to both the effect of biotic factors which produce growth regulators and the chemical effect of antioxidants (Kaur et. al., 2018), which play a clear role in improving plant physiology, metabolism and induce systemic resistance (ISR) (Nofal and Haggag, 2006) .

The direct effects of Trichoderma spp on pathogenic fungi of plants as a result of competition for space, food, and oxygen and its ability to fungal mycoparasitism, and the secretion of antibiotics as its main mechanisms (Ahmed, 2018 and Nasir et al., 2014). Also, Trichoderma spp. can produce antifungal substances such as endo chitinase, beta-glucosidase, alpha-1,3-glucanase, and trichodermin (Mehta et al., 2018).

Yield components:

Presented data in Table (3) illustrate that applying any of the tested biological control and natural compounds according to the organic agriculture law as a recommended biocide treatment significantly increased yield components i.e. No. of fruits/tree, fruit weight (g), and yield/tree (Kg) compared to the yield of non-treated Mango cv. Keitt trees during the two growing seasons 2020 and 2021.

Blight stop as biocide was recorded the highest significant increase in yield components and being 65.0; 545.6 35.5 in (No. of fruits/tree, fruit weight (g) and yield/tree (Kg)), respectively and followed by T. harzianum isolate and being, 61.5; 527.0 32.4 in (No. of fruits/tree, fruit weight (g) and yield/tree (Kg)), respectively in comparison with control treatment. In the contrary, humic acid treatment showed the lowest effect compared the other treatments rather than control treatment during two seasons. The obtained result are in agreement with Nofal and Haggag (2006) and Abo Rehab et al. (2014) who stated that, the bio control agents were reduced the infection of disease incidence and severity of powdery mildew and increasing the yield components.

These results are in harmony with Reuveni et al. (2018) and Ahmed (2018) who observed the mode of action of biocontrol agents due to produce growth regulators and resistant inducers which help to increase the yield productivity and quality (El-Mslmany et al., 2020).

Table 3. The efficacy of different treatments on mango yield under field conditions during the 2021 and 2022 seasons.

Different	No. of fruits/tree			Fruit weight (g)			Yield/tree (kg)		
treatments	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T. album	53	58	55.5	484.6	495.5	490.1	25.68	28.74	27.2
T. harzianum	58	65	61.5	525.9	528.1	527.0	30.50	34.33	32.4
T. viride	50	55	52.5	452.6	467.4	460.0	22.63	25.71	24.2
Micronic sulfur	48	50	49.0	437.1	443.3	440.2	20.98	22.17	21.6
Humic acid	45	48	46.5	426.6	428.5	427.6	19.20	20.57	19.9
Blight stop (T. harzianum)	60	70	65.0	530.4	560.8	545.6	31.82	39.26	35.5
Bio Zeid (T. album)	55	60	57.5	512.9	514.4	513.7	28.21	30.86	29.5
Control (Untreated)	36	40	38.0	350.5	353.8	352.2	12.62	14.15	
L S D at 0.05	2.33	2.44		3.12	4.22		1.66	1.88	

Fruit quality:

Data in Table (4) indicated that, the role of different biological control and natural compounds in controlling mango powdery mildew. Results stated that there were changes that occurred in fruit quality "total soluble solid (TSS), total acidity, ascorbic acid, and total sugar due to these treatments in comparison with untreated plants during the two seasons 2020 and 2021. Presented data in Table (4) illustrated that Blight stop biocide treatment was the highest effective one concerning total soluble solids (TSS), being 19.50 and 20.46%, total acidity, being 0.71 and 0.73%, ascorbic acid being 54.68 and 54.77 mg/100g FW and total sugar, being 14.60 and 14.70% during both seasons, respectively followed by T. harzianum isolate then Bio Zeid biocide.

On the opposite trend, the humic acid natural compound showed the least effective treatment in comparison with the control treatment. No clear trend can be deduced with other treatments. Finally, all treatments under investigation improved the fruit quality and the results in the 2021 growing season were higher than in the 2020 growing season.

These results are in agreement with those obtained by Ahmed (2018) who ensure that the synergistic effects might be due to the both effects of the bioagents, which produce growth regulators, and their effect as resistant inducer. The effect of biocontrol agents was observed inside of plant metabolism leading to increasing in plant chemical components and improving the plant growth which caused a significant effect on photosynthetic assimilation rate and in turn increased accumulation of total soluble solids in fruit and ascorbic acid, total acidity, and total sugar, which was intermediate products during photosynthetic assimilation process (El-Mslmany et al., 2020).

Table 4. The efficacy of different treatments on mango yield quality under field conditions during the 2021 and 2022 seasons.

Different	Total soluble solids (TSS %)		Total Acidity (%)		Ascorbic acid(mg/100g FW)		Total sugar (%)	
treatments	2020	2021	2020	2021	2020	2021	2020	2021
T. album	18.41	18.78	0.66	0.68	50.18	50.27	13.3	13.6
T. harzianum	19.22	19.65	0.68	0.69	52.45	52.55	14.20	14.40
T. viride	17.66	17.98	0.61	0.64	49.33	49.36	12.60	12.70
Micronic sulfur	17.34	17.55	0.60	0.62	48.11	48.18	12.30	12.50
Humic acid	16.61	16.97	0.57	0.59	47.22	47.50	11.90	12.10
Blight stop (*T. harzianum)*	19.50	20.46	0.71	0.73	54.68	54.77	14.60	14.70
Bio Zeid *(T. album)*	18.98	19.06	0.65	0.67	51.41	51.43	13.80	14.20
Control (Untreated)	14.23	15.22	0.43	0.45	32.95	33.14	9.50	10.10
L S D at 0.05	0.06	0.07	0.01	0.04	0.19	0.28		

Total chlorophyll, total carotenoids, and total protein in produced mango fruit:

Data of biochemical analysis in Table(5) including total chlorophyll (mg/100 g FW), total carotenoids **(**mg/100 g FW, and total protein (%) presented in Table (5) show a great increase in mango plant contents. Treated plants with Blight stop biocide was the best one for controlling powdery mildew disease and increasing the biochemical contents which recorded 4.71 mg/100 g FW, 6.77 mg/100 g FW, and 3.38% in total chlorophyll, total carotenoids and total protein, respectively, followed by T. harzianum biocontrol agent during the two successive growing seasons 2020 and 2021 compared with untreated plants. On the other hand, Humic acid as a natural compound showed the least effect

being, 3.28 mg/100 g FW, 4.51 mg/100 g FW, and 2.44% in total chlorophyll, total carotenoids, and total sugar, respectively in comparison with untreated plants. These results indicated that all treatments kept mango plants healthy and supported their optimal growth, which could be emphasized by too low chemical contents in the control treatment. This finding could be clarified by Abo Rehab et al. (2014) and El-Mslmany et al. (2020) who confirmed that the use of alternatives to chemical pesticides such as biological control and natural compounds have high efficacy in controlling powdery mildew disease by changing the biochemical metabolism of the plant to improve the systemic resistance acquired by the plant which help to increase the content of chlorophyll, carotenoids and protein in plants, in addition to that it produces healthy, safe food that is free of toxicity and it is environmentally friendly.

Table 5. Effect of different treatments on total (chlorophyll, carotenoids, and protein) of Keitt mango under field conditions during the 2020 and 2021 seasons.

Different treatments	Total chlorophyll (mg/100 g FW)			Total carotenoids(mg/100 g FW)			Total protein (%)		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T. album	4.10	4.17	4.14	5.88	6.00	5.94	2.78	2.83	2.81
T. harzianum	4.47	4.59	4.53	6.42	6.55	6.49	3.15	3.21	3.18
T. viride	3.96	4.00	3.98	5.55	5.77	5.66	2.70	2.72	2.71
Micronic sulfur	3.65	3.82	3.74	4.75	5.00	4.88	2.63	2.65	2.64
Humic acid	3.25	3.31	3.28	4.36	4.65	4.51	2.34	2.53	2.44
Blight stop (*T. harzianum)*	4.63	4.78	4.71	6.58	6.96	6.77	3.32	3.44	3.38
Bio Zeid *(T. album)*	4.36	4.40	4.38	6.11	6.33	6.22	2.80	2.90	2.85
Control (Untreated)	1.75	1.88	1.82	2.25	2.50	2.38	0.44	0.46	0.45
L S D at 0.05	1.11	1.12		1.65	1.66		0.44	0.66	

Enzymatic activity and total phenol in response to *O. mangiferae* disease development and mango plant resistance

Data in Table (6) show that applying any tested biological control or natural compounds significantly increased peroxidase (PO), polyphenoloxidase (PPO) activity and total phenol of mango plants compared to untreated plants during the two growing seasons 2020 and 2021 under field conditions. In the two successive seasons 2020 and 2021 compared to control treatment, Blight stop was the best treatment in increasing activity of PO (1.97 and 1.99), PPO (0.23 and 0.25) and total phenol (3.43 and 3.45) more than other treatments, while humic acid was the lowest effective one compared with untreated plants.

Table 6. Effect of different treatments on peroxidase (PO), polyphenol oxidase (PPO) activity, and total phenol of Keitt mango under field conditions during the 2020 and 2021 seasons.

Different treatments	Peroxidase activity (PO) mg/ml		Polyphenoloxidase activity (PPO) (mg/ml)		Total phenols (mg/100 g FW)	
	2020	2021	2020	2021	2020	2021
T. album	1.85	1.87	0.15	0.16	2.98	3.00
T. harzianum	1.93	1.95	0.20	0.22	3.22	3.24
T. viride	1.81	1.83	0.13	0.14	2.88	2.93
Micronic sulfur	1.75	1.79	0.12	0.13	2.73	2.83
Humic acid	1.65	1.67	0.10	0.11	2.58	2.64
Blight stop (T. harzianum)	1.97	1.99	0.23	0.25	3.43	3.45
Bio Zeid (T. album)	1.90	1.92	0.17	0.19	3.11	3.22
Control (Untreated)	1.21	1.23	0.04	0.06	0.43	0.45
L S D at 0.05	0.24	0.25	0.11	0.12	0.43	0.44

The obtained results are in agreement with those obtained by El-Mslmany *et al.* (2020) who insured that the application of biological control effects on powdery mildew of mango plants in addition to increasing its chemical content (Kaur *et. al*., 2018). Treating mango plants with sulfur as environmentally friendly compounds led to the control of powdery mildew disease and increased the metabolic activity of mango plants and recorded the highest content of total phenols, proteins, proline, and oxidative enzyme activity compared to the other treatments (Junqueira *et al.*, 2001; Sinha *et al.*, 2002 and El-Mslmany *et al*., 2020).

CONCLUSION

The aim of this investigation evaluates ~~the~~ some biocontrol agents *i.e. T. album*, *T. harzianum, T. viride* , biocides *i.e.* Blight stop (*T. harzianum*), Bio Zeid (*T. album*) and natural compound *i.e.* humic acid and micronic sulfur treatments in the controlling powdery mildew disease of mango cv. Keitt during the two successive seasons in 2021 and 2022 as alternative fungicides methods to reduce the chemical's toxicity in the food chain and produce sufficient food with high quality and quantity. All treatments proved effective in decreasing the powdery mildew disease caused by *O. mangiferae* and increased productivity, yield components, quality, chemical components and enzyme activity of mango cv. Keitt compared to untreated plants. Mango which treated with blight stop at the rate of 1: 50 caused the highest decrease in disease incidence, severity and recorded also, the highest increase in yield; fruit quality "total soluble solids (TSS), total acidity, ascorbic acid and total sugar; biochemical analysis *i.e.* total chlorophyll, total carotenoids and total protein; total phenol content and the enzyme activities of peroxidase (PO) and polyphenoloxidase (PPO) during both growing seasons in comparison with control treatment.

Availability of data and materials:

All data and material generated or analyzed during this study are available as a reference by other researchers.

Author's contribution:

The majority of the contribution for the whole article belongs to the authors. The authors read and approved the final manuscript.

Ethics approval and consent to participate:

Not applicable

Consent for publication:

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The authors declare that no competing interests.

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تقييم بعض عوامل المكافحة الحيوية لمكافحة مرض البياض الدقيقي في المانجو وتأثيرها على الإنتاجية.

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الملخص

أجريت هذه الدراسة في مزرعة عضوية خاصة في منطقة وادي الملاك بمحافظة الإسماعيلية ، مصر ، لتقييم بعض عوامل المكافحة الحيوية مثل: عزلات من فطريات التريكودرما "ترايكودرما ألبم، ترايكودرما هارزيانم، ترايكودرما فيردى" كما تم استخدام المبيدات الحيوية مثل المستحضر التجارى "بلانت أستوب" ترايكودرما هارزيانم" وبايوزيد " ترايكودرما ألبم " والمركب الطبيعي مثل حمض الهيوميك والكبريت الميكرونى في مكافحة مرض البياض الدقيقي في المانجو صنف كيت خلال الموسمين المتتاليين عامى 2020 و 2021 على التوالى. أثبتت جميع المعاملات السابقة فعاليتها في تقليل حدوث نسبة وشدة مرض البياض الدقيقي وزيادة الإنتاجية ومكونات المحصول والجودة والمكونات الكيميائية والنشاط الإنزيمى لصنف المانجو كيت مقارنة بالنباتات غير المعاملة. سجلت معاملة نباتات المانجو صنف كيت بالمركب الحيوى بلايت أستوب بنسبة 1: 50 أعلى نسبة فى أنخفاض حدوث المرض وشدة الأصابة لنباتات المانجو (71.01 و 92.10٪) وسجل أيضًا أعلى زيادة في أنتاجية المحصول "35.5 كجم / شجرة" ، وجودة الثمار مثل"إجمالي المواد الصلبة الذائبة بنسبة 19.50 و 20.46٪ ، والحموضة الكلية 0.71 و 0.73٪ ، وحمض الأسكوربيك 54.68 و 54.77 مجم / 100 جرام من وزن المادة الخام والسكر الكلي بنسبة 14.60 و 14.70٪" ؛ التحليل البيوكيميائي مثل الكلوروفيل الكلي (4.71 مجم / 100 جرام من وزن الثمار) ، الكاروتينات الكلية (6.77 مجم / 100 جرام من وزن الثمار والبروتين الكلي (3.38٪) ؛ محتوى الفينول الكلي وأنشطة إنزيم البيروكسيديز وبوليفينولوكسيديز خلال موسمى النمو يليها فى التأثير عزلة فطر ترايكودرما هارزيانم. على العكس من ذلك أظهرت معاملة حمض الهيوميك أقل تأثيراً ولم يلاحظ وجود فروق معنوية واضحة بين المعاملات الأخرى مقارنة بالنباتات غير المعاملة.