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Evaluation of certain mineral salts and microelements against mango powdery mildew under Egyptian conditions

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Abstract

During the two successive seasons 2014 and 2015, three mineral salts used as commercial fertilizers (Potassium di-hydrogen orthophosphate, Potassium bicarbonate (85%), Calcium nitrate (17.1%)) and four microelements (Magnesium sulfate, Iron cheated (Fe-EDTA 6%), Zinc cheated (Zn-EDTA 12%), Manganese cheated (Mn-EDTA 12%)) were evaluated against powdery mildew of mango caused by *Oidium mangiferea*. Data obtained showed that all materials reduced significantly the disease severity percentage of mango powdery mildew disease comparing the control. Compared fungicides; Topsin M 70 (Thiophanate methyl) and Topas 10% (Penconazole) showed the most superior effect against the disease followed by potassium di-hydrogen orthophosphate. Tested microelements were arranged as zinc, iron and manganese, respectively due to their efficiency. Calcium nitrate and magnesium sulfate revealed the less effect. Evaluated microelements showed the higher efficacy than mineral fertilizers during the two experimental seasons except potassium monophosphate. While, two compared fungicides were the most efficiency to control the disease, tested materials reduced significantly the disease severity of mango powdery mildew disease and showed ability to reduce the number of required applications with conventional fungicides.

Key words: Mango, powdery mildew, mineral salts, microelements, thiophonate methyl, penconazole.

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Introduction

Mango (*Mangifera indica* L.) occupies the third category among the fruit crops after citrus and grapes. In Egypt, It is considers one of the popular fruit to the Egyptian consumers and one of the important export crops. Accordingly, a large scale of the new reclaimed area in Egypt was planted with mango trees. Therefore, mango orchards have increased rapidly through the last few years reaching about 265350 acres. Under the prevailing Egyptian environmental conditions mango trees are attack with several diseases and pests significantly affected foliar and yield. Powdery mildew disease is the most economic disease on mango in Egypt. It is caused by an Ascomycetous fungus of the Erysiphales family was initially described by Berthet in 1914 as *Oidium mangiferae* (Nelson, 2008). Losses and risks increased because all commercially cultivated varieties are susceptible to the disease (Thind et al., 2005). However, application of fungicides is still the classical methods to control plant diseases. Bavistin 50 WP (carbendazim 0.05%), Sulfex 80 WP (wettable sulfur 0.25%), Bayleton 25 WP (triademefon 0.05%) , Roko 70 WP (thiophanate-methyl 0.1%) , Topas 10% EC (penconazole 0.05%) ,and Contaf 5EC (hexaconazole 0.05%) were reduced significantly powdery mildew of mango caused by *Oidium mangiferae* under orchard conditions compared with the check treatment when they were used at pre-bloom, 10 days after 1st spray and at fruit setting stage (Chavan et al., 2009). During the recent years, the sustainable agriculture is becomes one of the most important issues in agriculture. In addition, plant diseases play a limiting role in agricultural production. Plant diseases control applying traditional pesticides showed serious concerning about food safety, environmental improving and pesticide resistance, which indicated the need for alternative techniques of pest management. In particular, nutrients could affect the disease tolerance or resistance of plants to pathogens. Several plant pathologists proved the effects of mineral salts, micro and macro elements used as fertilizers on plant defense. However, salts using as an alternative fungicide in integrated farming systems is still confined. Spraying phosphate, di-potassium hydrogen orthophosphate, K_2HPO_4 (DKP) and Potassium di-hydrogen orthophosphate, KH_2PO_4 (MKP) were induced protection against powdery mildew in nectarine, grapevine, and mango, on flowers and bloom clusters. Systemic fungicides used alone, without application of the phosphate treatment on the same dates showed significantly less effect in disease control than either phosphate or the alternative treatment (Reuveni et al., 1998). Powdery mildew of mango caused by *Oidium mangiferae* on cvs. Alphonso and Seddek was controlled by using mineral salt (phosphate solutions, KH_2PO_4); antitranspirant (kaolin) and antioxidant (ascorbic acid) independently or in mixtures as alternatives to chemical fungicides in an integrated management system (Nofal & Haggag Wafaa, 2006). Also, powdery mildew severity significantly decreased when mango trees were sprayed with microelements such as ferrous, manganese and zinc, each alone or in combination on barley plants received the usual NPK fertilizers at their recommended doses (Fahim, 1994). In addition, Ehret et al. (2002) stated that Calcium chloride ($CaCl_2$), Calcium nitrate ($Ca(NO_3)_2$) and dipotassium phosphate (K_2HPO_4) salts applied as foliar spray were significantly reduced powdery mildew on tomato leaves at greenhouse. Plant diseases were controlled by Manganese (Mn) due to its role in biosynthesis of lignin and phenol, photosynthesis and several other functions. Also, Zinc (Zn) showed various effects since they were decreased in some cases and increased in others while it not affects plant susceptibility. At the same time, severity of many diseases was reduced by Boron (B) due to its function on wall structure, membranes and metabolism in plant cell. Calcium (Ca) application enhanced resistance to plant diseases. Some diseases were controlled with Silicon (Si) due to its restriction of hyphae penetration, or it induced the accumulation of antifungal compounds (Dordas, 2008). This research was done to evaluate the efficiency of certain inorganic mineral fertilizers against mango powdery mildew under Egyptian conditions.

Materials and methods

During the two successive seasons of the years 2014 and 2015 field trials were conducted in mango orchard at Manssouriya location, Giza Governorate, Egypt. Mango trees belonges to the susceptible cultivar Taymour, similar in their foliar growth (10 years old) were applied. Five replicates each consisted from 5 trees were used for each treatment. At the same time, similar number of trees sprayed with water was left as control. Foliar spray technique was used. The spray was implemented at the beginning of February at bud burst stage. Five sprays, 15 days interval were emplemented. Table (1) indicates the utilized mineral fertilizers, microelments and recommended fungicides and their rates per 100 litter of water.

Table 1: Mineral fertilizers, microelements and the systemic fungicides were used in this study.

Tested materials	rate per 100 litter of water
Mineral fertilizers	
Potassium di-hydrogen orthophosphate (KH2PO4)	2 kg
Potassium bicarbonate (85%)	50 gm
Calcium nitrate (17.1%) Ca(NO3)2	1.5 kg
Microelements	
Magnesium sulfate (MgSO4)	300 gm
Iron cheated (Fe-EDTA 6%)	200 gm
Zinc cheated (Zn-EDTA12%)	100 gm
Manganese cheated (Mn-EDTA12%)	100 gm
Compared fungicides	
Topsin M70 WP(Thiophanate-methyl)	100 gm
Topas 10% EC (penconazole)	25 ml

Each tested material was individually sprayed. The experiment was done in a randomized block design. Randomize samples of inflorescences and leaves were collected 15 days after each spray. Disease incidence was determined as percentage of disease severity (PDS). Townsend and Heuberger (1943) scale was used with modified as follow:

1= 0 %, 2= 1-5%, 3= 5.1-10%, 4= 10.1-15%, 5= 15.1-25%, 6= 25.1-50%, 7= 50.1-75%, 8= 75.1-100% of infected area.

Mean percentage of the average of infected area of each treatment was calculated. Treatments efficacy was recorded using the following equation:

$$\text{Efficiency (\%)} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100$$

Prevailing meteorological factors in the experimental location (Manssuorya location, Giza Governorate, Egypt) were recorded during the period of the trials through the two seasons. They were suitable for disease incidence (temperature arranged from 20-25 at 60-90% RH). This conclusion was confirmed by Johnson (1994). Data were statistically analyzed according to Snedecor and Cochran (1967). Least significant difference (LSD) at 5% probability was used to compare between treatment averages.

Results and Discussion

Obtained data were tabulated in Table (2 and 3) showed that all tested materials were significantly decrease disease severity percentage of mango powdery mildew disease comparing the control in the both trials. Also, tested two fungicides were the most superior method against mango powdery mildew followed by potassium monophosphate treatment. While, magnesium sulfate was the lowest one in the two seasons. Topsin M70 was more efficient than Topas, while both gave the highest efficiency percentage. Microelements showed higher efficacy percentage than mineral fertilizers except potassium monophosphate during the two experimental seasons. Similarly, potassium monophosphate followed by potassium bicarbonate was the effective mineral fertilizers against mango powdery mildew disease. Among the microelements, zinc recorded the best effect against the disease followed by iron and manganese. Likewise, magnesium sulfate and calcium nitrate occupied the final ranks, respectively. In general, disease severity percentage was more evident on inflorescences than leaves. This may be referred to the chemical components of leaves from the antifungal materials such as saponin, steroids, tannin, flavonoid, reducing sugars, glycosides and anthraquinone. Our results were in accordance with El-Kafrawy (1997), who reported that all application with iron, zinc and manganese showed the less percentage of powdery mildew infection. This conclusion may be referred to the role of the microelements in closing the stomata, delaying the penetration and pathogen development or their toxic effect, which causes reduction of pathogen growth. The intermediate effect on disease severity was recorded when plants were treated with potassium monophosphate. These results were in agreement with those obtained by Dik et al. (2003) and Abd El-Kareem (2007). The application of microelements enhanced the mechanical barriers formation (lignifications) such as synthesis of toxins (Phytoalexins). Moreover, micronutrients were also affected disease resistance indirectly, as nutrient-deficient plants not only exhibit an impaired defense response, but often become more suitable for feeding as many metabolites such as reducing sugars and amino acids leak outside the plant cell (Bolle-Jones & Hilton, 1956). In addition, the application of nutrient such as Mn was exchanged and therefore released Ca_2+ cations from cell walls, which interact with salicylic acid and activate systemic acquired resistance mechanisms. The microelements, *i.e.* Fe, Zn and Mn play a great role in the enzyme functions in the plants and their growth, where many enzymes are of organic mineral complex structure (Reuveni & Reuveni, 1998; Reuveni et al., 1996). Microelements affect the oxidative reduction system in the plants. On the other hand, the influence of Fe and Mn supply on plant growth, Fe and Mn uptake as well as catalase and peroxidase activities. Catalase activity increase with Fe supply. However, the higher concentration of Mn produced high catalase activity (Leidi et al., 1986). Results obtained proved that potassium bicarbonate showed significant efficacy in reducing disease severity comparing with control. This was attributed that bicarbonates has several modes of action against fungi, including buffering an environmental elevated pH, and increasing osmotic levels on leaf surfaces. Both conditions detrimental to fungal spores. Even though elevated pH buffered by bicarbonates prevent germination, conidial adhesion was dramatically reduced only above pH 11 (Marloth, 1931). Also, data in Table (2) clear that influence of tested materials against powdery mildew disease may be referred to their direct effect on host cells and indirect effect against the causal pathogen during their interactions through the pathogenesis process.

Table 2: Disease severity percentage after spraying of tested materials on mango leaves in the two seasons 2014 and 2015.

Tested Materials	2014 season		2015season	
	Infected surface of leaves (%)	Efficiency (%)	Infected surface of leaves (%)	Efficiency (%)
Potassium monophosphate	7.11	85.84	9.20	83.28
Potassium bicarbonate	16.82	67.49	19.71	64.19
Calcium nitrate	18.14	63.86	20.91	62.01
Magnesium sulfate	20.52	59.12	23.14	57.96
Iron (chelated)	13.35	73.41	15.27	72.26
Zinc	11.03	78.03	12.65	77.02
Manganese	13.71	72.69	14.03	74.51
Topsin M 70	6.70	96.65	7.30	86.74
Topas	8.11	83.84	10.49	80.94
Control	50.20	--	55.04	--
LSD test (P=0.05)	1.37		1.39	

Table 3: Disease severity percentage after spraying of the tested materials on inflorescences mango in the two seasons 2014 and 2015.

Tested Materials	2014 season		2015season	
	Infected surface of inflorescences (%)	Efficiency (%)	Infected surface of inflorescences (%)	Efficiency (%)
Potassium monophosphate	12.07	82.79	13.36	82.23
Potassium bicarbonate	22.15	68.42	24.13	67.91
Calcium nitrate	25.18	64.19	27.14	63.90
Magnesium sulfate	26.35	62.44	28.16	62.55
Iron (chelated)	18.72	73.31	19.30	74.33
Zinc	17.35	75.27	18.25	75.73
Manganese	19.10	72.77	20.05	73.33
Topsin M 70	9.15	86.96	11.25	85.03
Topas	10.11	85.59	13.18	82.47
Control	70.15	--	75.20	--
LSD test (P=0.05)	1.71		1.86	

Bicarbonate salts may directly interacted with membranes to alter normal membrane activities or may disrupt cellular physiology at concentrations well below saturation. The bicarbonate salts causes the collapse of hyphal walls and shrinkage of conidia. Also, pH elevation may play a significant role (Peoples & Koch, 1979). Also, KH_2PO_4 caused systemic resistance against powdery mildew disease by forming crystallized compounds with Ca_2 inside the healthy plant cells. Calcium nitrate as mineral nutrient is also a non-toxic, even in high concentration and is very effective to detoxify the high concentrations of other mineral elements in plants. Many enzymes activities were stimulated or inhibited by calcium**.** Proteins, nucleic acids and lipids are bind with calcium in plants to affect cell adhesion, organizing chromatin of membrane and conformation of enzyme (Gottstein & Kuc, 1989). Deliopoulos et al. (2010) reported that inorganic salts (mainly bicarbonates, phosphates, silicates, chlorides and phosphites) reduced disease severity of mango powdery mildew disease and enable to reduce the number of required applications with conventional fungicide. In previous study, alternative treatments include phosphate gave significantly effective in controlling mango powdery mildew disease. This indicates that the use of phosphate fertilizer has a significant role in disease control. It can reduce treatment number of necessary fungicides to control powdery mildew up to 50% **(**Reuveni et al., 1998). Phosphate solutions were not toxic to plant tissue except on the young, newly developed leaves of nectarine. Due to inhibitory effectiveness of phosphate salts, they are considered ideal foliar fertilizers and useful ‘biocompatible’ fungicides for orchard application to control mango powdery mildew disease (Reuveni & Reuveni, 1995).

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