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Nutritional and Chemotherapeutic Management Strategies of Powdery Mildew in Pumpkin

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Abstract

Several disease management strategies adopted by researcher that based on host resistance, chemicals and nutrient supplements. These measurements were effective for reducing the disease caused by *Sphaerotheca fuliginea*. Some measures were easily recommended but less easily applied. The effective use of fungicides and nutrient supplements requires the knowledge of epidemiology of disease. Powdery mildew reduces the economic gains, so the aim of integrated disease management is to reduce the economic loss. Crop protection is increasingly dependent on chemical pesticides that may cause environmental hazards. Integrated management may helps to avoid such problem. Integrated management of pumpkin powdery mildew is an environment suitable strategy, which seeks to minimize the use of chemical by placing more reliance on other non-chemical methods like nutritional management. The ultimate objective of the management strategy is to produce the optimum crop yield of high quality at minimum cost and the long-term goal is to reduce the environmental hazards by less dependence on chemical control measures.

1. Introduction

Pumpkin (*Cucurbita pepo* L.) is normally used in green and mature stage as vegetable; the flesh is somewhat coarse and strongly flavored, and number of different preparations is made from pumpkin fruits. It is mixed with tomato in the perpetrating of sauce. The fruit contains protein, fat, carbohydrate and vitamins A. Seeds are diuretics, anthamentics, teanicides, and tonics (Tellez et al., 2002). The leading producer of pumpkin are USA, Mexico, India, Australia, Japan, and Thailand (Roberts et al., 2008). Pumpkins seeded in cool soils may suffer from seed corn maggot injury. Since they are a warm-season crop, they should not be seeded until the soil temperature reaches 16°C and three inches beneath the soil surface (Furnkranz et al., 2012).

There are three important mosaic viruses viz. pumpkins zucchini yellow mosaic virus, papaya ring spot virus and watermelon mosaic virus, which cause severe fruit distortion, (Vucurovic et al., 2012).

2. Management

Powdery mildew is a common disease of squash in most areas of the world and can be a major production problem in future. *Sphaerotheca fuliginea* has been observed as causal agent of powdery mildew in the USA (McCreight et al., 1987), Israel (Cohen and Eyal, 1995a) and Japan (Hosoya et al., 2000). The disease can reduce photosynthetic area of leaves, and in severe cases causes defoliation of plants, and reduce yield and quality of fruit (Cohen et al., 2007). The major symptoms of powdery mildew are white superficial spots on the leaves and affected stems gradually dry up and ultimately death of vines occur. Usually, the disease seriously affects the plant growth, fruit formation and development. Powdery mildew may cause considerable crop losses, sometimes up to 50% (Reuveni and Reuveni, 1995).

2.1. Nutritional supplements against powdery mildew of pumpkin

The powdery mildew can be control by different ways such as use of resistant or tolerant cultivars and by the application of fungicides. Use of chemical to control the disease is not always best ways since pathogens may develop resistance to some fungicides (Gullino et al., 2002). In addition, people understanding of the inference of harmful effects to the environment and human health the use of chemical pesticides has intensified the hunt for substitute ways of disease control

(Gullino et al., 2000). Mineral nutrients are regularly applied to enhance yield of crop and improve overall quality and plant health. Their judicious use and environmental settings is critical for improved production efficiency. Nutrient amendment or modification of the soil environment is an important cultural component for plant disease management. Foliar application of chlorite mica clay, which contains silicon, have also verified suppression of powdery mildew in cucurbits (Ehret et al., 2001).

Different salts of monovalent cations, such as potassium ammonium bicarbonate (mono-potassium phosphate) have ability to control powdery mildew occurrence in pumpkin. Commercial potassium bicarbonate and mono-potassium phosphate products may contain as much potassium as 30%, they are also publicized for foliar fertilizer characteristics. In fact, in integrated management program (IMP) have stated that the application of a foliar-fertilizer have a valuable significance. Intensive use of agricultural chemical fertilizer engaged in degradation of the environment of rivers, lakes and aquifers. Foliar application of potassium and phosphate salts induce systemic protection against pathogens in different crops such as rose, grapevine, cucumber, maize, apple, mango, and nectarine.

The relation between fertilizer amounts and combinations, and the expression of resistance or susceptibility to plant pathogens has been thoroughly investigated and has received increased attention in recent years. In general, elements P and K tend to improve plant health. It was also indicated that the balance between various nutrients is as important as their absolute rates. P and K may affect the reaction of a plant to pests in one or more of the following ways, Direct effects on the pathogen multiplication, development and survival, effects on the internal metabolism of the plant, thus affecting food supply for the pathogen and effects on the internal metabolism of the plant .on the establishment of the pathogen and its spread within the plant, through the influence of the elements on plant defense responses and cell-wall ultra-structures and function of stomata. Although P and K fertilizers improve plant health in the majority of cases (Reuveni and Reuveni, 1998), disease cannot be controlled by the use of fertilizers alone.

In many cases to maintain the cost benefit ratio number of spray of fungicides reduced. However, optimal fertilization is an important component of an integrated program for disease management. Use of foliar fertilizers for induction of plant resistance is very much important at present but the mode of action still unclear (Hammerschmidt and Becker, 1997).

Foliar application of phosphate induced systemic protection against powdery mildew in cucumbers (Reuveni et al., 1995).

Application of phosphate was noted on leaf 1, applied 2 or 4 days pre-inoculation of spore suspension that stimulated plant growth, in spite of disease control (Reuveni et al., 1996). Spraying of a 1, l mixture of both P and K fertilizer salts did not improve the systemic protection against powdery mildew over that obtained by use of each compound alone (Reuveni et al., 1995). This study showed that systemic protection was not reduced when inoculum concentration increased. Evidently, post-inoculation application of phosphate on the first leaf of cucumber plants induced systemic protection against powdery mildew on upper leaves, even when it was sprayed 4 days after inoculation. However, it should be noted that the efficacy of phosphate in inducing resistance against powdery mildew in cucumbers and in maize against other pathogens is highly related to time of induction before challenge inoculation. The best protection was always obtained when phosphate salts were sprayed as early as 2 h before inoculation, suggesting that these chemicals rapidly trigger the plant's response. Kuc (1987) stated that phosphates compounds induce systemic resistance to *S. filiginea* (Rasmussen et al., 1991). In a study by Descalzo et al. (1990) phosphate was sprayed 1 and 2 weeks before challenge inoculation and was ineffective in inducing systemic resistance against powdery mildew in cucumber plants. Increased susceptibility to powdery mildew has been reported in barley (Oerke and Schonbeck, 1990) and grapevine varieties as a result of high N fertilization. The timing of application as reported by Descalzo et al. (1990) and more importantly, the previous supply of fertilizers before the induction treatment of the test plants can certainly change the balance among the nutrients and therefore might be the reason for this contradiction.

Foliar fungal pathogens, such as the powdery mildew fungi, are widely distributed and cause serious diseases of a large number of greenhouse- and field grown crops. In grapevine, powdery mildew may attack flowers, leaves, stems and fruits and cause considerable crop loss (Bulit and Lafon, 1978) and deterioration in juice quality (Stummer et al., 2005). Significant damage has been reported on nectarine and on mango infected with powdery mildew Fungicides are important in the control of many diseases. Sulfur and compounds belonging to the sterol biosynthesis inhibitor group are widely used to control powdery mildews. The development of fungicide resistance has hampered efforts to control mildew on cucurbits and grapes (McGrath, 2001). Once resistant strains appear, many can survive for long periods. For example, the resistance of *S. fuliginea* to benzimidazoles can persist for 10 years after withdrawal of the fungicides from use (Reuveni et al., 1995).

A single application of phosphates was effective in direct suppression of the lesions and eradication of the conidia on the diseased foliage of cucumber that had not been sprayed previously with phosphate (Reuveni et al., 1996). Horst et al. (1992) reported that sodium bicarbonate controlled powdery mildew and black spot in rose. A similar effect of bicarbonates was reported on cucurbit powdery mildew (Ziv and Zitter, 1992).

2.2. Monopotassium phosphate:

Reuveni and Reuveni (1995) applied foliar sprays of 0.43% and 0.01% solutions of K_2HPO_4 and KH_2PO_4+KOH. The efficiency of phosphates for controlling powdery mildew was like systemic fungicide. Alternating treatments of phosphate salt with each of these fungicides, however, enhanced the inhibitory effect against the fungus in each crop. With the exception of young, newly developed leaves, these phosphate solutions were not phytotoxic to plant tissue. The inhibitory effectiveness of phosphate salts makes them useful 'biocompatible' fungicides and ideal foliar fertilizers for field application for disease control.

Reuveni et al. (1996) controlled *Sphaerotheca fuliginea* was significantly controlled by a foliar spray pre-inoculation treatment of 20 mM solutions of either mono-potassium phosphate or potassium nitrate, or a 0.01% solution of the systemic fungicide pyrifenox. Further foliar sprays of mono-potassium phosphate, sodium bicarbonate (1%) and pyrifenox remarkably suppressed powdery mildew colonies on diseased foliage. Solutions of 25 mM of monopotassium phosphates applied on a 7 or 14 dayintervals were highly protective against natural infection by the mildew fungus. Pyrifenox was not significantly more effective in controlling *S. fuliginea* than either phosphate or the potassium salts. These salt solutions were not phytotoxic to plant foliage. Reuveni et al. (2000) applied potassium containing nutrient solutions at concentrations of 5, 20 and 40 ppm, applied through a hydroponics system, provided induced systemic resistance (ISR) against *Sphaerotheca fuliginea* in young cucumber plants. ISR was also 91% reduction in the number of *S. fuliginea* conidia per infected leaf area as determined on leaves at 9 days after inoculation. Foliar application of 1% solution of mono-potassium phosphate (MKP) effectively protected the foliage against powdery mildew, regardless of the P concentration in the nutrient solutions. This treatment was persistent up to 21 days after inoculation, inhibited powdery mildew development and caused a reduction of 72.3% in sporulation of the fungus as compared with the control. The results suggest different mechanisms for the two phenomena and highlight the role of P in ISR.

2.3. Potassium silicate

Nutrient supplements play an important role for controlling the fungal disease in plants. However, there are several reports on the selection of isolates either resistant or insensitive to different groups of fungicides (McGrath, 2001). Thus, the development of additional control measures with low environmental impact represents an important research topic for this disease. Despite not being considered as an essential nutrient for most plants to complete their life cycles, it has been widely reported that silicon (Si) reduces the effects of biotic and abiotic stresses (Epstein, 2009). Although the physiological and molecular mechanisms underlying this phenomenon are still poorly understood, accumulation of Si in plant tissues is known to be a necessary condition for these observable effects (Dallagnol et al., 2011b).

Savvas et al. (2009) supplied silicon nutrient solution for enhancing the tolerance of grown pumpkin to powdery mildew infection. The exposure of the plants to high external powdery mildew restricted significantly the vegetative growth as well as the fruit yield of pumpkin due to a reduction of both the number of fruits per plant and the mean fruit weight. However, the supply of Silicon nutrient solution mitigated powdery mildew (*S. fuliginea*) infection in the leaves.

In cucumber, for example, Si reduced the severity of *P. xanthii* infections by reducing the number of colonies and their size, the germination frequency of conidia, and the number of haustoria per colony (Menzies et al., 1991a; Menzies et al., 1991b). The reports by (Menzies et al., 1992) suggested that Si can also be used to control powdery mildew in melon. Thus, the present study investigated the effects of foliar and root applications of potassium silicate on various epidemic components and on disease progress in melon plants grown under greenhouse conditions.

A number of studies have indicated that Si application can reduce the severity of fungal diseases. For example, foliar application of 1% Si (w/v) solution to sweet cherry reduced blue mold decay by 63% and brown rot decay by 87% (Qin and Tian, 2005). Potassium silicate application to soil reduced powdery mildew in strawberry by 86% in the first year and 60% in the second year (Kanto et al., 2006). Application of 100 and 200 mM sodium silicate solution decreased the diameter of dry rot lesions in potato tubers by 44% and 45%, respectively (Li et al., 2009). The mechanism(s) by which Si protects plants from fungal diseases is not well understood (Bi et al., 2006). One hypothesis is that Si acts as a physical barrier that protects plants from fungal infection. Another possible mechanism is that Si acts as a modulator of host resistance to pathogens (Ma and Yamaji, 2008). Some studies suggest that Si has fungicidal effects *in vitro*. For example, soluble silicic acid reduced hyphal elongation of the fungus by 62%. Bekker et al., (2006) reported that mycelial growth of several phytopathogenic fungi was inhibited when cultured on potassium silicate amended media. Bi et al. (2006) reported that 100 mM sodium silicate completely inhibited mycelial growth of *Alternaria alternata*, *Fusarium semitectum*, and *Trichothecium roseum*, which cause Alternaria, Fusarium, and pink rots of Hamimelon (*Cucumis melo* L.). Potassium silicate solution reduced the germination of powdery mildew conidia by 40-60% (Kanto et al., 2004). Replant disease in strawberry, which is caused by *Rhizoctonia solani*, *Fusarium oxysporum* and *Verticillium dahliae* individually or in combination, slows plant growth, reduces yield, and causes economic loss to the strawberry industry (Wang et al., 2007).

3. Chemical Control

Briggs et al., (2007) investigated with the series of experiments and concluded that fungicides having a unique mode of action controlling a spacious range of biotrophic pathogens. Normally a protectant fungicide and a systemic fungicide are tank mixed and alternated weekly basis with a different tank mix consisting of fungicides with different modes of action, in order to reduce selection pressure for resistance in the pathogen. An example of such a program is chlorothalonil (Bravo) and alternating with mancozeb (Manzate)+famoxadone+cymoxanil (Tanos). Keinath and Dubose (2004) evaluated the curative and preventive effect of systemic and contact fungicides against powdery mildew disease. Those chemicals which were applied as a preventive measure were the azoxystrobin, myclobutanil and pyraclostrobin, changes with mancozeb. Alternating preventative applications of mancozeb with azoxystrobin was one of the most effective fungicides to test the combinations in order to prevent and control this disease. Curative applications of systemic fungicides generally were less effective than preventative applications of fungicides showed best result than the curative application of systemic fungicides.

Fungicides provide the significant control when compared to untreated muskmelon plants and Bayleton provide the best control against powdery mildew than any other fungicides (Matheron and Porchas, 2000). Fungicidal trial was established to evaluate the fungicides like benomyl, thiophanate methyl, azoxystrobin, micronized sulfur, potassium bicarbonate and trifloxystrobin on the base of time of application and rotation of these fungicides against powdery mildew of muskmelon to increase the efficiency of fungicides. Application of fungicides on lower surface of the leaves showed best control as compare to upper surface of the leaves (Percival and Haynes, 2008).

Severity of powdery mildew was reduced significantly by all the treatments when made comparison to untreated plants. Efficacy of systemic fungicides and resistance inducing chemicals were evaluated under both field and greenhouse conditions in order to control the powdery mildew disease of muskmelon. Rubigan 12%, Master 10%, Topas 10%, Vectra 10% as well as resistance inducing chemicals, calcium chloride, Sumi-85% and salicylic acid efficiently reduced the disease severity. Systemic fungicides were more efficient (Ashour et al., 2009).

Disease management in cucurbits usually involves foliar applications of synthetic fungicides, use of disease resistant cultivars and clean cultivation (Mondal et al., 2013). Fungicides such as azoxystrobin, myclobutanil, quinoxyfen, trifloxystrobin, triflumizole, and micronized sulfur can be used to treat plants (Sankaran et al., 2010). Sulfur has the advantage of little or no risk of selecting for resistant mildew strains (Choi et al., 2004). Previous work has also shown that quinoxyfen, triflumizole, and penthiopyrad were highly effective in managing powdery mildew in disease susceptible varieties (Zhang et al., 2011).

4. Conclusion

Chemical control is easy, direct and rapid action and easy to solve the disease problems, continues reliance on chemical control has proven increasingly by unsuitable in reality a great problem for disease management such as environmental problem and degradation. Mineral nutrients are regularly applied to enhance yield of crop and improve overall quality and plant health. Their judicious use in crop production is critical for improved production efficiency and a sustainable ecosystem. Nutrient application is an important cultural control for plant disease and an integral component of disease management.

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