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Research Article

Chemical and nutritional management of powdery mildew caused by *Sphaerotheca fuliginea* on pumpkin vines

Rabia Rasheed, Subhan Ali, Umair Rafiq, Uswa Maryam, Sara Ijaz

Institute of Plant Protection, MNS- University of Agriculture Multan, 61000, Pakistan.

ABSTRACT

Pumpkin is a popular vegetable crop in Pakistan and India which is grown in rainy season. Numerous biotic and abiotic factors have an impact on this crop. *Sphaerotheca fuliginea* is one of the biotic agents that poses a major risk to the crop, leading to significant losses in both quantity and quality. Applying nutritional supplements to strengthen resistance against pumpkin powdery mildew infection is an economical and ecologically sustainable approach to managing the disease. Three treatments including 1% potassium monophosphate, 1% potassium silicate, and their combination (1:1) given in the field have been tested in order to control the disease. The spraying procedure used before the inoculation revealed that the disease was infected. A maximum 49% decrease in disease was achieved in the control group when potassium silicate and mono potassium phosphate were combined. The distinctive effects of 1% potassium silicate and 1% potassium phosphate mono shown, for comparison control, a 43% and 39% lower incidence of disease, respectively. In the field, tests were conducted to determine the efficacy of three fungicide combinations: Bravo (chlorothainal), score (Difenaconazole), and Bravo + score. The standard concentration of each combination was tested against *S. fuliginea*. The disease control was reduced by 61% when the two fungicides were combined (Bravo+ score). Compared to the control, the partition effect score and Bravo produced a 56% and 54% reduction in disease, respectively. By choosing an appropriate formulation and application technique of nutritional supplements can be effectively used in inhibiting the growth of *S. fuliginea*.

Keywords: *Sphaerotheca fuliginea*, Pumpkin, Nutritional Management, Chemical Management, Pakistan.



Correspondence

Rabia Rasheed
rabiarasheed973@gmail.com

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INTRODUCTION

Many important vegetables, including different gourds, pumpkins, zucchini, and squash, are members of the *Cucurbitaceae* family (Schaefer et al., 2011). Among them pumpkin is one of the significant crop in both tropical and temperate regions. Around the world, they are extensively cultivated and consumed in tropical and subtropical areas (Jun et al., 2006). In 2012, the global production of cucurbits reached 24 million metric tonnes. With an average yield of 10 metric tonnes, it is cultivated jointly over a land area of 26,500 hectares. Thailand, Japan, Mexico, India, Australia, and the United States are major pumpkin producers (Roberts et al., 2006). The majority of plants in this family are huge, showy vines that bloom every year. The inferior ovaries of the unisexual blooms are present called pepo, and it resembles a berry. Within the 960 species of the cucurbitaceae family, there are 125 active genera. Typically, the first two weeks of July are used to seed pumpkin culture in the field (Kammen, 2013). There, it is necessary to cultivate pumpkins with adequate water retention and soil penetration. Having access to water is crucial for achieving optimal plant development, acceptable fruit quality, and sufficient yield when planting crops on sandy soil (Schafer and Blanke., 2012).

Numerous diseases are negatively impact pumpkin crops, such as powdery mildew (*Sphaerotheca fuliginea*), Fusarium foot rot (*Fusarium solani*), downy mildew (*Pseudoperonospora cubensis*), and bacterial leaf spot (*Xanthomonas campestris*). However, powdery mildew is becoming more significant among these diseases as a result of its occurrence rising in recent years, which has decreased agricultural productivity (Kiss, 2003).

Globally, pumpkin fields and greenhouse crops are severely afflicted by powdery mildew (Hansen, 2009). According to Mossler and Nesheim (2003), the disease often affects older leaves and stems first, resulting in early foliage loss and a drop in output due to smaller and fewer fruit. In severe situations, the disease affects photosynthesis that ultimately lower fruit quality and production (Cohen et al., 2007). White superficial patches on leaves and stems that gradually dry up and finally cause the vines' yield to die are the primary symptoms of powdery mildew. The disease generally has a major negative impact on plant growth, fruit production, and development. Fruits are often not damaged; nevertheless, due of the attack on the covering, they might get sunburned and deformed. Powder can result in significant crop losses; reports have indicated that in certain situations, disease infection can reach 50–70% and production losses can reach 30–50%. It damages plants more when they are grown in warm, dry climates (El-Naggar et al., 2012). The proper use of fungicides and nutritional additives is required to increase production. As a result, several fertilizers and fungicides are used to prevent pumpkin powdery mildew. Nutritional supplements are ecofriendly for the environment and useful in the treatment of disease.

A study employed several disease control methods that depend on host resistance, chemicals, and dietary supplements (Matheron and Porchas, 2013). The number of colonies of *S. fuliginea* has decreased due to these measures. Understanding the disease's epidemiology is essential for the efficient use of fungicides and nutritional supplements, as this information is used to predict epidemics (Gent et al., 2013). Chemical fungicides are becoming more and more important for crop protection. Even though chemical control is a relatively simple, quick, and easy way to solve health problems (Matheron and Porchas 2013), its application has proven to be increasingly unsuitable for really significant health problems, like environmental degradation and problems with the environment, as time has gone on. A suitable environmental approach that seeks to reduce the use of pesticides and increase the use of non-chemical measures, such as nutritional management, is integrated pumpkin powdery mildew management (McGrath, 2001). By preserving the environment and producing high-quality crops at a low cost, the management technique seeks to reduce reliance on chemical control. Approaches are required to stop pumpkin powdery mildew epidemics from happening commonly. The epidemiology of powdery mildew development is poorly understood, and research on the influence of environmental factors on the establishment of inoculum and disease transmission in Pakistan has not been conducted. To address powdery mildew disease, a study strategy has been developed to explore possible fungicides and nutritional supplements.

MATERIALS AND METHODS

Site Preparation

All the site preparation and management practices were performed for the sowing of crop. Disease susceptible Mahadeev variety seeds were taken from Ayub Agriculture Research Institute Faisalabad. The sowing were carried out in area 54 × 29 square foot. Randomized complete block design (RCBD) were carried out by three replication.

The seeds were sown at a distance of 2 feet apart. Each hole received 3 up to 4 seeds. Germination started from the 7th day after sowing and the process was completed after ten days.

Inoculation of Powdery Mildew

Samples of fungi were taken from the Nuclear Institute for Agriculture and Biology (NIAB), located in Faisalabad. The conidia were carefully examined in a small quantity of distilled water with two drops, and then counted using a hemocytometer to produce a conidia suspension of 3 × 10⁴ ml⁻¹ for inoculation. A hand sprayer was used to equally spray the conidia suspension over the upper surface of each sheet of plants. Inoculation were carried at the three- to four-leaf stage of plant.

Disease Assessment

Following weekly intervals, plants were thoroughly examined to determine the powdery mildew disease incidence using this formula:

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected plant}}{\text{Total number of plant}} \times 100$$

(Mir, 2011).

Identification of Pathogen

For identification and conformation of the pathogen were performed by slide preparation method and examined under the microscope.

Characterization of the Environmental Factors

Environmental data, including relative humidity (%), °C maximum and minimum temperatures, precipitation (mm) and wind speed (km / h) were collected from the meteorological section, Faisalabad. Incidence data of powdery mildew of pumpkin were recorded.

Management through Nutritional Supplements and Chemicals

A field evaluation was conducted on two chemicals, chlorothalonil and dienocazole, along with their combination at a standard dosage. Two supplements were used to treat the condition after a week: Agsil nutrients (potassium silicate) and Peak (monophosphate-potassium). Each supplement was taken in a different combination and concentration.

Table 1. Fungicides used against powdery mildew disease of pumpkin.

Sr. No	Fungicide	Active Ingredient	Recommended
T1	Score	Difenconazole	250ml/100L
T2	Bravo	Chlorothalonil	150ml/100L
T3	Bravo +Score	Chlorothalonil+ Difenconazole	2.4+1.5mL/L
T4	Control	No spray	–

Table 2. Nutrient supplements used against powdery disease of pumpkin.

Sr. No	Nutrient supplements	Active Ingredient	Concentration
T1	Agsil	Potassium Silicate	0.1%
T2	Peak	Monopotassium Phosphate	0.1%
T3	Agsil+ Peak	Potassium Silicate+ Monopotassium Phosphate	0.2%
T4	Control	No spray	-

Statistical Analysis

Data was recorded and analyzed statistically using statistical analysis software Statistix 10. All the possible interactions and effects were analyzed using ANOVA test and means were compared by LSD test at 5% significance level (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Symptomology and Disease Development

Seven days following the infection, the upper surface of the sheet started to show signs such as chalk dust and white patches. Typically, the symptoms were observed on the underside of fully grown leaves with brown edges that were dispersed by pale mycelium. Symptoms often appear when fruit starts to grow and flowers. Older leaves with yellow chlorotic patches on the upper surface and a mound of white powder on the lower surface are the first to exhibit signs of the disease. On the lower surface of the diseased leaves, white sporulating patches with copious conidia production were usually observed. In extreme situations, a white mass also extended across the sheet's upper surface. The damaged leaves curl, and severe infection causes the leaves to become defoliated. Later, the disease became apparent on immature leaves, which resulted in complete defoliation. As a matter of fact, the marginally impacted leaves frequently tend to fall. Plants with severe damage had all of their foliage removed. On the plant, a growing white, powdery substance was observed. The most obvious indication of the assault is found in the portions of the plant that are visible, such as the leaf, stem, and fruit (Figure 1).

Characterization of the Environmental Factors

The relation between temperature and disease incidence is greatest at temperatures over 40 °C (Figure 2). The higher value of $r = 0.94$ (Figure 4) indicates that temperatures between 28 and 32 °C are ideal for the development of diseases. This relationship was explained by linear regression in all treatments. The disease incidence and wind speed had a positive correlation. The frequency of the disease was negatively correlated with rainfall. Models using linear regression have provided an explanation for the relationship. Linear regression models also explain the minimal association between relative humidity and disease incidence (Figure 4). The disease incidence was negatively correlated with the presence of rain. Pumpkin powdery mildew had a positive link with wind speed, lowest and maximum temperatures, and a significant adverse effect with rainfall on its development (Figure 2, 3, 4 and 5).



Figure 1. Characteristics symptoms of powdery appears on pumpkin leaves (a) lower side of leaf (b) upper side of leaf.

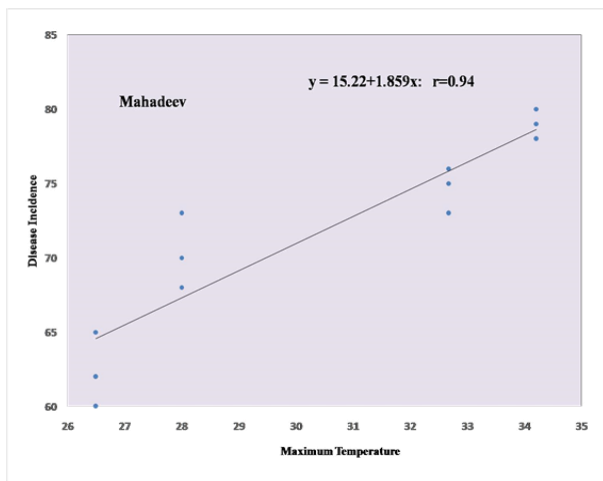


Figure 2. Relationship of maximum temperature (°C) on powdery mildew disease.

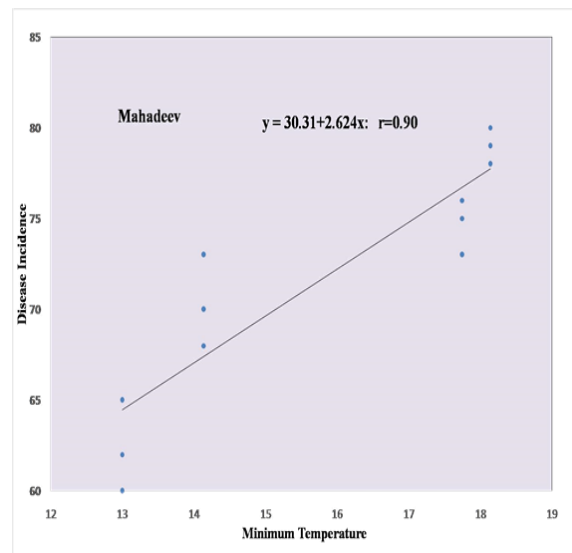


Figure 3. Relationship of minimum temperature (°C) on powdery mildew disease.

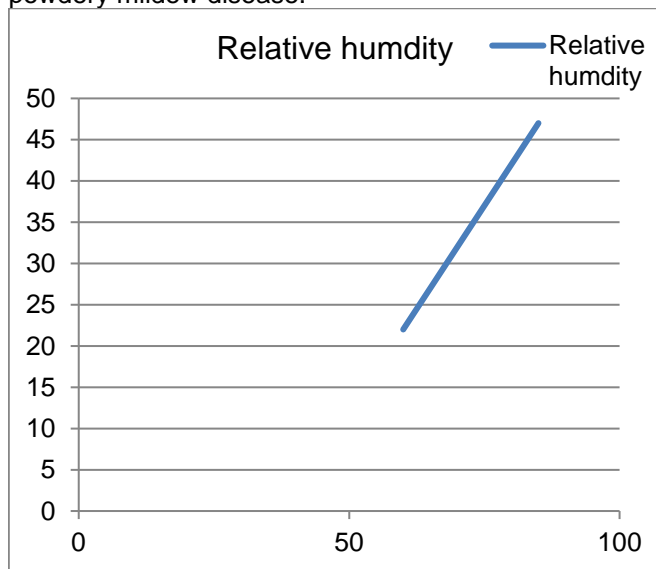


Figure 4. Relationship of Relative Humidity (%) powdery mildew disease.

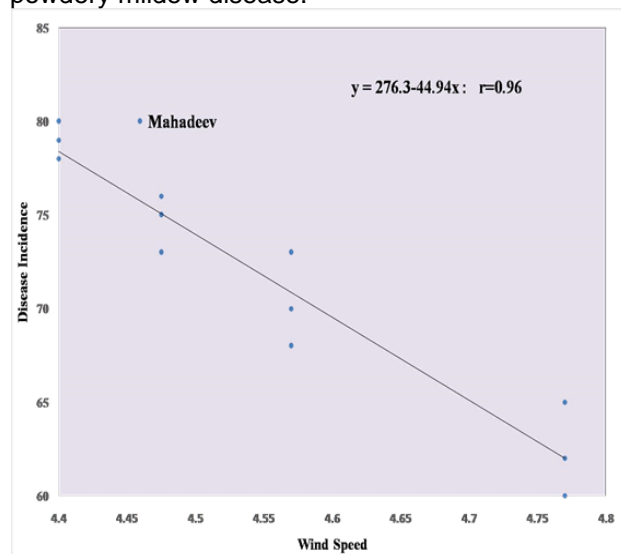


Figure 5. Relationship of wind speed (km/h) powdery mildew disease.

Management through Nutritional Supplements and Chemicals

The most effective outcome is shown after the third spray application when Bravo+Score are applied jointly. Score, Bravo, Agsil+Peak, Agsil, and Peak followed next. Disease incidence is highest in the control condition (Figure 6). In the past, fungicides have been employed to lessen the damage that pathogenic fungus produce. The most effective way to protect crops against powdery mildew disease is chemical management. According to Olsen et al. (2002), employing registered fungicides (azoxystrobin, micronized sulphur, thio-phanate methyl, and score) is the most efficient strategy to manage powdery mildew. On the top leaf surface, powdery mildew was somewhat reduced by all treatments. However, results show that fungicides with a protective and systemic mode of action are more effective, and that the efficacy reduced with repeated applications and varied more on the lower leaf surface.

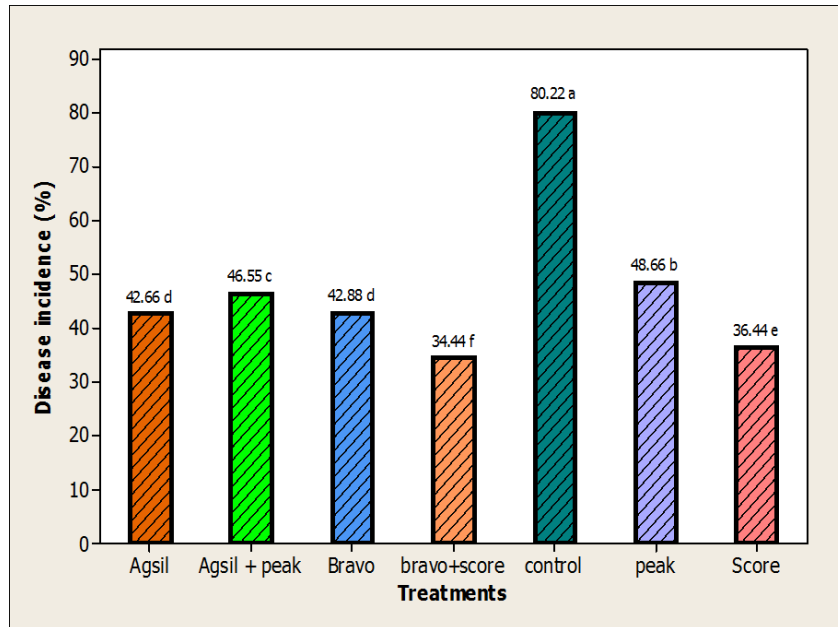


Figure 6. All treatments comparison for the Pumpkin powdery mildew management.

After the third spray application, the most successful results display Bravo+peak. as well as bravo, agsil+peak, agsil, and peak in that order. Maximum disease incidence is shown in the control condition (Figure 7). Bravo was able to minimise the powdery mildew on pumpkins. These findings were confirmed by Matheron and Porchas (2013), who conducted a field study to assess fungicides against powdery mildew on ridge gourd. In comparison to the control group, all therapies resulted in a substantial reduction in both the disease severity and the pace of disease progression. Crops treated with fosetyl-AI, chlorothalonil, and metalaxyl + mancozeb were used to estimate the effective consequences.

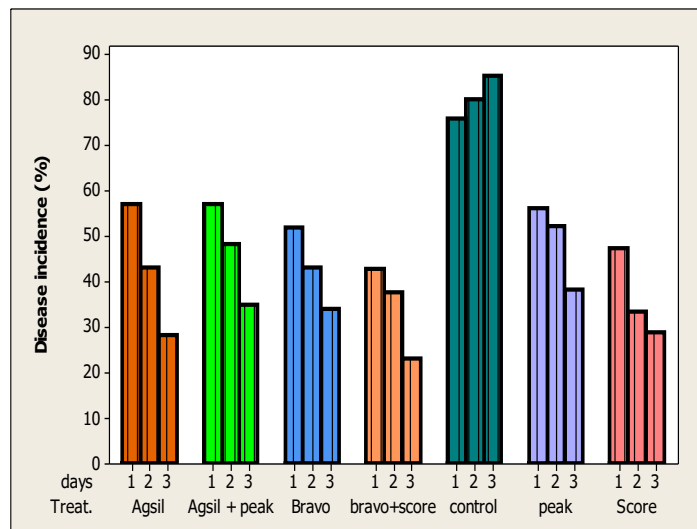


Figure 7. All treatments comparison of in different concentration for the Pumpkin powdery mildew management.

In this particular study, two chemicals were applied in the field: bravo (chlorothalonil) and score (difenoconazole), collectively with their typical dose combination. Our findings show that applying a mixture of fungicides inhibits powdery mildew and lowers disease infection by 61%. Bravo was evaluated against pumpkin powdery mildew as well, and it was shown to be effective against the disease (54%) since chlorothalonil is a broad-spectrum fungicide that acts as a preventive and has a multi-site mode of action. These findings support the successful management of less fungus and provide a healthy or disease-free crop by providing preventative control over diseases (Naidu *et al.*, 2012). According to Keinath *et al.* (2007), difenoconazole, benlate, quinoxyfen, nova, topsin, and chlorothionil decrease the powdery mildew produced by *S. fuliginea*. These findings are consistent with their findings. According to Percival and Haynes (2008), these findings are further supported by the results they achieved. To effectively manage powdery mildew, a mixture of fungicides performs best.

In the field, employed a mixture of these salt solutions, peak nutrient fertilizers, and agsil in the research conducted. The findings of (Dallagnol *et al.*, 2011) corroborate our findings about the potassium silicate assessment of the powdery mildew outbreak. When the nutritious solution was given to the leaves, pathogen infections were substantially decreased. Reuveni and Reuveni's (1995) results, which showed that foliar application of mono-potassium phosphate is similar to systemic fungicides, boost its inhibitory properties against fungus, and act as a biocompatible fungicide, confirm the current findings. Regardless of the potassium content in the nutrient solutions, foliar application of 1% solution of mono-potassium phosphate hindered the development of powdery mildew and reduced the amount of fungal sporulation by 72.3% when compared to the control. The inhibitory effect lasted for up to 21 days after inoculation (Reuveni *et al.*, 2000).

CONCLUSION AND FUTURE PROSPECTS

The study aimed at the control of fungus *S. fuliginea* powdery mildew on pumpkin plants by the use of foliar supplements Agsil and Peak, from single salt solutions. The mixture of both of the compounds was found to be extremely effective in combating powdery mildew. Bravo and Score are also fungicides that were tested and they were most effective when they were used together against powdery mildew. The other finding from the study was a strong relationship between temperature, relative humidity, wind speed and rain falls and severity of powdery mildew disease. Environment factors were concluded to be a determining factor in the progression of the powdery mildew disease in pumpkin, and a foliar application of nutrient supplements and fungicides were the most appropriate disease management methods. This research is really a new discovery of the ways of controlling the powdery mildew disease. Future practical research on nutritional supplements may focus on choosing an appropriate formulation and application technique. The choice of compatible in the activity of these additives and other methods of the commercialization of ecofriendly supplements can make them even better.

COMPETING OF INTEREST

The authors declare no competing interests.

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