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Short Communication

Effect of micronutrients and systemic acquired resistance activators on powdery mildew of Indian mustard incited by *Erysiphe cruciferarum*

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Abstract

Studies with micronutrients and systemic acquired resistance (SAR) activators were performed in field to assess their potential in managing powdery mildew of Indian mustard (*Brassica juncea* L.) incited by *Erysiphe cruciferarum*. This stress from living organisms has become a serious problem for growers in the Indian state of Rajasthan and, in general, causes economic losses when the climate changes. This study investigated six micronutrients in the field, including Zn, B, Cu, Mn, Fe, and Mg, as well as six SAR activators, including salicylic acid, isonicotinic acid, ethylene, fosetyl Al, β-amino butyric acid, and gamma-amino butyric acid. The most efficient treatments for lowering disease severity (46.5%) and boosting yield (33.1%) were two foliar applications of copper sulphate (0.5%), followed by borax. Salicylic acid (200 ppm) was shown to be superior thanisonicotinic acid (150 ppm) in SAR activators for both reducing intensity (54.5%) and boosting yield (43.4%). Thus, foliar sprays of copper sulphate and salicylic acid hold out a significant amount of potential for application in the treatment of diseases that are both efficient and ecologically benign for the benefit of the end users.

Keywords: *Erysiphe cruciferarum, Indian mustard, micronutrients, powdery mildew, SAR activators*

Introduction

Indian mustard [*Brassica juncea* (L.) Czern. & Coss.], is one of the most major oilseed crops produced in India and across the world. It is the third-most major oilseed crop in the world, and the second-most significant in India, after soyabean (*Glycine max*) and palm oil (*Elaeis guineensis* Jacq.). The mustard crop is susceptible to a range of fungi and microbe caused diseases. Diseases are the main issue causing unpredictable yields in rapeseed-mustard. Among these, fungus-based diseases severely damage the crop like powdery mildew (*Erysiphe cruciferarum*), Alternaria blight (*Alternaria alternata, A. brassicae* (Berk.) Sacc), downy mildew (*Hyaloperonospora parasitica*), club root (*Plasmodiophora*) (Kolte, 2005; Mehta *et al.,* 2005), white rust (*Albugo candida* (Pers.) Kuntze. One of these key diseases that considerably lower plant production is powdery mildew of Indian mustard, which is brought on by *Erysiphe cruciferarum*. According to reports, this disease causes yield losses of 17.5 to 45.0 % and oil content reductions of 6.47 % (Dange *et al.,* 2002). Previously a minor issue, this disease has become a serious issue in India's rapeseed-mustard producing regions (Dange *et al.,* 2003; Saharan *et al.,* 2005). In addition to leaves, powdery mildew also damages growing green siliqua, mature plants, and plants with smaller pods (Enright and Cipollini, 2007). Clean white circular patches with white, floury surface mycelia, conidiophores, conidia, and pinhead-sized dark brown cleistothecia are the primary signs of this disease. The luxuriant growth and development of powdery mildew pathogens need both dry conditions and the high water content of their big, turgid conidia (Braun, 2012).

One of the most important factors in achieving economic plant production is preventing crop losses brought on by diseases. Synthetic pesticides are often used nowadays to quickly and effectively manage fungal and other plant diseases. For the chemical control of fungal diseases, systemic and non-systemic fungicides are necessary. These substances have significant environmental effects, are dangerous to animals, and enhance the likelihood that bacteria may develop resistance (Isman, 2000; Roy and Dureja, 1998).

There is a hereditary component to a plant's resistance to disease; however, this resistance is also influenced by the physiological and biochemical processes that are tied to the plant's nutritional state. A plant's histological or morphological structures, as well as the potential of its tissues to either speed up or slow down pathogenesis, are all determined by the plant's nutritional state. The vast majorities of nutrients have an adverse impact on disease susceptibility and have the potential to greatly reduce the severity of the vast majority of diseases (Huber and Haneklaus, 2007). Copper (Cu) is a nutrient for plants that is also often used topically as a fungicide. In order for copper to be effective as a fungicide, it must be applied directly to the surface of the plant as well as the fungus that is causing the infection. A lack of copper in the diet leads to a reduction in the generation of disease-fighting chemicals, a buildup of carbohydrates that are easily soluble in water, and lignification, all of which contribute to a lowered resistance to disease. Boron is used widely in the manufacturing of chemicals that are relevant to defense. Borate-binding molecules induce the production of various plant defense chemicals at the site of infection (Schumann *et al.,* 2010). Mineral nutrition has a multitude of effects on plant health, including both directly and indirectly. Directly, it can change the root exudates, rhizosphere pH, and microbial activity that give plants their greatest strength or resistance. Indirectly, it can activate enzymes that produce defense metabolites such as lignin and phytoalexins (Elmer and Lawrence, 2014).

The use of dangerous chemicals like fungicides, bactericides, and insecticides for either direct or indirect disease management now accounts for a major portion of disease control. Because of the influence these compounds have on human and animal health as well as the environment, it is imperative that we begin an early search for alternative and more effective methods of disease management. Since the use of toxic chemicals in agriculture has the potential to drop significantly, SAR has emerged as an alternative, non-traditional, non-biocidal, and ecologically friendly strategy for plant protection and, as a result, for sustainable agriculture. This is because SAR does not use radiation. Once a plant detects an invading pathogen, it will begin to propagate resistance across its various cells and tissues via a process known as SAR. Signals for the synthesis of structural proteins to fortify cell walls, the development of digestive enzymes that will destroy the fungal cell walls, and the production of defensive toxins are a few examples (Prell and Day, 2000).

Alternative environmentally friendly methods are required to manage the powdery mildew of Indian mustard due to environmental pollution, the related health risks, and the evolution of fungicidal resistant pathogen strains. The use of micronutrients and SAR against mustard powdery mildew in *Rabi* (2020–2021) under field circumstances at Jobner (Jaipur) was studied to see if fungicides may be replaced by alternative environmentally acceptable solutions.

Materials and Methods

The field experiments were carried out in *Rabi* season 2020-21 at SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan. Jobner is located 200 m above mean sea level at latitude 26° 5' N, longitude 75° 20' E and categorized under the Agro Climatic Zone IIIA (Semi-Arid Eastern Plain).

Foliar application of micronutrients

Three replications of the experiment using the susceptible Indian mustard cultivar Varuna were set up in randomized complete block design during *Rabi* 2020-21. Six micronutrients in the required amount were twice sprayed at 45 and 75 days after sowing (DAS). With a 0.5% concentration of commercial product, zinc was obtained from zinc sulphate, boron from borax, copper from copper sulphate, manganese from manganese sulphate, iron from ferrous sulphate, and magnesium from magnesium sulphate. By analyzing 20 leaves from 10 randomly chosen plants per plot after 15 days after the second spray, the percentage of disease severity was calculated. The yield was determined when the crop was harvested at maturity. According to the 0–5 disease rating scale, the % disease severity was recorded and computed as follows (McKinney, 1923):

$$\text{Per cent disease intensity} = \frac{\text{Sum of individual ratings}}{\text{Total no. of observations} \times \text{Maximum disease rating}} \times 100$$

Disease rating scale for powdery mildew disease of mustard is as follow:

Grade/ numerical scale	Description of the symptoms
0	0 %- No infection
1	1-10%- leaf area covered with pathogen
2	11-25%- leaf area covered with pathogen
3	26-50% - leaf area covered with pathogen
4	51-75% - leaf area covered with pathogen
5	76-100% - leaf area covered with pathogen

Foliar application of SAR activators

Six systemic acquired resistance (SAR) activators were sprayed twice, at 45 and 75 DAS, at the necessary amount. The SAR activators used were salicylic acid (200 ppm), isonicotinic acid (150 ppm), ethylene (100 ppm), fosetyl Al (1000 ppm), β-amino butyric acid (150 ppm) and gamma-amino butyric acid (150 ppm).

Statistical analysis

The experiments were designed using a randomized complete block design with three replications, and after angular transformation, the data were subjected to a one-way analysis of variance (ANOVA). Fisher-LSD test was used to compare means with a 0.05 level of significance.

Results and Discussion

All of the mineral nutrients were shown to be noticeably better in lowering disease severity and raising production. The experimental results show that two foliar sprays of $CuSo_4$ (0.5%) at 45 and 75 DAS led to the greatest decrease (46.5%) in disease severity and greatest yield gain (33.0%) compared to the untreated control, which was followed by borax (37.6 and 21.7%, respectively) (Table 1). Boron, zinc, manganese, iron and magnesium were found statistically at par to each other. Our findings are consistent with those of Sobti and Mathur (1992), who found that reducing the incidence of powdery mildew on roses by treating them with zinc, copper, manganese, magnesium, and molybdenum, as well as gibberellic acid. Fouly (2004) found that spraying strawberry plants with micronutrients (Fe, Mn, and Zn) resulted in improved fruit output and a considerable reduction in the severity of powdery mildew disease, which was caused by *Sphaerotheca macularis*. This discovery followed a specific pattern. According to Kumar *et al.* (2015) the *Alternaria brassicae* fungus, which is responsible for the Alternaria blight of Indian mustard, was successfully combated by employing a foliar spray of $CaSO_4$ (23.58%), which resulted in a minimal disease severity on leaf over check. The overwhelming majority of nutrients have an effect on a person's susceptibility to disease, and prudent nutrition management has the potential to significantly reduce the severity of the vast majority of diseases. Copper (Cu), which is a nutrient for plants, is often used as a fungicide. Cu is an efficient fungicide; however, it must come into close touch with both the surface of the plant and the fungus that is causing the infection. A lack of copper in the diet results in a reduction in the synthesis of disease-fighting compounds, an increase in the amount of soluble carbohydrates, and an impairment in lignifications; all of these factors contribute to a plant's diminished susceptibility to disease (Huber and Haneklaus, 2007). Mineral nutrition has a multitude of effects on plant health, including both directly and indirectly. Directly, it can change the root exudates, rhizosphere pH, and microbial activity that give plants their greatest strength or resistance. Indirectly, it can activate enzymes that produce defense metabolites such as lignin and phytoalexins (Elmer and Lawrence, 2014).

Table 1: Effect of micronutrients on powdery mildew disease of mustard under natural field conditions

Micronutrients	Concentration (%)	Percent disease intensity	Reduction in PDI over control	Yield (q/ha)	Increase in yield over control (%)
Zinc	0.5	38.7 (38.46)	27.7	10.2	20.3
Boron	0.5	37.6 (37.83)	29.7	10.3	21.7
Copper	0.5	28.6 (32.32)	46.5	11.2	33.0
Manganese	0.5	40.2 (39.38)	24.7	9.8	16.2
Iron	0.5	43.6 (41.32)	18.5	9.4	11.0
Magnesium	0.5	42.6 (40.74)	20.4	9.6	13.4
Control	-	53.5 (47.02)	-	8.4	-
SEm±		1.67		0.29	
CD (p=0.05)		5.21		0.90	

Figure in parenthesis are angular transformed values as: Degrees (Asin (SQRT (% value/100); PDI = per cent disease intensity.

Prior disease appearance, two foliar application of systemic acquired resistance inducers at 45 and 75 DAS were proved efficacious in imparting disease resistance against powdery mildew in susceptible variety of Indian mustard (Table 2). The most efficient SAR activators in terms of lowering disease severity (54.5%) and improving yield (43.4%) over check were two sprays of salicylic acid (200 ppm), which was followed by isonicotinic acid (40.5%) and 31.9%. According to statistics, ethylene, isonicotinic acid, fosetyl al, beta-amino butyric acid (BABA), GABA and BABA were all on par with one another. Plant pathogen resistance is connected to the accumulation of proteins, enzymes, inhibitors, and antibiotics in the plant. The administration of salicylic acid from the outside to plants has the potential to boost their resilience. Even though it is only found in trace amounts in some plants naturally, it is now known to play a crucial role in the process of signal transduction and to contribute to the development of both localized and systemic resistance to a wide variety of plant diseases. Our findings are consistent with Delaney *et al.* (1995) and Maleck *et al.* (2000). Other studies (Fouly, 2004; Zeighaminejad *et al.,* 2016; Hamza *et al.,* 2017) found that spraying strawberry plants with salicylic acid alone was more efficient in eradicating the disease known as strawberry powdery mildew. According to Zeighaminejad *et al.* (2016), BABA, an amino acid that is not found in proteins, increased the defensive response of squash, which in turn increased squash's resistance to microbial diseases such as powdery mildew disease. Hamza *et al.* (2017) investigated the effectiveness of various resistance inducers against cucumber powdery mildew (*Sphaerotheca fuliginea*). These resistance inducers included potassium dihydrogen phosphate, potassium monohydrogen phosphate, oxalic acid, salicylic acid, sodium salicylate, ferrous sulphate, and magnesium sulphate. The second-best therapies for powdery mildew were salicylic acid, potassium dihydrogen phosphate, magnesium sulphate, ferrous sulphate, oxalic acid, and potassium monohydrogen phosphate. Flusilazole was the most effective therapy overall.

Table 2: Effect of SAR activators on powdery mildew disease of mustard under natural field conditions

SAR activators	Concentration (ppm)	Percent disease intensity	Reduction in PDI over control	Yield (q/ha)	Increase in yield over control (%)
Salicylic acid	200	24.3 (29.57)	54.5	11.98	43.4
Isonicotinic acid	150	31.8 (34.38)	40.5	11.02	31.9
Ethylene	100	39.3 (38.92)	26.5	10.22	22.3
Fosetyl Al	1000	32.1 (34.53)	40.0	10.9	31.3
?-amino butyric acid	150	34.4 (35.91)	35.8	10.8	29.9
Gamma-amino butyric acid	150	38.4 (38.29)	28.3	10.3	23.6
Control	-	53.6 (47.08)	-	8.35	-
SEm±		1.54		0.31	
CD (p=0.05)		4.74		0.95	

Figure in parenthesis are angular transformed values as: Degrees (Asin (SQRT (% value/100); PDI = per cent disease intensity.

Conclusion

Copper is toxic to fungus, and plants need Cu as a mineral nutrient. Application of two foliar sprays of copper sulphate (0.5 %) at intervals of 45 and 75 DAS was found the most successful strategy for improving yield while simultaneously lowering the severity of disease. Among the systemic acquired resistance activators, use of two foliar sprays of salicylic acid (200 ppm) at 45 and 75 DAS was found the most efficient in reducing disease severity and increasing yield. That sounds like a great opportunity! Discoveries that support organic farming not only align with consumer health concerns but also open up potential revenue streams for farmers. Organic food is increasingly popular due to its perceived health benefits and environmental sustainability. Farmers who adopt organic practices could potentially access premium markets where consumers are willing to pay more for organic products. Moreover, these practices often contribute to soil health and biodiversity conservation, which can have long-term benefits for agricultural productivity. It's definitely a promising direction for farmers looking to diversify and cater to conscientious consumers

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