International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(4): 343-345
www.biochemjournal.com
Received: 09-01-2024
Accepted: 19-02-2024

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Disease control strategies for Knol-Khol: Bio-agents, botanicals, and chemical fungicides

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DOI: https://doi.org/10.33545/26174693.2024.v8.i4e.954

Abstract
Knol-Khol (*Brassica oleracea* var. *gongylodes* L.) is a Brassicaceae family cold-season crop planted mostly for its tasty knob. It is widely farmed in Jammu and Kashmir, West Bengal, Maharashtra, Assam, Uttar Pradesh, Punjab, Odisha, and areas of South India under the names Khol rabi, Navakol, and Ganthgobhi (Mishra *et al*., 2012). The study sought to elucidate crucial characteristics of Knol-Khol's downy mildew and its management through the use of chemicals, bio-control agents, and botanical treatments. The most effective treatment involved two foliar sprays of Metalaxyl + Mancozeb (0.25%), followed by Azoxystrobin (0.1%) with a disease intensity of 18.32% and a yield of 202.23 q/ha, compared to the control's 54.29% disease intensity and 140.73 q/ha yield. *Trichoderma viride* (@ 0.6%) had the lowest disease intensity (32.38%) and yield of 174.20 q/ha when compared to the control. Metalaxyl + Mancozeb > Azoxystrobin > Mancozeb > Propiconazole > Copper oxychloride > *Trichoderma viride* > *Trichoderma harzianum* > *Pseudomonas fluorescence* > Neem > control was the order of efficacy and yield.

Keywords: Bio-control agents, botanical treatments, chemicals, management and Knol-Khol

Introduction
Knol-Khol, also known as Brassica oleracea var. gongylodes, is a winter crop native to countries along the Mediterranean coast. It is closely related to cabbage and is a member of the Brassicaceae family. In India, the most prevalent growing regions for knol-khol are Kashmir, West Bengal, and Karnataka. It has recently gained popularity in the majority of Indian states (Choudhary, 2015) [3]. Among cole crops, it is a rather short-duration and resilient crop. The edible element of Knol-khol is the knob, which arises from stem tissue expanding above the cotyledons. The fleshy, turnip-like growth of the stem rises entirely above the ground. Acidosis, asthma, cancer, high cholesterol, heart problems, indigestion, muscle and nerve disorders, prostate and colon cancer, skin troubles, and weight loss have all been treated with the fruit. Metalaxyl and Mancozeb, fungicides, help to prevent disease and promote good growth in the production of Knol-khol crops. Azoxystrobin functions as a fungicide to prevent infections and increase production. Bio-control agents such as *Trichoderma viride* and *Trichoderma harzianum* are utilised to effectively lower disease intensity and enhance overall disease management in Knol-khol crops. The beneficial bacterium Pseudomonas fluorescence improves vegetable development and aids in disease reduction. Neem, a natural pesticide, keeps pests at bay while also promoting healthy Knol-khol plants. The current study sought to explore the impacts of bio-agents, botanicals, and chemical fungicides on the downy mildew management strategy in Knol-khol, Jammu, taking into account the crop's importance, disease prevalence, pathogen aggressiveness, and degree of damage.

Materials and Methods
During the 2020-21 season, a field experiment was conducted at the ACRA Dhiansar Research Farm, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, to evaluate the efficacy of various fungicides, botanicals, and bio-agents for disease management. Five distinct chemicals, three bio-agents, and plant treatments were used to control sickness. The field was prepared according to agronomic guidelines and laid out in a Randomised Block Design (RBD) with dimensions of 2m x 0.90cm.

Ten different treatments were used, each of which was reproduced three times. The plant-to-plant and row-to-row spacings were kept at 20 and 30 cm, respectively. The 'large green' Knol-Khol cultivar was planted. All treatments were supplied as foliar sprays after disease start, with following doses given every 15 days using a hand sprayer. Only sterile water was used in the control plots. Trichoderma viride (0.6%), *Trichoderma harzianum* (0.6%), Pseudomonas fluorescens (0.6%), Copper oxychloride (0.3%), Metalaxyl + Mancozeb (0.25%), Mancozeb (0.25%), Neem oil (0.4%), Azoxystrobin (0.1%), Propiconazole (0.1%), and Control were the therapies used to manage Knol-khol.

Results and Discussion

Data on the treatment of downy mildew in Knol-khol using fungicides, bio-control agents, and botanicals reveal that all treatments significantly reduce disease. Five fungicides, Metalaxyl + Mancozeb, Mancozeb, Copper oxychloride, Propiconazole, and Azoxystrobin, as well as three bio-control agents (Trichoderma harzianum, Trichoderma viride, and Pseudomonas fluorescens) and one botanical (Neem), were utilised as curative foliar sprays. Two sprays were supplied 15 days after the problem began. Table 1 shows the results of measuring the severity of the condition in response to various therapy. When compared to the control, two foliar sprays of Metalaxyl + Mancozeb (0.25%) resulted in a minimum disease intensity of 16.29% and a disease reduction of 69.99%. In comparison to the control, which had a disease intensity of 54.29%, Azoxystrobin (0.1%) was at 18.32%, Mancozeb (0.25%) was at 21.70%, Propiconazole (0.1%) was at 24.06%, and Copper oxychloride (0.3%) was at 29.75%. When compared to the control, Trichoderma viride (0.6%) had the lowest disease intensity at 32.38%, followed by *Trichoderma harzianum* (0.6%) at 36.10%, and Pseudomonas fluorescens (0.6%) had the highest at 37.54%. Neem oil, when administered as a foliar spray, reduced disease intensity by 43.25% when compared to the control. Overall, the following treatments have been demonstrated to be beneficial in the fight against the disease: Azoxystrobin > Mancozeb > Propiconazole > Copper oxychloride > Trichoderma viride > *Trichoderma harzianum* > Pseudomonas fluorescens > botanical Neem control. Downy mildews can be efficiently managed with one to two treatments of fungicides, bio-control agents, and botanicals, according to research by Anahosur and Patil (1983) [1] and Singh and Shetty (1990) [10].

When it comes to the management of downy mildew in Knol-khol through the use of fungicides, bio-control agents, and botanicals, all treatments significantly enhance yield in comparison to the control. The yield was measured for each treatment, and the results are shown in Table 2. The application of two foliar sprays of Metalaxyl + Mancozeb (0.25%) resulted in the highest yield of 205.80 q/ha and a 46.24% yield improvement over the control. Copper oxychloride (0.3%) yielded the most, at 176.46 q/ha, compared to the control's 140.73 q/ha. Azoxystrobin (0.1%) was followed by Mancozeb (0.25%) at 192.36 q/ha and Propiconazole (0.1%) at 189.56 q/ha.*Pseudomonas fluorescens* (0.6%) generated the lowest yield of 166.06 q/ha, while *Trichoderma viride* (0.6%) gave the highest yield of 174.20 q/ha. *Trichoderma harzianum* (0.6%) came in second, with 168.26 q/ha. A foliar spray application of neem oil produced a yield of 157.13 q/ha when compared to the control. Overall, the following treatments were ranked in terms of illness effectiveness and yield: Metalaxyl + Mancozeb > Azoxystrobin > Mancozeb > Propiconazole > Copper oxychloride > Trichoderma viride > *Trichoderma harzianum* > *Pseudomonas fluorescens* > botanical Neem) are used to control the infection. The findings of our current study are congruent with the findings, who investigated different fungicides and reported that Ridomil MZ was the most effective at reducing downy mildew disease and boosting crop yield. Additional research by Jensen *et al.* (1998) [4], Verma *et al*. (1994) [11], Paulus and Nelson (1977) [7], Kolte (1985) [5], and Saharan (1992) [8] supports these conclusions. Furthermore, when studying downy mildew of cabbage, Saxena and Tewari (2017) [9], Ark and Thompson (1959) [2] discovered that the use of botanicals and bio-control agents significantly boosted crop yield while decreasing disease prevalence.

Future of Scope

The efficacy of integrated disease management strategies combining fungicides, bio-agents, and botanicals in suppressing downy mildew and increasing yield in Knol-khol cultivation, as demonstrated in the ACRA Dhiansar field trial, offers a potential future for sustainable disease management practices. The encouraging results highlight the significance of ongoing research and development in optimizing such integrated techniques. Further research into novel fungicides, bio-agents, and botanicals, as well as innovations in application procedures, are likely to improve their effectiveness. The findings also emphasize the need for larger-scale practical application in agricultural operations, underlining the possibility for farmers to embrace integrated crop health and production measures. Overall, the study sets the way for ongoing attempts to refine and adopt integrated management approaches, which will help to ensure the long-term viability and resistance of Knol-khol cultivation against downy mildew.

Table 1: Evaluation of Bio-agents, botanical and chemical fungicides against downy mildew of Knol-khol

Treatments	No. of sprays	Dose (%)	Disease Intensity (%)	Disease reduction over control (%)
Trichoderma viride	2	0.6%	32.38	40.36
Trichoderma harzianum	2	0.6%	36.10	33.51
Pseudomonas fluorescens	2	0.6%	37.54	30.8
Copper oxychloride	2	0.3%	29.75	45.19
Metalaxyl+ Mancozeb	2	0.25%	16.29	69.99
Mancozeb	2	0.25%	21.70	60.02
Neem oil	2	0.4%	43.25	20.32
Azoxystrobin	2	0.1%	18.32	66.25
Propiconazole	2	0.1%	24.06	55.68
Control			54.29	0.00
C.D. $p<0.05$) = 2.121				
SE(m) = 0.708				

Table 2: Effect of different treatments on the yield parameter for the management of downy mildew disease of Knol-khol

Treatments	Yield (q/ha)	Percent increase in yield over control (%)
Trichoderma viride	174.2	23.78
Trichoderma harzianum	168.26	19.56
Pseudomonas fluorescens	166.06	18.00
Copper oxychloride	176.46	25.39
Metalaxyl + Mancozeb	205.8	46.24
Mancozeb	192.36	36.69
Neem oil	157.13	11.65
Azoxystrobin	202.23	43.70
Propiconazole	189.56	34.70
Control	140.73	0.00
C.D. (5%)	1.28	
SE(m)	0.20	

Conclusion

In conclusion, the field experiment at ACRA Dhiansar examined the efficacy of different fungicides, bio-agents, and botanicals for managing downy mildew in Knol-khol during the 2020-21 season. Ten different treatments were applied as foliar sprays every 15 days after the disease start, comprising five fungicides, three bio-agents, and one botanical. The results showed considerable reductions in illness intensity, with Metalaxyl + Mancozeb demonstrating the greatest efficacy (69.99% reduction). Furthermore, when compared to the control, all treatments significantly enhanced yield, with Metalaxyl + Mancozeb resulting in the largest yield enhancement (46.24%). These findings are consistent with earlier research, emphasizing the potential of integrated management strategies incorporating fungicides, bio-agents, and botanicals for successful downy mildew control and crop yield enhancement in Knol-khol farming.

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