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Evaluation of difenconazole 25% EC against paddy sheath blight

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Abstract
Plant diseases are among the major biotic constraints limiting crop productivity and contributing to the global food crisis. In rice cultivation, diseases pose a serious threat, causing both qualitative and quantitative yield losses. Among fungal diseases, sheath blight—caused by *Rhizoctonia solani*—is recognized as the second most destructive disease of rice after blast. A field experiment was conducted at the Agricultural Research Station, Gangavati, to evaluate the efficacy of Difenoconazole 25% EC against sheath blight of rice. The trial included six treatments, replicated four times in a Randomized Block Design (RBD). The performance of Difenoconazole 25% EC was compared with standard checks and an untreated control. Results revealed that Difenoconazole 25% EC was highly effective in reducing sheath blight severity. Application of Difenoconazole 25% EC at 250-500 ml/ha significantly decreased disease incidence and enhanced grain yield. The treatment with 500 ml/ha recorded the lowest Percent Disease Index (PDI) of 8.56 and 10.12, with corresponding grain yields of 67.3 q/ha and 66.0 q/ha during Kharif 2012 and 2013, respectively. The study clearly indicates that Difenoconazole 25% EC at 250-500 ml/ha is effective for managing sheath blight in rice and can be recommended for sustainable disease control.

Keywords: Difenoconazole 25% EC, fungicide, sheath blight, rice, Percent Disease Index (PDI)

Introduction

Globally, more than three billion people depend on rice as their staple food, contributing 50-80% of their daily caloric intake. In India, rice is cultivated under diverse agro-ecological conditions. Worldwide, rice occupies about 166 million hectares, producing approximately 750 million tonnes with an average productivity of 4.5 t/ha. India ranks first in rice area (43 million ha) and second in production (170 million tonnes), with a productivity of 3.9 t/ha (Pathak *et al*., 2020) [61]. According to Anonymous (2022) [3], rice in India covers 46.38 Mha, with a production of 130.29 Mt and productivity of 2809 kg/ha.

Plant diseases are among the major biotic constraints affecting global crop productivity, often leading to food insecurity (Khoa *et al*., 2017) [43]. In rice, nearly 50 different biotic agents including fungi, bacteria, viruses, nematodes, and insects can cause substantial yield losses. Among these, fungal pathogens pose the greatest threat to sustainable rice production (Webster and Gunnell, 1992) [75].

Of the fungal diseases affecting rice, sheath blight, caused by *Rhizoctonia solani*, is regarded as the second most important rice disease worldwide after blast (Pan *et al*., 1999; Groth, 2005; Zhou and Jo, 2014) [60, 29, 79]. It is a major constraint in rice-growing regions and leads to significant economic losses (Ou, 1985; Savary *et al*., 2000; Savary *et al*., 2006) [59, 65, 64]. Yield losses due to sheath blight range from 20-50%, depending on the severity of infection (Groth and Bond, 2007; Margani and Widadi, 2018) [34, 53], and 5-10% in subtropical lowland rice cultivars of Asia (Savary *et al*., 2006) [64].

The pathogen *R. solani* can infect rice plants at any growth stage (Dath, 1990) [20], with disease severity increasing as the crop matures (Singh *et al*., 2004) [70]. The incidence is particularly high in early-maturing, semi-dwarf, highly tillering, and compact cultivars (Bhunkal *et al*., 2015) [9]. It has been reported that a 1% increase in sheath blight severity results in a 0.38% (Roy, 1993) [63] to 0.74% (Savary *et al*., 2006) [64] reduction in grain yield. Yield losses may reach 59-69% (Naidu, 1992; Singh *et al*., 2016) [55, 69], depending on crop stage, disease intensity, and environmental factors (Singh *et al*., 2004; Zheng *et al*., 2013; Bhunkal *et al*., 2015) [70, 78, 9].

In India alone, potential yield losses due to sheath blight range from 50-54.3% (Rajan, 1987; Roy, 1993; Chahal *et al*., 2003; Seebold, 2004) [62, 63, 14, 66]. The disease is especially prevalent in intensive rice cultivation systems where excessive use of nitrogenous fertilizers favors pathogen development the absence of effective host plant resistance against the sheath blight pathogen in rice, chemical control remains the primary management strategy (Naik *et al*., 2017) [56]. Although several integrated management approaches have been proposed (Yellareddygari *et al*., 2014; Datta and Vurukonda, 2017) [77, 22], chemical control continues to be the most widely adopted and effective method for mitigating sheath blight incidence. Judicious use of fungicides provides a cost-effective, practical, and reliable means of disease suppression (Bhuvaneshwari and Raju, 2012) [10].

Fungicide-based management of sheath blight has proven successful in most field trials (Kandhari *et al*., 2003; Groth and Bond, 2006; Kumar *et al*., 2013; Kumar and Veerabhadraswamy, 2014) [38, 40, 32, 46, 45]. Among available methods, foliar spray and seed treatment are the most common modes of fungicide application against *R. solani* (Singh *et al*., 2019) [68]. Both systemic and non-systemic fungicides are used, but systemic fungicides are generally more effective due to their translocation ability within plant tissues (Naik *et al*., 2017) [56].

Periodic field monitoring and timely fungicide application at the initial stages of infection, particularly around the booting stage, are critical for effective disease management in susceptible rice varieties (Singh *et al*., 2016; Uppala and Zhou, 2018) [69, 74]. Numerous fungicides such as carbendazim, chloroneb, captafol, mancozeb, zineb, edifenphos, iprobenphos, thiophanate, and carboxin have shown significant efficacy in controlling sheath blight under field conditions (Dash and Panda, 1984; Kannaiyan and Prasad, 1984; Singh and Sinha, 2004) [17, 41, 67]. Among these, carbendazim, edifenphos, and iprobenphos are reported as the most effective chemicals (Roy, 1993) [63].

Given the economic importance and widespread prevalence of sheath blight, identifying highly effective and low-dose fungicidal options is essential for sustainable disease control. Fungicides remain a preferred choice among farmers because of their availability, ease of use, broad-spectrum activity, and consistent performance (Chou *et al*., 2020) [15]. Consequently, chemical control continues to be one of the most successful strategies for reducing yield losses caused by rice diseases, including sheath blight and blast (Kumar *et al*., 2021) [47].

To ensure long-term effectiveness, systematic evaluation of commercially available fungicides is necessary to develop practical recommendations based on both efficacy and cost (Ganesha Naik *et al*., 2017) [27]. Therefore, the present study was undertaken to evaluate and screen the fungicide Difenconazole 25% EC at different concentrations against sheath blight (*Rhizoctonia solani*) in paddy under field conditions.

Materials and Methods

The field experiment was conducted during the *Kharif* seasons of 2012 and 2013 at the Agricultural Research Station, Gangavati, to evaluate the efficacy of Difenconazole 25% EC against sheath blight (*Rhizoctonia solani*) of rice. The trial was laid out in a Randomized Block Design (RBD) with six treatments and four replications. The popular rice variety BPT-5204 was used, maintaining a spacing of 20 cm × 10 cm in a 5 × 5 m² plot. Standard agronomic practices recommended by the University of Agricultural Sciences, Raichur were followed throughout the crop growth period.

The fungicide treatments were evaluated along with standard checks and an untreated control to assess their effectiveness in managing sheath blight incidence and severity. The treatment details were as follows:

- **T_1:** Difenconazole 25% EC @ 250 ml/ha
- **T_2:** Difenconazole 25% EC @ 500 ml/ha
- **T_3:** Difenconazole 25% EC @ 1000 ml/ha
- **T_4:** Score @ 250 ml/ha
- **T_5:** Hexaconazole 5% SC @ 500 ml/ha
- **T_6:** Untreated control

The fungicides were applied as foliar sprays in the respective plots 45 days after transplanting (DAT), coinciding with the initial appearance of sheath blight symptoms. Two subsequent sprays were applied at 15-day intervals, the first at 60 DAT and the second at 75 DAT. Regular field inspections were carried out to monitor disease progression and evaluate treatment effectiveness.

Observations were recorded on disease severity in each treatment after three sprays as per the standard method. The incidence of disease were recorded on leaves as Per cent Disease Index (PDI) on the basis of scoring of the diseases as per the degree of severity was graded based on height of the plant portions affected by the disease and expressed as percentage of the total area as per the SES scale of rice (IRRI, 2013). In the present study, observations for disease incidence were recorded from the randomly selected twenty clumps / hills per plot for recording the disease severity in each replicated plots of the treatments. The observations were recorded on intensity of diseases were observed in each replicated plot for each treatment on 10th day after each spray. After 10 days of last spray, the final scoring of the disease incidence was recorded. Further, the scored data were converted into Per cent Disease Index (PDI) of plants using formula given by Wheeler (1969)

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of numerical rating}}{\text{Total no. of plants observed} \times \text{Maximum rating scale}} \times 100$$

In order to record the yield, crop was harvested plot-wise from the individual replicated plots and average paddy yield was recorded and converted into q/ha.

The original PDI values were suitably transformed into arcsine transformed values and subjected to statistical analysis for drawing conclusions

Results and Discussion

It has been found that Difenconazole 25% EC @ 250-500 ml/ha reduced the sheath blight infection more than rest of the treatments and improved the rice yield. The fungicide Difenconazole 25% EC was found to be effective in reducing the severity of the sheath blight disease. The treatment Difenconazole 25% EC @ 500 ml/ha recorded least sheath blight disease incidence of 8.56 per cent PDI and was significantly superior over control treatment (44.64%). The same treatment was statistically and significantly on par with Difenconazole 25% EC @ 250 ml/ha and Difenconazole 25% EC @ 750 ml/ha treatments with PDI of 8.85 and 9.36 per cent, respectively. All other treatments were inferior to these treatments though significantly superior to the untreated check (44.64%). Among other treatments Hexaconazole 5% EC @ 500ml/ha was found least effective with higher sheath blight (18.33%) (Table-1). Results of the second season showed similar trends with the treatment Difenconazole 25% EC @ 500 ml/ha recorded least PDI of sheath blight disease incidence (10.12%) and was significantly superior over control treatment (48.56%). The same treatment was statistically and significantly on par with Difenconazole 25% EC @ 250 ml /ha and Difenconazole 25% EC @ 750ml/ha treatments with PDI of 10.43 and 10.50 per cent, respectively. All other treatments were inferior to these treatments though significantly superior to the untreated check (48.56%). Among the treatments evaluated, Hexaconazole 5% EC @ 500 ml/ha was found to be the least effective, recording a higher sheath blight incidence of 21.00% (Table 2). Similar observations have been reported by several researchers, including Dubey and Toppo (1997) [25], Tiohuat (1997) [72], Akter *et al*. (2001) [1], Ali and Archer (2003) [2], Nath *et al*. (2005) [57], Bag (2009) [4], Lenka and Bhaktavatsalam (2011) [52], Neha *et al*. (2017) [58], Laxmikant *et al*. (2017) [50], Swamy *et al*. (2009) [71], Bhuvaneswari and Raju (2012) [10], Goswami *et al*. (2012) [28], Kumar *et al*. (2014) [45], Hegde (2015) [35], and Kumar *et al*. (2018) [48]. The promising effects of Hexaconazole 5% SC and Propiconazole 25% EC were also corroborated by Nagaraju *et al*. (2017) [54].

Although both systemic and non-systemic fungicides are used in the chemical management of sheath blight, systemic fungicides generally provide more effective and sustained control of the disease (Naik *et al*., 2017) [56]. Timely application, particularly at the booting stage, is critical for effective disease suppression (Singh *et al*., 2016; Uppala and Zhou, 2018) [69, 74]. Chemical fungicides such as Flutolanil, Carbendazim, Iprobenfos, Mancozeb, Thifluzamide, and Validamycin have been found to offer effective control against sheath blight under different agro-climatic conditions.

However, the continuous and indiscriminate use of a single fungicide with a similar mode of action over time can lead to the development of fungicide resistance in the pathogen population (Uppala and Zhou, 2018) [74]. The present findings align with earlier research, reinforcing that timely and judicious application of potent fungicides remains the most reliable approach for managing sheath blight disease. Effective fungicide use is essential to prevent disease spread and sustain productivity, given the wide availability of commercial fungicides for rice disease management worldwide.

Yield: A significant difference in yield levels was observed between the treated and untreated plots, corresponding to the varying degrees of reduction in sheath blight incidence. The maximum grain yield of 67.3 q/ha was recorded with Difenconazole 25% EC @ 500 ml/ha, followed by the same fungicide applied at 250 ml/ha (66.5 q/ha) and 750 ml/ha (66.0 q/ha). These treatments were statistically superior and more effective than the remaining fungicidal treatments. The lowest grain yield (44.6 q/ha) was recorded in the untreated control (Table 1).

Similarly, during the second cropping season, the highest grain yield (66.0 q/ha) was again obtained with Difenconazole 25% EC @ 500 ml/ha, followed by **250** ml/ha (65.8 q/ha) and 750 ml/ha (65.5 q/ha), while the untreated control recorded the lowest yield (41.4 q/ha) (Table 2). Across both seasons, fungicide treatments not only reduced sheath blight severity but also minimized yield losses effectively.

These findings are in agreement with previous studies demonstrating the efficacy of azoxystrobin (Groth, 2005) [29], and azoxystrobin + flutolanil (Groth and Bond, 2007) [34] in reducing sheath blight and minimizing yield reduction. Fungicidal application has been widely reported to enhance crop yield by reducing disease load (Biswas and Bag, 2010; Bag, 2011) [12, 5]. The current results are also consistent with those of Bhuvaneshwari and Raju (2012) [10] and Bag *et al*. (2016) [6], who reported that fungicide application improves rice yield primarily through reduced sheath blight severity.

Fungicides limit pathogen establishment on rice sheaths and inhibit sclerotia formation through multiple mechanisms, such as damaging fungal cell membranes, inhibiting degrading enzymes (Kumar *et al*., 2018) [48], disrupting energy production (Lal *et al*., 2017) [49], and interfering with sterol and chitin biosynthesis pathways (Singh *et al*., 2019) [68]. Upmanyu *et al*. (2002) [73] also observed that carbendazim effectively reduced sheath blight severity, leading to enhanced grain yield. Similarly, Nagaraju *et al*. (2017) [54] reported that Carbendazim 50% WP and Validamycin 3% L performed on par, both recording higher yields under field conditions.

Further studies by Uppala and Zhou (2018) [74], Behera *et al*. (2022) [7], and Kabdwal *et al*. (2023) [37] confirmed the effectiveness of fungicides such as Azoxystrobin (alone or in combination with Propiconazole), Trifloxystrobin + Propiconazole, Pyraclostrobin, and Flutolanil against sheath blight of rice, all contributing to increased grain yield. Overall, chemical control remains the most practical and effective management approach, being applicable across different regions and varieties. It not only reduces disease incidence and spread but also significantly enhances crop productivity.

Table 1: Effect of Diffenconazole 25% EC on sheath blight of rice during *Kharif* - 2012

Sl. No.	Treatment	Dose Formulation (ml/ha)	Sheath blight (PDI)			Yield (Q/ha)
			Initial score	10 days after I spray	10 days after II spray	
1	Difenoconazole 25% EC	250	4.71 (12.53)	6.44 (14.58)	8.85 (17.31)	66.5
2	Difenoconazole 25% EC	500	4.33 (12.01)	5.44 (13.44)	8.56 (17.01)	67.3
3	Difenoconazole 25% EC	1000	4.56 (12.33)	6.89 (15.11)	12.87 (21.02)	57.9
4	Difenoconazole 25% EC	750	4.67 (12.47)	5.89 (13.97)	9.36 (17.55)	66.0
5	Hexaconazole 5% SC	500	5.05 (12.98)	14.66 (22.51)	18.33 (25.35)	54.9
6	Untreated check	-	5.23 (13.24)	30.33 (33.42)	44.64 (41.92)	44.6
	CD at 5% level	-	NS	2.48	2.74	1.24

* Figures in the parentheses represent arcsine transformed values

Table 2: Effect of Diffenconazole 25% EC on sheath blight of rice during *Kharif* - 2013

Sl. No.	Treatment	Dose Formulation (ml/ha)	Sheath blight (PDI)			Yield (Q/ha)
			Initial score	10 days after I spray	10 days after II spray	
1	Difenoconazole 25% EC	250	5.00 (12.92)	7.34 (15.74)	10.43 (18.86)	65.8
2	Difenoconazole 25% EC	500	5.37 (13.40)	7.03 (15.39)	10.12 (18.57)	66.0
3	Difenoconazole 25% EC	1000	5.74 (13.86)	8.98 (17.46)	14.43 (22.32)	56.7
4	Difenoconazole 25% EC	750	5.19 (13.16)	7.69 (16.12)	10.50 (18.93)	65.5
5	Hexaconazole 5% SC	500	5.37 (13.40)	16.53 (24.01)	21.00 (27.29)	54.0
6	Untreated check	-	5.56 (13.63)	35.63 (36.67)	48.56 (44.19)	41.4
	CD at 5% level	-	NS	3.09	3.35	1.58

* Figures in the parentheses represent arcsine transformed values

Conclusion

The fungicide Difenconazole 25% EC at different doses were evaluated during *Kharif* 2012 and 2013 at Krishi Vigyan Kendra / Agriculture Research Station, Gangavati was found effective in reducing the severity of Rice sheath blight and thereby increased the grain yield. Results clearly indicated that Difenconazole 25% EC @ 250 and 500 ml/ha dose can effectively control sheath blight of Rice. This dose was at par with higher dose and resulted better yield than other treatments. Hence the use of Difenconazole 25% EC @ 250-500 ml/ha is suggested for the control of sheath blight disease in Rice crop.

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