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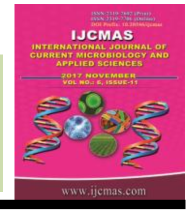

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Effect of New Generation Chemicals in Changing Host Physiological Traits to Manage Sheath Blight Disease Caused by *Rhizoctonia solani* Kuhn in Rice

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A B S T R A C T

With the changing climate, disease scenario has been rapidly changing in a given environment. Some of the minor pest and diseases are playing greater role in rice ecosystem. Sheath blight Sheath blight, under high rainfall areas, is becoming fatal to the rice production. As there is no true resistance yet been identified for this disease, farmers are still dependent on chemical management. This study includes *In-vivo* analysis of seven new generation chemicals to test their efficacy in altering the host physiological traits in order to manage sheath blight, the devastative disease of rice caused by *Rhizoctonia solani*. Chemical treatment was given twice at 15 days interval. The significant change in the physiological traits in terms of increase in chlorophyll content (AUSDC-817) and reduction in canopy temperature (AUCTPC-575) was observed in treatment plot Azoxystrobin 23% SC with highest projected yield (6.9t/ha), Benefit Cost ratio and maximum disease reduction (69.27%) followed by the Tebuconazole 50% + Trifloxystrobin 25%WG with 6.67t/ha projected yield, 1:0.88 BCR and 68% disease reduction.

Introduction

To achieve food security for the ever increasing world population the immediate action to be taken is to restrict the pre and post-harvest crop losses. Estimates of global crop losses in rice due to weeds, animal pests, and diseases are 10.2%, 15.1%, and 12.2% of the attainable yield, respectively. A wide range of rice diseases affect rice (Ou,1985) among which blast, sheath blight, bacterial blight, brown spot, and several virus diseases, including rice tungro, are of primary concern. An estimation of losses due to sheath blight disease alone in India has been up to 54.3% (Rajan, 1987; Roy, 1993). The pathogen has a wide host range and can infect all plants belonging to more than 32 plant families and 188 genera (Gangopadyay and Chakrabarti 1982). The available existing literature indicates the disease to be of significant importance and under the changing climatic scenario its seriousness can prove fatal to rice production. It also signifies the need to study the factors both which influences and explains sheath blight resistance and causes of still dependence on chemicals and to find out the best management practices with the available resources to reduce the losses. As we know chemicals are harmful for both the environment and human health, it should be kept in mind that research on chemicals which will work at lower doses, leave low chemical foot print in terms of residue and induce resistance in plant system should be encouraged. By keeping all these, this study concentrated on the screening of new generation chemicals *In vivo*, and studies on their effect in manipulating host physiology to manage disease, to find out the effective chemical control measure against Sheath Blight.

Materials and Methods

Pathogen isolation

The test pathogen viz., *Rhizoctonia solani* causing sheath blight in rice isolated from infected rice sheath and leaf by inoculating on Modified Ko and Hora medium (Ko and Hora 1971, Castro *et al.*, 1988).

The inoculated Petri plates were incubated at 27 ± 1^0C. The single hyphal tip culture was done to get the pure culture of the pathogen. *Rhizoctonia* pure culture was maintained on PDA (Riker and Riker, 1936) at 4^0C for further use.

Mass culturing and field inoculation

Fresh rice leaves were chopped into 0.5cm - 1cm pieces and washed twice in sterile distilled water in which antibiotic (Chloramphenicol) was added. The washed leaves were kept in polythene bags and sterilized in autoclave at 121^0 C, 15 lb psi for 15 minutes. 10mm agar disks from actively growing 3 days old fresh *Rhizoctonia* culture were inoculated in the polybags containing sterilized rice leaf bits. Inoculation was done at 45 days after transplanting. The cultured sclerotia were used for field inoculation. Both the sclerotia and infected leaf bits were inserted in the joint between third leaf sheath and main stem. Two panicles were inoculated in each hill.

In vivo evaluation of chemicals

The field experiments were carried out at the Instructional farm, Uttar Banga Krishi Viswa vidyalaya, Pundibari, Cooch Behar, West Bengal, India during the kharif season of 2015.Rice cultivar Swarna mashuri (MTU 7029) which is susceptible for sheath blight disease was used and seeds were collected from University Research Farm, UBKV. Seed was treated with Tricyclazole 75%WP @ 3g/2Kg seeds in 3 lit. of water and sown during 1^{st} fortnight of June. 25 days old seedlings were used for transplanting. Two sprays were given at 15 days interval from the initial appearance of the disease in the field. The control plots were sprayed with same volume of water only. Ten hills were selected randomly from the central zone of the each plot of the treatment to avoid border effect. The severity of sheath blight disease was assessed based on the relative lesion height as mentioned in standard evaluation system (SES) for rice and subsequently its corresponding rating value on 0-9 scale given by Anonymous (1996), Percent Disease Index was calculated by using the formula given by the Wheeler (1969) and Area Under Disease Progress Curve was calculated by using Shaner and Finnay (1977) formula as given below:

$$AUDPC = \sum_{i=1}^{n} [(X_{i+1} + X_{i)} / 2][t_{i+1} - t_i]$$

Where,

X_i = the proportion of the host tissue damaged at i^{th} day

t_i = the time in days after appearance of the disease at i^{th} day

n = the total number of observations

The records of physiological parameters like chlorophyll content leaves and canopy temperature were taken with help of Konica Minolta SPAD meter and Infra-red thermometer respectively, at 7 days interval right from the maximum tillering. Area under Canopy Temperature Progress Curve (AUCTPC) was calculated by using the formula given by the Rosyara (2009).

$$AUCTPC = \sum_{i=1}^{n} [(X_i + X_i + 1)/2] (t_i + 1 - t_i)]$$

Where,

x_i is the Canopy Temperature Depression on i^{th} date

t_i is the i^{th} day and n is the number of scoring days.

Area Under Spad Decline Curve (AUSDC) was calculated by using the formula given by the Rosyara *et al.*, (2007).

$$AUSDC = \sum_{i=1}^{n} [(X_i + X_i + 1)/2] (t_i + 1 - t_i)]$$

Where,

xi is the SPAD value on i^{th} date
t_i is the i^{th} day and n is the number of scoring days

The grain yield of each plot was recorded after harvesting on net plot basis.

Yield loss assessment

When 90-95% grains were riped, panicles were harvested and sun dried for one week. After threshing, grain weight was recorded for each plot and compared with the control plot to assess the yield loss.

Statistical analysis

Data was analyzed using statistical package SAS and Indo-stat software. The comparisons were done at 0.05 probability level. Bivariate analysis was done to identify the contribution of physiological traits towards sheath blight disease development, resistance or susceptibility and yield in Rice by taking sheath blight disease score and yield as dependent variable.

Results and Discussion

All the fungicidal treatments were found to give significantly lower disease severity than control. This is evident from the final observation that lowest diseases severity was obtained in case of Azoxystrobin 23% SC with a PDI of 15.93% which is followed by Tebuconazole 50%+ Trifloxystrobin 25% WG and Difenconazole 25% EC with disease severity of 16.67 and 24.44%, respectively. The maximum disease reduction was found in Azoxystrobin 23% SC (69.27%) as compared to check with a projected yield of 6.91 t/ha which is significantly different from control. Among the other treatments good results were obtained by (Tebuconazole 50%+ Trifloxystrobin 25% WG) and Difenconazole 25% EC with 67.84 and 52.86% disease reduction, respectively with projected yield of 6.67 and 6.30 t/ha. Even the benefit cost ratio also follows the same trend i.e., highest for Azoxysrobin (1:0.89) though the fungicide is high cost as it is giving better results this can be recommended for the future purpose. The findings of Kumar *et al.*, (2011) is corroborated with the outcome of the present study they also found Azoxystrobin as the most effective fungicide against Sheath blight (Table 1).

Among the treatments, no significant difference was found in terms of AUCTPC and AUCTDC values. But significant differences have been found in case of AUSDC and AUDPC values. The lowest AUDPC value (191.20) was found in case of (Tebuconazole 50% + Trifloxystrobin 25% WG) followed by Azoxystrobin 23% SC with AUDPC value of 202.22 which are significantly different from other treatments (Table 2).

Higher yield was obtained in case of Azoxystrobin 23% SC which is significantly higher than control and the yield obtained by Tebuconazole 50% + Trifloxystrobin 25% WG was found statistically at par with Azoxystrobin 23% SC. The fungicidal treatments are not having significant direct effect on the physiological traits but it is believed that they may have indirect effect on plant physiology by reducing the deterioration of chlorophyll by pathogen so that plant canopy can be kept at cooler temperature. But the fungicides showed significant effect on disease severity as well as yield of Rice.

Bivariate analysis of physiological traits and AUDPC of treatment plots

In the bivariate analysis, a positive correlation was found between AUDPC and AUCTPC this may be because *Rhizoctonia* is temperature loving pathogen. Whereas, the two other physiological traits, AUCTDC and AUSDC were found to be negatively correlated with AUDPC. As we know higher the chlorophyll content, cooler the micro climate of the canopy which ultimately limits the disease.

Table.1 Variation in the Percent Disease Index and B: C Ratio for different treatments

Treatments	PDI					Disease reduction %	Plot Yield (Kg)	Projected yield (t/ha)	Benefit Cost Ratio (BCR)
	1st	2nd	3rd	4th	5th				
Azoxystrobin 23% SC	6.66 (2.67)*	8.88 (3.05)	9.62 (3.17)	14.07 (21.97)	15.93 (23.48)	69.27	4.15	6.91	1:0.89
Difenconazole 25% EC	8.14 (2.93)	11.11 (3.40)	14.81 (3.91)	18.51 (25.45)	24.44 (29.38)	52.86	3.78	6.30	1:0.76
Validamycin 3% L	8.14 (2.93)	11.11 (3.40)	13.33 (3.71)	22.96 (28.62)	25.19 (30.11)	51.41	3.70	6.16	1:0.77
Propiconazole 25% EC	12.59 (3.61)	13.33 (3.71)	17.77 (4.26)	23.70 (28.82)	28.89 (32.48)	44.28	3.55	5.91	1:0.70
Tebuconazole 50%+ Trifloxystrobin 25% WG	7.96 (2.90)	6.66 (2.65)	8.88 (3.05)	15.55 (23.19)	16.67 (24.06)	67.84	4.00	6.67	1:0.88
Tebuconazole 25% EC	8.14 (2.93)	11.85 (3.50)	13.33 (3.71)	23.70 (29.11)	34.07 (35.70)	34.29	3.59	5.98	1:0.71
Hexaconazole 5%SC	7.40 (2.80)	9.62 (3.17)	13.33 (3.69)	16.29 (23.65)	26.67 (31.05)	48.56	3.78	6.31	1:0.82
Control	11.11 (3.40)	16.29 (4.09)	20.00 (4.52)	27.40 (31.50)	51.85 (46.08)	-	3.42	5.70	1:0.67
CV %	6.453	9.993	8.638	11.769	12.341	-	8.520	-	
CD	0.342	0.590	0.568	5.4709	6.818	-	0.559	-	
SEm±	0.1128	0.1946	0.1873	1.8037	2.2477	-	0.1844	-	

Data within the parentheses are angular and Arc Sin transformed values

Table.2 Relation various traits and yield for treatment plots

Treatment	**AUCTPC**	**AUCTDC**	**AUSDC**	**AUDPC**	**Yield**
(Azoxystrobin 23% SC)	574.82^A	205.80^A	816.62^A	202.22^D	4.15^A
(Difenconazole 25% EC)	586.37^A	186.32^A	778.26^ABC	274.82^C	3.78^ABC
(Validamycin 3% L)	601.37^A	179.25^A	770.44^ABC	279.99^BC	3.70^ABC
(Propiconazole 25% EC)	587.30^A	177.45^A	746.78^CD	344.81^AB	3.55^BC
(Tebuconazole 50%+Trifloxystrobin25%WG)	576.22^A	204.40^A	799.63^AB	191.20^D	4.00^AB
(Tebuconazole 25% EC)	596.05^A	184.57^A	760.43^BC	287.78^BC	3.59^BC
(Hexaconazole 5%SC)	588.70^A	191.92^A	778.14^ABC	243.70^CD	3.79^ABC
Control	613.20^A	167.42^A	705.49^D	388.89^A	3.42^C
α=0.050 t=2.14479	**NS**	**NS**	**S**	**S**	**S**
$CD_{(0.05)}$	43.56	49.68	40.58	0.55	0.56

NS - Non Significant; S - Significant

Table.3 Relation between area under disease progress curve and yield

Treatment	AUDPC	Yield	% Reduction in AUDPC	% Increase in yield
T1	892.22	4.15	48.00^AB	21.44^A
T2	1510.00	3.78	29.33^CD	10.53^B
T3	1603.33	3.70	28.00^CD	8.19^B
T4	1673.70	3.55	19.90^D	12.48^AB
T5	932.31	4.01	50.83^A	17.15^AB
T6	1616.67	3.59	26.00^CD	7.60^B
T7	1231.85	3.79	37.33^BC	10.72^AB
Control	2211.85	3.42	0.00	0.00

Fungicides used for field evaluation

S. No	**Fungicide**	**Concentrations**	**Dose**
F_1.	Azoxystrobin 23%SC (Amistar)	10, 20,40,80 and160 ppm	1ml/L
F_2.	Difenconazole 25% (Score)	10, 20,40,80 and160 ppm	1ml/L
F_3.	Validamycin 3% (Sheathmar)	10, 20,40,80 and160 ppm	2ml/L
F_4.	Propiconazole 25% (Tilt)	10, 20,40,80 and160 ppm	1ml/L
F_5.	Tebuconazole25% EC (Folicure)	10, 20,40,80 and160 ppm	1ml/L
F_6.	Tebuconazole 50%+Trifloxystrobin 25% WG (Nativo)	0.5, 1.0,2.0,4.0 and8 ppm	0.5g/L
F_7.	Hexaconazole 5%SC (Contaf)	0.5,1.0,2.0,4.0 and 8 ppm	2ml/L

Relation between physiological traits, AUDPC with yield

A positive correlation has been found in between the yield and AUCTDC, AUSDC. Simultaneously a negative correlation found in between AUCTPC, AUDPC and yield. Here, in first case, if the plant maintains chlorophyll for some period it's temperature depression will be more so that disease effect will be minimized to get higher yield. In the second case, higher canopy temperature favours the disease which results into the yield loss.

Yield loss assessment by using AUDPC model

A positive quantitative correlation was found in between percent reduction in AUDPC and percent increase in yield of rice. This implies that reduced disease severity results in increased yield of rice vice-versa. As shown in Table 3 the maximum % reduction in disease was observed in T1 (Azoxystrobin 23% SC) where the maximum % increase in yield also observed.

Simultaneously the maximum yield reduction was observed in control where maximum disease also observed. This increase in yield is the result of retention of high chlorophyll till the harvest and balancing the canopy temperature with environment temperature to stop the disease outbreak. Triazoles can be used as a promising chemical control tool for rice sheath blight management as the treatment T1 (Azoxystrobin23%SC) has given the maximum BC ratio (1:0.89) with highest % disease reduction (48) and highest projected yield (6.91) with lowest AUCTPC (574.82) and highest AUSDC (202.22).

This clearly indicates that the chemicals will help in reduction of the inoculum load, also help the plant to maintain high chlorophyll content and optimum canopy temperature which will not favour the spread of fungus. Though fungicides leave a chemical foot print, new fungicides with novel action help in managing the diseases without hampering the ecological balance. These chemicals does not act directly on pathogen, they choose indirect ways either through plant or may be pathogen metabolism to protect plant from diseases.

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Author contributions

All authors equally contributed

Abbreviations

AUDPC - Area Under Disease Progress Curve

AUSDC - Area Under Spad Decline Curve

AUCTDC - Area Under Canopy Temperature Decline Curve

AUCTPC - Area Under Canopy Temperature Progress Curve

BCR - Benefit Cost Ratio

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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