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Management of Brown Spot of Rice (*Oryza sativa* L.) Through Different Approaches

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ABSTRACT

Brown spot of rice is a chronic disease that affects millions of hectares of rice every growing season, grown by some of the most resource-poor farmers caused by *Cochliobolus miyabeanus* (*Bipolaris oryzae, Drechslera oyyzae*, *Helminthosporium oryzae*). Brown spot of rice is considered one of the major yield attributing factor in West Bengal causing considerable losses to the crop. It causes yield losses that, on average, are in the range of 10 % of the attainable yield wherever it occurs. The severity of brown spot of rice varied with the location, variety and season. A terminal disease severity of brown spot of rice ranging from 14.65 % to 34.14% was obtained from different locations in *Kharif* rice. While, the natural severity level of the same disease was a little bit lower in *Boro* rice and it was observed in the range from 19.35 % to 30.6%. Maximum incidence 34.14 % was recorded from Purulia district of .W.B. in variety Lakshmi (CNM-6) during *Kharif* season. While, it was maximum in Burdwan district (28.4 to 30.6%) during *Boro* season. A range from 5.04% to 15.37% increased in yield was observed with different fungicides. The severity of disease was found to decrease with the early transplanting of rice. While, it was increased considerably with the late transplanted crop .Maximum severity disease (37.35 % PDI) was recorded from the field transplanted 30 days later than the scheduled time followed by 32.85% from 45 days. Maximum yield (4921 kg/ha) was obtained from the field transplanted on 25.07.2019 (schedule time of transplanting) followed by (4785 kg/ha) from 15 days early transplanted rice (10.07.2013). Among the phyto-extracts, minimum severity of brown spot disease (15.3% PDI) and maximum yield 49.23 qt/ha were noticed in the field treated with leaf extract of *Derris indica* (karanj) followed by *Lantana camera* (19.3 % PDI and yield 48.75 qt/ha). Among the different chemicals tested, Azoxystrobin 23 SC (Amistar 25 SC), the newly emerged fungicide was found to be very effective at both of the concentration (0.1 % and 0.125%) and reduced the brown spot disease up to the level of 8.5 % and 5.8 % (79.58 % and 86.07% reduction) respectively. The present investigation was highlighted the actual level of severity of brown spot of rice (*Kharif* and *Rabi*) and provide a complete package for controlling the brown spot of rice with the help of newer chemical molecules, botanicals and by changing the time of transplanting.

Key words : Brown spot, *Oryza sativa* , Disease severity , Phytoextracts, fungicides.

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Introduction

Rice (*Oryza sativa* L.) has been regarded as one of the most important cereal crops and a major food grain contributor to the total world food grain basket and feeds more than a third of the world's population (Khush, 1997; Burgos *et al.*, 2013).Agriculture in West Bengal is the means of livelihood of about 65% of the population of the state living in villages with over 95% as small and marginal farmers. The percentage share of rice (total) alone in West Bengal in the case of area and production was 91 and 93 respectively. Out of different biotic stresses which influence the performance of rice crop, brown spot of rice caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker; Synonym -*Helminthosporium oryzae* (Breda de Haanyashi) Drechsler; Telomorph (*Cochliobolus miyabeanus* (Ito & Kuribaex Dastur) is the disease that impairs grain quality and results in about 67% yield reduction (Kohls *et al.*, 1987; Jones *et al.*, 1993). Rice brown spot was responsible for the "Bengal Famine" in India in 1942 and 1943 (Padmanabhan, 1973). It is one of the most important seedborne diseases of rice (Ou, 1985). This disease is associated with low soil fertility and often referred as 'poor man's disease' (Lee,1992).The disease especially occurs in environments where water supply is scarce and it is often combined with imbalances in plant mineral nutrition, especially the lack of nitrogen. These factors are commonly associated with resource poor farmers' fields (Ou, 1985; Zadoks, 1974). Brown spot is becoming more frequent and severe as drought is becoming more frequent (Savary *et al.*, 2005). The pathogen of brown spot disease produces multiseptate conidia generally curved, boat or club-shaped, with 6 to 14 transverse septa or cross walls (Ou, 1985). Optimal temperatures for conidial germination (25–30^0 C) and hyphal growth (27–30^{0}C) (Nisikado, 1923). Changes to the architecture of a crop, due to increasing CO_2, may lead to increased humidity within the canopy and more favourable condition for pathogen survival (Chakraborty & Datta, 2003; Pangga *et al.*, 2011; Biswas *et al.*,2018). Increased photosynthetic rate under elevated CO_2 levels (Fuhrer, 2003) could lead to the availability of new growth flushes earlier in the season for pathogens to colonize and the subsequent increase in plant biomass will result in a larger reservoir for pathogens to colonize and multiply in. Host plant resistance to disease is an effective and economical way to manage brown spot. Despite its importance little work has been done in this field and researchers suggest that work is still required on the topic. There is also need to explore the linkages, among identified QTLs for drought tolerance and brown spot resistance. Few reports are available for the improvement of brown spot control involving biological control agents. At present, there are very limited strategies for the control of brown spot and cultivars with an adequate level of resistance are not available in India (Srinivasachary *et al.*, 2011).The existing information is inadequate particularly in eastern India. Application of fungicides for the control of brown spot is the most effective management option, but under high disease pressure effective control is not achieved (Lore *et al.*, 2007). Considering the potentiality of the disease in lateritic belt of West Bengal and its

annual recurrent, an investigation was carried out to explore the possibilities of managing brown spot disease through alternation of date of sowing and also with different chemicals and botanicals for controlling the brown spot disease under field condition.

2. MATERIALS AND METHODS

Field experiments were conducted at farmer's field of village Binuria, District Birbhum, West Bengal, during *kharif* season of 2019 and 2020 on rice (*Oryzae sativa*). The experimental areas are under the sub- humid and sub- tropical climatic conditions. The texture of the soil was sandy loam, with high percentage of sand and low percentage of clay. Wet nursery bed was prepared for raising seedlings. After the land preparation, the soil was enriched with recommended doses of N: P: K in a ratio of 75:35:35 kg/ha. The age of seedlings at transplanting was 15 to 20 days. The most widely accepted local variety of rice Swarna (MTU-7029) was selected for the study. The experimental field was divided into eight sub-plots. Data were collected from different locations of the field. The percentage severity index of the disease was measured at every seven days interval till the full maturity of crops.

2.1. Identification and characterization of the disease and pathogen :

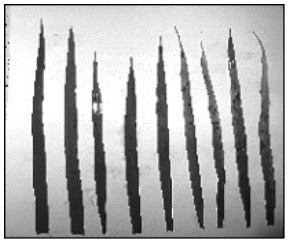
Diseased leaves were collected and associated pathogen was isolated by standard tissue culture technique (Rangaswami and Bagyaraj, 1998). Identification of the pathogen was carried out according to the cultural, morphological and microscopic characteristics described by Mew and Gonzals (2002).

2.2. Pathogenicity test :

Pathogenicity test was carried out in plastic cups. In each of these two cups (Treatment and control) 5 seeds of susceptible variety (Basmati-370) were placed containing sterilized soil. The spore suspension of the *B. oryzae* / *H. oryzae* (1 × 10^5 spores/ml) was sprayed on the seedlings at two leaves stage, and evaluation of the symptoms so developed was carried out after 7 days of inoculation (Kania *et al.*, 2023).

2.3. Assessment of Percent Disease Index (PDI) :

The percent disease index was assessed on rice crop by recording the number of leaves showing brown spot disease symptoms such as elliptical brown spot, proportion of plant parts showing symptoms. In each plot 20 hills were selected randomly and from each hill three leaves were taken at random from the basal middle and top portion of plants and severity of the disease was recorded on the basis of 0 to 9 (Aluko, 1970). Disease scoring was done at 7 days interval. Percent disease index (percent infection) was recorded on the basis of 0 to 9 scale using the following formula



Disease severity scale of brown spot (0-9)

$$\textbf{Percent Disease Index} = \frac{\text{Sum of all numerical ratings}}{\text{Maximum rating x Total number of observations}} \times 100$$

2.4. *In vivo* Evaluation of Fungicides :

Different popular fungicides along with Azoxystrobin 23 SC (Amistar 25 SC),a newly emerged fungicide was evaluated against brown spot of rice diseases during *kharif* season. The fungicides i.e. Azoxystrobin 23 SC (Amistar 25 SC) @ 0.075, 0.1 and 0.2%, Kitazine 48% EC @ 2% and Hexaconazole 5% EC @ 2% were applied with the help of Knapsack sprayer . The first spraying was done during the appearance of first disease symptoms in field. Two sequential sprays were done at an interval of 15 days from the first spraying. The severity of the disease was recorded every 10 days after each spraying and terminal score was calculated. The disease was scored using a 0-9 scale.

2.5. *In vivo* Evaluation of botanicals / phyto-extracts :

Phytoextracts of leaves of *Azadirachta indica* (neem), *Eucalyptus* spp. (eucalyptus), *Datura* sp. (datura), *Caesalpinia bonduc* (karanja) ,leaves and twigs of *Lantana camara* (wild fire) and *Tagetes* sp. (marigold) were prepared by grinding of solution (100% concentration). Phyto-extracts were mixed in water @ 2 %. Freshly prepared extracts were used in each treatment. The paddy variety Khitish (IET-4094) was used for the study. No seed treatment was done during the experiments. Two sequential sprays were given at an interval of 15 days from the first spraying. Foliar application of the botanical /fungicides was carried out.

2.6. Effect of date of transplanting on the severity of brown spot disease of rice :

To study the effect of date of transplanting on the severity of brown spot disease in field, the common rice variety IR-36 was selected for the study .The dates of transplanting were fixed on the basis on schedule time of transplanting date i.e. 3rd to 4th week of July, generally being followed by the farmers in lateritic belt of West Bengal. Accordingly, different dates were fixed with 15 days intervals from the scheduled date of sowing viz. 15 days early, 30 days early, 15 days late ,30 days late and 45 day late. To record the initial infection of brown spot disease in field, all plants were examined properly after transplanting. Percentage severity index of brown spot disease was recorded after the appearance of first disease symptoms. Similarly, data on time interval between date of transplanting and the appearance of first disease symptoms and interval between 1st and final date of observation were recorded. The apparent infection rate of spread of the disease was calculated according to the following formula (Vander Plank, 1963).

$$R = \frac{2.3}{t_2 - t_1} \left\{ \text{Log} \left(\frac{X_2}{1-X_2} \right) - \text{Log} \left(\frac{X_1}{1-X_1} \right) \right\}$$

Where, r = Apparent infection rate at exponential growth stage

t_1 = First day of observation

t_2 = Last date of observation

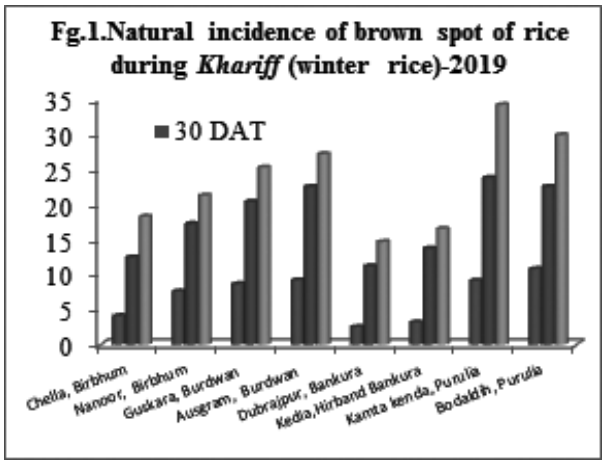
X1 = Production of the disease on first day of observation

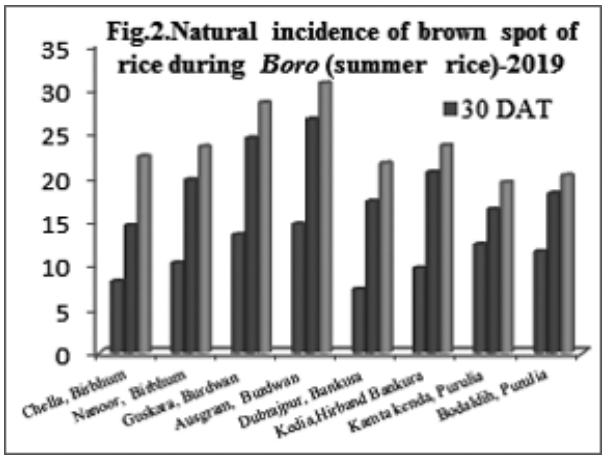
X_2 = Production of the disease on last day of observation

Results and Discussion :

The severity of brown spot of rice varied with the location, variety and season. A terminal disease severity of brown spot of rice ranging from 14.65 % to 34.14% was

obtained from different locations in *Kharif* rice. While, the natural severity level of the same disease was a little bit lower in *Boro* rice and it was observed in the range from 19.35 % to 30.6% . Maximum incidence 34.14 % was recorded from the farmer's field of Kamta Kenda Purulia.W.B. in variety Lakshmi (CNM-6) followed by 29.85 % from Bodaldih, Purulia, W.B. farmer's field in variety Lalat (IET-9947) and 27.13 % from Ausgram, Burdwan farmer's field in variety Lalat (IET-9947). Minimum severity of brown spot (14.65%) was recorded from the farmer's field of Dubrajpur, Bankura,W.B in variety Swarna mukhi (NLR-145) during *Kharif* season. The severity of brown spot of rice was found to be higher in Purilia and Burdwan districts in comparison to Bankura and Birbhum districts of West Bengal during *Kharif* season. While, in *Boro* season the severity of disease was found to be maximum in Burdwan district (28.4 to 30.6%) in comparison to other three districts (Fig.1 &2). The severity level of the disease, which was highest in Purulia district during *Kharif* season, found minimum during *Boro* season (19.35 to 20.15%). Higher incidence of brown spot in Purulia districts during *kharif* season in comparison to Burdwan, Bakura and Bhirbhum districts was probably due to the little higher atmospheric temperature and the congenial microclimate inside the rice field which help the pathogen *Bipolaris oryzae / Helminthosporium oryzae* for faster multiplication and growth in field. The slower rate of growth of PDI after 50 DAT during *boro* season was also owing to the fact that the maximum temperature level of the Undulating red and lateritic belt of West Bengal has always exceeded the optimum level of temperature of pathogen (*Bipolaris oryzae / Helminthosporium oryzae*).





Ref : Jantasorn *et al.* (2023)

Effect of date of transplanting on the severity of brown spot disease of rice :

The severity of brown spot of was found to be influenced greatly by changing the date of transplanting (Table 1). The severity of disease was found to decrease with the early transplanting of rice. While, it was increased considerably in late transplanted rice than schedule time of transplanted rice i.e. 3rd to 4th week of July (here it is considered as 25.07.2019), generally being

followed by the farmers in lateritic belt of West Bengal. Maximum severity disease (37.35 % PDI) was recorded from the field transplanted 30 days later than the scheduled time followed by 32.85% from 45 days. The disease was increased initially in late transplanted crop and reached the maximum level of 37.35 % at 30 days of transplanting but, thereafter it was decreased again and gave 32.85% at 45 days late transplanted crop. Fifteen days early transplanted rice did not differ significantly from the normal transplanted rice in terms severity (PDI) and yield, however, all other dates of transplanting showed significant differences from actual time of transplanting in terms of different parameter tested.

Table 1 : Effect of different dates of sowing on the severity of brown spot of rice in Variety IR 36 during *Kharif* Season (winter rice) - 2019-2020

Sl No.	Date of Transplanting	Time taken for developing 1st disease symptoms in field	Interval between initial to final incidence (Days)	Initial PDI (%)	Final PDI (%)	Apparent infection rate (r)	Yield kg / ha
1.	25.06.2013	27 days	45	3.13	12.2	0.051	4355
2.	10.07.2013	24 days	45	2.16	14.6	0.068	4785
3.	25.07.2013	16 days	45	5.00	17.36	0.086	4921
4.	09.08.2013	15 days	45	7.11	24.35	0.091	4575
5.	24.08.2013	12 days	45	9.78	37.35	0.108	3920
6.	08.09.2013	09 days	45	12.44	32.85	0.072	3721
S EM (+)				1.0169	.00084	64.88	
CD at 5%				3.2035	.00267	204.38	

Maximum yield (4921 kg/ha) was obtained from the field transplanted on 25.07.2019 (schedule time of transplanting) followed by (4785 kg/ha) from 15 days early transplanted rice (10.07.2019). It was revealed from the table -1 that, the yield of rice was not increased in early transplanted rice irrespective of the fact that it had lower rates of disease severity. Low severity of brown spot disease in early transplanted rice was probably due the presence of minimum level of primary inoculum in the field which took much time for colonization and multiplication to get proper load of inoculums of pathogen for rapid progress of the disease in the field. Moreover, the weeds and other collateral hosts serves as source of inoculums were minimum in field during initial period. The finding were corroborated with the observations made by Jha *et.al.*(2003).

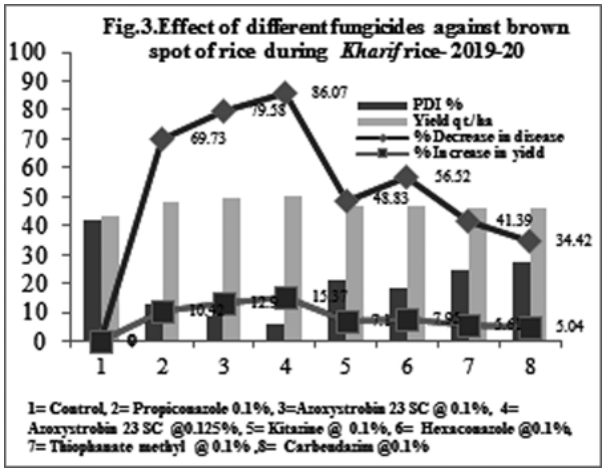
Evaluation of fungicides against brown spot of rice *In vivo* :

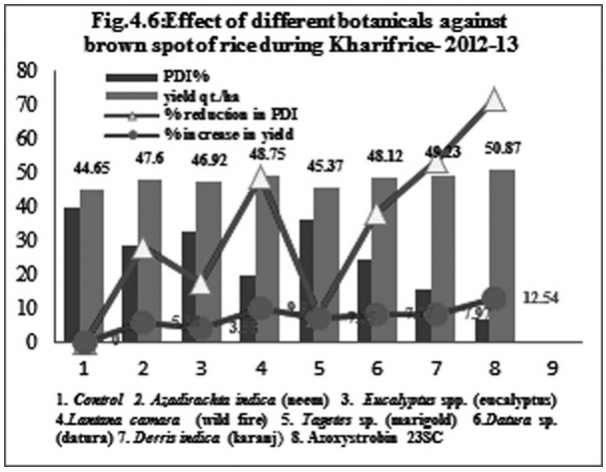
Seven fungicides viz. Propiconazole, Kitazine, Hexaconazole, Thiophanate methyl and Carbendazim all are @ 0.1%, Azoxystrobin 23 SC (Amistar 25 SC) @ 0.1 and 0.125% were evaluated during *Kharif* season of 2013 on variety Khitish (IET-4094). The observations taken on different parameters are presented in Table-2.

All the treatments performed well in terms of reducing the disease severity over the untreated control table-2. Among the different chemicals tested, Azoxystrobin 23 SC (Amistar 25 SC), the newly emerged fungicide was found to be very effective at both of the concentration (0.1 % and 0.125%) and reduced the brown spot disease up to the level of 8.5 % and 5.8 % (79.58 % and 86.07% reduction) respectively. This was followed by Propiconazole and Hexaconazole treated field which showed 12.6 % and 18.1% disease severity (PDI) respectively in field. A range from 5.04% to 15.37% increased in yield was observed with different fungicides. However, maximum increase in yield 15.37% was achieved by the application of Azoxystrobin 23 SC (Amistar 25 SC) @ 0.125 %, which differs significantly over control (fig.3).

Table 2 : Effect of different fungicides against brown spot of rice during *Kharif* rice- 2019-20, Variety –Khitish (IET-4094)

Treatment	Product	Dose% conc. (Product)	Trade Name	Terminal Severity index of Brown spot	% disease control (brown spot)	Grain yield (qt/ha)	% increase in yield
1	Untreated check	—	—	41.63	0.00	43.65	0.00
2	Propiconazole	0.1	Tilt 25% EC	12.6	69.73	48.2	10.42
3	Azoxystrobin 23SC	0.1	(Amistar 25 SC)	8.5	79.58	49.28	12.90
4	Azoxystrobin 23 SC	0.125	(Amista 25 SC)	5.8	86.07	50.36	15.37
5	Kitazine 48% EC	0.2	Kitazine	21.3	48.83	46.75	7.10
6	Hexaconazole 5% EC	0.2	Contaf 25 EC	18.1	56.52	47.12	7.95
7	Thiophanate methyl	0.1	Roko	24.4	41.39	46.10	5.61
8	Carbendazim	0.1	Bavistin 50% WP	27.3	34.42	45.85	5.04
S EM (+)	0.87564		1.1862				
CD at 5%	2.6557		3.5975				





Azoxystrobin (Amistar 25 SC) possesses a novel biochemical mode of action. Its fungicidal activity results from the inhibition of mitochondrial respiration in fungi. This is achieved by the prevention of electron transfer between cytochrome b and cytochrome c. Because of its novel mode of action, azoxystrobin is effective against pathogens which have developed reduced sensitivity to other fungicides (Hewitt, 1998). Azoxystrobin shows a unique spectrum of disease control and is active against Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (*Anand et al.*, 2008*)*. In the present investigation, the high performance of Azoxystrobin (Amistar 25 SC) @0.125% against the brown spot pathogen was due to fact that it has a novel biochemical mode of action and the available race and biotype present in this region have not developed proper resistance against that potent chemical, which of course being a problems for the other chemicals popularly being used by the farmers for longer periods. **Cunha** and **Rizzo (2003) observed c**ross resistance in *Helminthosporium solani* against the fungicides thiophanate-methyl and benomyl. The results obtained with Propiconazole against the disease in field were further confirmed the observation made by Gupta *et.al.* (2013); Jantasorn *et. al.* (2023) under the agro- ecological conditions of Jammu sub-tropics, India.

4.4 Evaluation of botanicals / phyto-extracts against brown spot of rice :

Phyto-extracts of leaves of *Azadirachta indica* (neem), *Eucalyptus* spp. (eucalyptus), *Datura* sp. (datura), *Derris indica* (karanj) leaves and twigs of *Lantana camara* (wild fire) and *Tagetes* sp. (marigold) were applied along with newer fungicide Azoxystrobin 23SC (Amistar 25 SC) in rice field for evaluating their effect on brown spot disease, and the data obtained on various parameters are presented in table-3. All the treatments performed well in terms of reducing the severity of brown spot disease in field and most of the treatments increased the yield of rice significantly over the untreated control. However, application of fungicide Azoxystrobin 23SC (Amistar 25 SC @ 0.1%) was proved its superiority among all the treatments (6.5% PDI) which reduced the severity of brown spot disease considerably up to (83.46%) and increased the yield of rice about 13.93%.

Table 3 : Effect of different botanicals against brown spot of rice *in vivo*.

Treat-ment	Product	Dose % conc.(gai)	Dose% conc. (Product)	Terminal Severity index of Brown spot	% disease control (brown spot)	Grain yield (qt/ha)	% increase in yield
1	Untreated check	—	—	39.3	0.00	44.65	0.00
2	*A .indica* (leaf)	100	2%	28.2	28.24	47.6	6.61
3	*Eucalyptus* spp.(leaf)	100	2%	32.35	17.68	46.92	5.08
4	*L. camara* (leaf)	100	2%	19.3	50.89	48.75	9.18
5	*Tagetes* spp. (leaf)	100	2%	36.16	7.99	45.37	1.61
6	*Datura* spp. (leaf)	100	2%	24.25	38.30	48.12	7.77
7	*Derris indica* (leaf)	100	2%	15.3	61.07	49.23	10.26
8	Azoxystrobin 23SC (Amistar 25 SC)	0.023	0.1%	6.5	83.46	50.87	13.93
S EM (+)				1.518		0.3612	
CD at 5%				4.603		1.095	

Among the phyto-extracts, minimum severity of brown spot disease (15.3% PDI), maximum disease reduction 61.07% and maximum yield 49.23 qt/ha were noticed in the field treated with leaf extract of *Derris indica* (karanj) followed by *Lantana camera* (19.3 % PDI, 50.89 % and yield 48.75 qt/ha which differ significantly from untreated control. (Fig.-4). Extract of karanj oil and leaves contain karanjin, oleic acid, karanjic acid and their three esters , karanj ketone and its oxime derivatives. All these compounds have outstanding antifungal activity (Tirkey, 2006; Parajuli *et al.*, 2022) The karanj based products exhibited excellent antifungal activity against the soil-borne phytophagous fungus like *Sclerotium rolfsii* (Sacc.) (Kesari *et al*,, 2010).Similar type of antifungal activity of *Lantana camara* against other fungi were also reported by (Biswa**s** and Tanmay Ghosh, 2018).

Conclusion

The present investigation was highlighted the actual level of severity of brown spot of rice (*Kharif* and *Rabi*) under

the undulating red and lateritic belt of West Bengal. The investigation also provides a complete package for controlling the brown spot of rice with the help of newer chemical molecules , botanicals and by changing the time of transplanting. By adopting this information, farmers can increase their yield substantially and maximize their profit lavel.

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