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Factors affecting incidence of narrow brown leaf spot of rice caused by *Passalora janseana*

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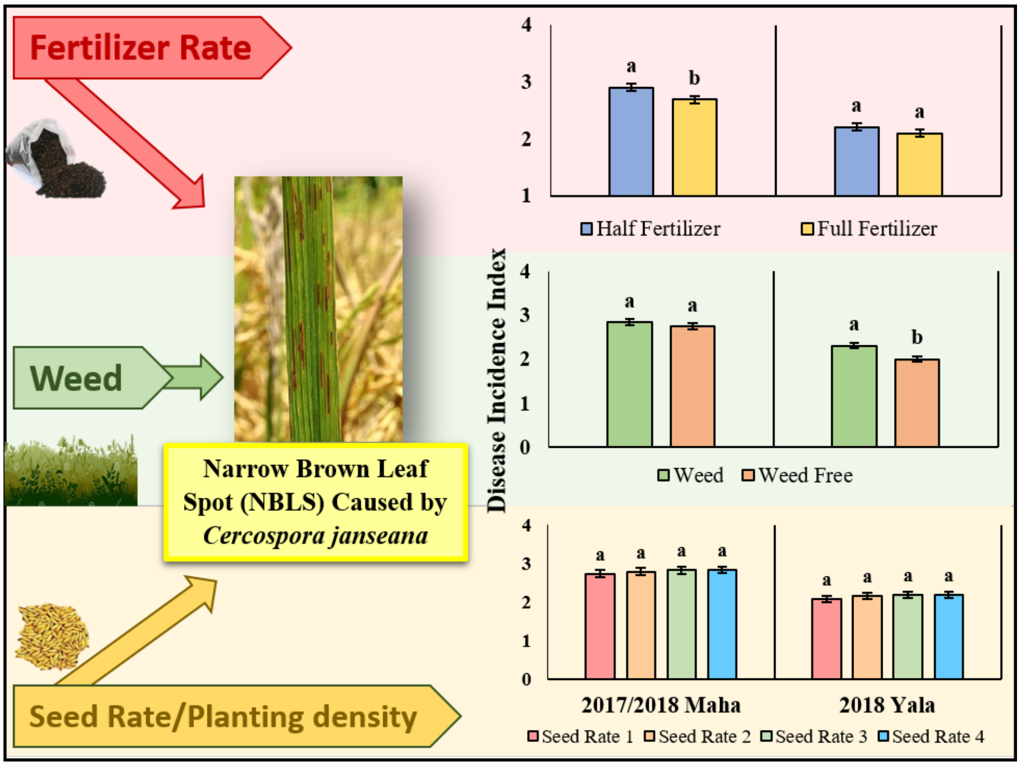

Highlights

- Narrow Brown Leaf Spots were observed in both 2017/2018 *Maha* and 2018 *Yala* seasons.
- Higher disease incidences were observed during 65-75 DAS with half nitrogen rate.
- Weed control led reduction of disease incidence during 50-80 DAS in *Yala* season 2018.
- Planting density (seeding rate) had no significant impact on disease incidence index.

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Factors affecting incidence of narrow brown leaf spot of rice caused by *Passalora janseana*

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Abstract: Fertilizers, weeds, and planting density affect the narrow brown leaf spot (NBLS) disease in rice. This study was conducted to assess the factors contributing to the occurrence of NBLS at different stages of paddy cultivation during the *Maha* and *Yala* seasons. The degree of the disease occurrence was evaluated by calculating the Area Under the Disease Progress Curve (AUDPC). Nitrogen fertilizer influenced the determination of the disease incidence index in both seasons and its effect was greatest during 64-72 days after sowing. The presence of weeds throughout the life cycle affected the disease incidence index during the *Yala* season.

Keywords: AUDPC; Narrow Brown Leaf Spot; Nitrogen Fertilizer; Weeds.

INTRODUCTION

Rice (*Oryza sativa* L.) crop in tropical environments is constrained by biotic stresses; where, diseases are at upfront along with the conventional management of crop using high densities, irrigation, and high nitrogen. Narrow Brown Leaf Spot (NBLS), a fungal disease caused by the pathogen *Passalora janseana* which will infect to leaf lamina, mid-vein, leaf sheath, panicle, seed coat, and glumes of the rice plant. Long cylindrical dark brown spots consisting of greyish centre with or without chlorosis will appear on the infected plant parts as symptoms late in the season (Groth and Hollier, 2010; Mani, 2015). Depending on the severity, in certain regions, NBLS is a critical disease with an economic significance (Department of Agriculture, Sri Lanka, 2019). The agronomic management of a crop is the fundamental basis for maintaining the hygiene of the crop, which has a direct impact on disease incidence. At the farmers' level, fertilizer management, weed management, and the planting density substantially may vary from the recommendation, thus the incidence of diseases could have differed.

The incidence of NBLS disease can change with surrounding factors such as climate, agronomy, and management of cultivation (Biswas, 2006). The mineral nitrogen fertilizer is hypothesized to be a critical factor for disease development. At high mineral nitrogen doses, the luxurious growth and high foliar nitrogen concentrations reported an increased rice crop susceptibility to pathogens, even including NBLS (Mitchell *et al*., 2003: Veresoglou *et al*., 2013). In contrary, the incidents were lower and disease tolerance is enhanced by high mineral nitrogen inputs due to compensatory growth of crops and quick recovery (Veresoglou *et al*., 2013). Weeds among crops have been reported in increasing the disease incidence by the competition on crops acting as a pest itself; while being a vector of a pathogen or a reservoir of a pathogen or its vector is very common (Wisler, 2009). Dual role of weeds; one by weakening crop via competition for resources and second by being an alternative host for pathogens, the probability of pathogen infections has been enhanced in rice fields all over the globe (Schreiber *et al.*, 2018). The density of rice filed, especially in a broadcasted field, the seeding rate shows a great impact on the incidence of disease with diversified microclimate. High seed rates, i.e., high planting densities have shown increased severity of rice diseases including sheath blight, blast, brown spot, and false smut (Mithrasena *et al.*, 2007; Mani, 2015).

The incidence and severity of the disease vary over the life cycle of a plant; hence, disease at a specific time can be assessed using incidence and severity or a combination of both. Generally, disease progress with time from a low initial level to an economically injurious level. Disease progression curves are used to study the temporal changes of disease. The Area Under the Disease Progress Curve (AUDPC) and contrasting using analysis of variance procedure are key concepts in qualifying repeatedly measured disease incidents and severities (Simko and Piepho, 2011). The objectives of this study were to assess the factors affecting the incidence of NBLS and to identify the critical stage of the factors of disease development in a rice crop, in two seasons (*Maha*/ Wet and *Yala*/ dry) in the year 2017/18.

MATERIALS AND METHODS

A field trial was carried out during 2017/2018 *Maha* (Wet) (2017 November – 2018 March) and 2018 *Yala* (Dry) (April – August) seasons at the research field of the Faculty of Agriculture, Rajarata University of Sri Lanka (RUSL), Puliyankulama, Anuradhapura. The mean annual rainfalls

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were 1507 mm and 1624.3 mm for 2017 and 2018 years respectively while mean seasonal rainfall was 467.9 mm and 674.6 mm for wet and dry seasons respectively. Agro ecologically, the region is classified as to dry zone low country (DL1). Soils were mainly Reddish Brown Earth (RBE).

Two fertilizer managements were used to distinguish fertilizer effect i.e., full/ 100% Department of Agriculture (DOA) recommendation (N-103.5 kg/ha (urea – 46%); P-10.5 kg/ha (P_2O_5 – 43.7%); K-30 kg/ha (K_2O - 60%)) and i.e., half/50% of DOA recommendation (N-51.75 kg/ha (urea – 46%); P-5.25 kg/ha (P_2O_5 – 43.7%); K-15 kg/ha (K_2O - 60%)). The presence of weeds, i.e., weedy and weed-free, and four seed rates, i.e., 100 kg/ha, 125 kg/ha (control), 150 kg/ha and 175 kg/ha were also used. Factorial combinations were laid out on a split-split plot design, with a plot size of 4 m^2, with four replicates. The mineral nitrogen fertilizer rate was the main plot factor, the weed management was the medium-plot factor, and the seeding rate was the sub-plot factor. The main plots and subplots were separated with bunds and to avoid horizontal movement of fertilizers and movement of air-borne pathogens were controlled using a separation 1.5 m height white colour polyethylene.

Crop establishment and management

Pre-germinated seeds of the rice variety *Bg* 300 were direct seeded according to the seeding rates of 64 plots used for the study. Time and frequencies of fertilizer were carried out according to the DOA recommendation in splits. Apart from the application of agronomic weed control in un-weeded plots, neither manual nor chemical weed controlling was done. In weed-free plots, pretilachlor + safener 300 EC at a rate of 1.6 L/ha in three days after sowing and Bispyribac Sodium at a rate of 225 g/ha in 14 days after sowing was done. Afterward, manual weeding was used to maintain the plots weed-free.

Data collection and analysis

The incidence of NBLS was collected at sampling intervals of 04 days starting from 50 DAS. Four random samples of an area of a quadrate of 0.5 m × 0.5 m were collected in assessing the disease incidents.

The disease incidence was calculated using equation 1.

$$\text{Disease Incidence} = \frac{\text{Number of infected plants per quadrate}}{\text{Total number of plants per quadrate}} \quad (1)$$

The reordered disease incidence was used to develop disease progress curves of two mineral nitrogen regimes and two seasons.

The incidence index was calculated by transforming disease incidence data into the area under the disease progress curve (AUDPC) (American Phytopathological Society [APS] 2018). The AUDPC was calculated using equation 2.

$$A_k = \sum_{i=1}^{N_i - 1} \frac{(y_i + y_{i+1})}{2} (t_{i+1} - t_i) \quad (2)$$

Where;

t_i = Sample time points in a sequence

y_i = Disease level

The analysis of disease index values in both 2017/2018 *Maha* and 2018 *Yala* seasons were performed using a repeated mixed model procedure (SAS 9.0, SAS Institute). Three factors and two seasons were considered fixed factors and the replicate (block) and interactions with sub-plot factors were considered as random factors.

RESULTS AND DISCUSSION

The NBLS disease progression curves of both 2017/2018 *Maha* and 2018 *Yala* seasons and three agronomic factors (mineral nitrogen, weed, and seed rates) separately are shown in (Figure 1). In the 2017/2018 *Maha* Season, the general pattern of the disease progression showed an increasing trend of the disease from 50-54 DAS and then a decrease from 54-60 DAS. 2018 *Yala* two peaks of the incidences could be observed in the 64 and 76 DAS.

The disease incidence had reached a maximum of 1, in *Maha* season in between 76-80 DAS, irrespective of the three factors considered. In contrast, the dry season disease incidents had reached a maximum of 0.8 with respect to all factors (Figure 1). After reaching the maximum, the incidences in the *Maha* season have remained unchanged. A generalizable drop of incidents was observed in the *Yala* season in between 64-76 DAS.

It was revealed that only fertilizer (*P = 0.02*) in the *Maha* season and only weeds (*P < .0001*) in the *Yala* season have been shown to change the index of diseases. Further exploration of factorial impacts by pooling indecent data of different sample dates revealed the significant differences of main factors, despite no difference between interactions (Table 1).

The NBLS disease incidences in 2017/2018 *Maha* and 2018 *Yala* were significantly different ($p < 0.05$) by the nitrogen fertilizer application between 64-68 days and 68-72 DAS respectively. (Table 1) A higher disease incidence index was observed in plants treated with half the rate of fertilizer.

Mineral nitrogen fertilizer inputs have shown both variable responses in disease incidences of crops under different climatic and ecological conditions. (Long *et al.*, 2000; Okari, 2004; Mukerjee *et al.*, 2005; Westerveld *et. al.*, 2008; Mani, 2015). In this study, the development of NBLS was the lowest at recommended levels of mineral nitrogen (50% fertilizer - 2.9 disease index, 100% fertilizer - 2.7 disease index) which was also similar to the study by Mani (2015).

Balanced nutrient management is one of the most crucial factors for the control of diseases in crops. The resistance of a plant to a particular disease and its passive and active control is mediated through physiological and biochemical processes related to the nutritional status of the plant. An adequate supply of essential nutrients can ensure either maintenance or induction of higher disease resistances (Huber and Haneklaus, 2007). The inadequate

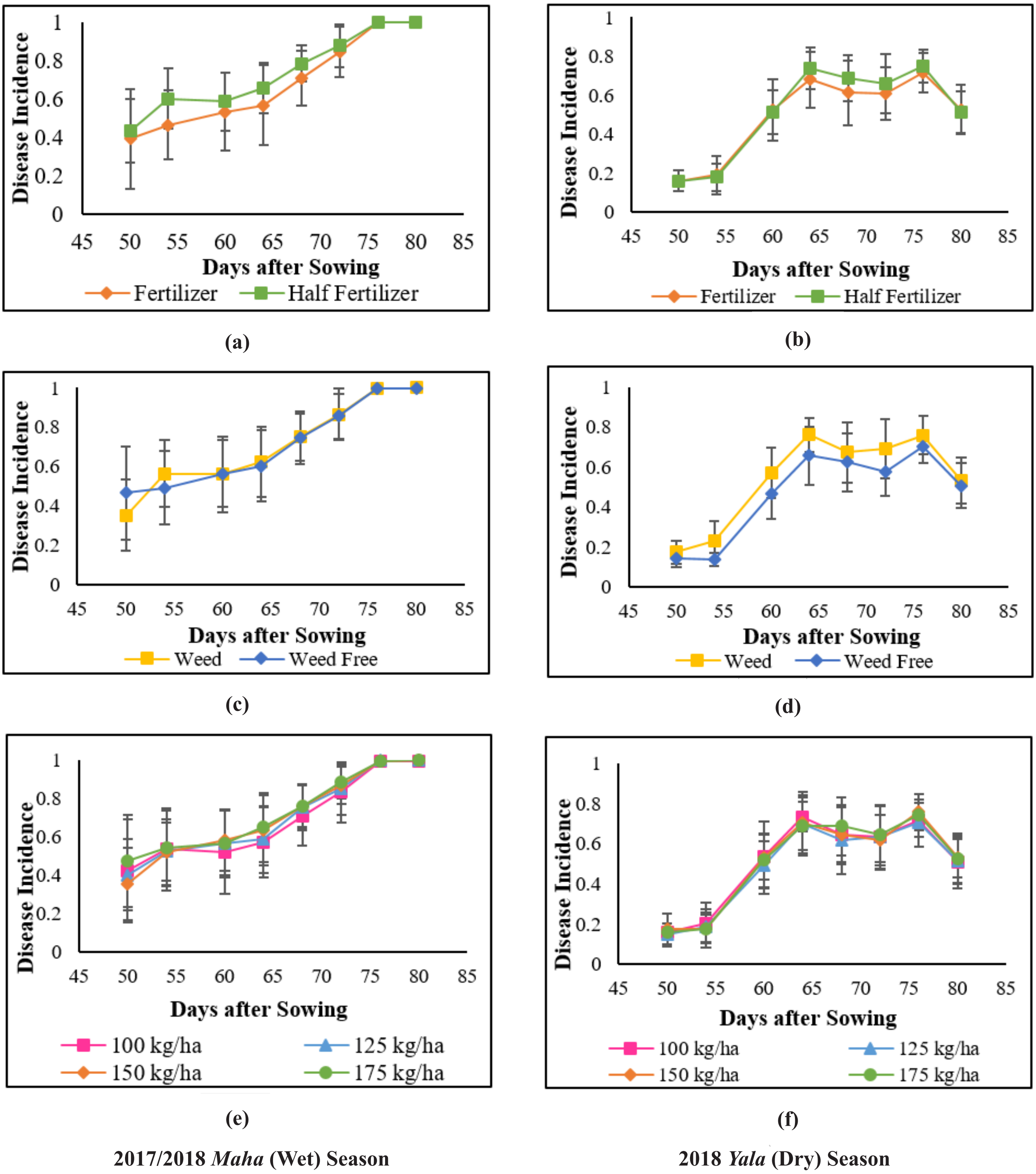

Figure 1: Incidence of NBLS within the applied treatments in 2017/2018 *Maha* season and 2018 *Yala* season: (a) Incidence of NBLS with nitrogen rate in 2017/2018 *Maha* season excluding the effect of weed infestation and seed rate; (b) Incidence of NBLS with nitrogen rate in 2018 *Yala* season excluding the effect of weed infestation and seed rates; (c) Incidence of NBLS with presence and absence of weeds in 2017/2018 *Maha* season excluding the effect of nitrogen rate and seed rate; (d) Incidence of NBLS with presence and absence of weeds in 2018 *Yala* season excluding the effect of nitrogen rate and seed rate; (e) Incidence of NBLS with different seed rates in 2017/2018 *Maha* season excluding the effect of nitrogen rate and weed infestation; (f) Incidence of NBLS with different seed rates in 2018 *Yala* season excluding the effect of nitrogen rate and weed infestation.

Table 1: Associated probability values for the effect of nitrogen fertilizer, weed control, and seed rate on the disease incidence index in the 2017/2018 *Maha* season, 2018 *Yala* season.

	2017/2018 *Maha* Season							**2018 *Yala* Season**						
	1*	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fertilizer (F)	0.16	0.12	0.14	**0.02**	**0.05**	0.30	0.20	0.74	0.74	0.38	0.01	0.04	0.06	0.64
Weeds (W)	0.42	0.05	0.80	0.54	0.57	0.73	0.20	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.01**	**<0.001**	**0.04**
Seed rate (SR)	0.90	0.99	0.73	0.80	0.84	0.72	0.46	0.67	0.81	0.76	0.54	0.68	0.80	0.64
F*W	0.44	0.47	0.83	0.92	0.68	0.98	0.48	0.78	0.54	0.70	0.48	0.21	0.88	0.18
F*SR	0.70	0.98	0.88	0.81	0.92	0.90	0.31	0.94	0.93	0.82	0.96	0.66	0.52	0.67
W*SR	0.83	0.85	0.79	0.91	0.95	0.90	0.74	0.86	0.96	0.81	0.99	0.34	0.42	0.68
F*W*SR	0.98	0.83	0.86	0.73	0.86	0.97	0.56	0.85	0.53	0.78	0.87	0.79	0.28	0.77

*Sampling dates are in order of 50-54; 54-60; 60-64; 64-68; 68-72; 72-76; 76-80 DAS

application of P and K and also the imbalances on N:P:K had led to a quick progression of NBLS during this study, which also triggered during the most nutrient demanding phase of the rice crop (Figure 01). The high N ratio to P and K in full (100%) recommendations may have reduced the resistance to NBLS, thus higher incidences were observed.

Generally, the time of nitrogen application, especially respective to the phenology of a crop shows substantial impacts on disease development. The recommendations for mineral nitrogen in the Sri Lankan context apply as few splits and substantially high doses, which creates an ideal situation for speeding diseases due to sudden increment in tissue nitrogen levels. (Kapoor and Sood, 2000; Mani, 2015).

The presence of weeds showed a significant impact ($p < 0.05$) (Table 01) on disease incidence during 50 - 80 DAS in *Yala* season 2018 (Presence of weed - 2.3 disease incidence index; Weed-free - 2.0 disease incidence index). Weed controlled to a reduction of disease by alleviating the sources of the pathogen, alternative hosts, and continuity between crops for disease spreading (Adebitan, 1996; Islam *et al.*, 2002). The presence of weeds tends to create a favorable microclimate for the pathogen through the increase in relative humidity and decrease in temperature, which allows the pathogen to thrive well. Especially, in rice fields, the inundation and rainfall generate more moisture in the canopy microclimate, which favors the NBLS pathogen to spread. Hence, higher disease incidence was observed in stages with a dense canopy in the life cycle of rice.

Interestingly, the impact of planting density (i.e., seeding rate) was not significant ($p > 0.05$) on the disease incidence index, which could be a contrasting difference between the current study and previous studies. A study on the incidence of NBLS discovered significant differences at comparable seedling densities, which was attributed to the compact growth and close canopy favoring the pathogens (Mani, 2015).

CONCLUSIONS

The incidence of NBLS during the life cycle of the rice crop is affected by the rate of nitrogen fertilizer application and the weedy conditions in the field and was unaffected by the changes in the planting density. In *Maha* season, the rate of nitrogen fertilizer application was the most crucial factor for disease incidence and its impact was highest between 64-72 DAS of rice. Both nitrogen fertilizer application and the presence of weeds were most influential between 64-72 DAS and throughout the life cycle of rice crop respectively in *Yala* season.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

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