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Influence of plant nutrition on the sheath blight disease severity caused by *Rhizoctonia solani* Kuhn. in rice genotypes

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Sheath blight of rice is one of the economically important disease which has a substantial impact on grain yield and quality of rice. In this study, an effort was made to reveal the effect of plant nutrients on sheath blight severity in different rice genotypes. Correlation and regression analysis between nutrients and sheath blight severity in different genotypes revealed that , nitrogen (0.88), phosphorous (0.77), magnesium (0.21), iron (0.25) and zinc (0.012) were found to have significant positive correlations and were responsiblefor 79%, 59%, 4.5%, 6.2%, and 0.14% increase in disease severity, respectively. But a significant negativecorrelation was observed in case of potassium (0.50), calcium (0.4), sulphur (-0.02), copper (0.15) and manganese (0.26) with 25.0%,15.9%,0.5%, 2.3% and 6.8% increase in severity, respectively. The effect of nutrient ratios on disease severity in infected genotypes had greater N: S, N: P and P: S ratios.

Keywords: Correlation, disease, plant nutrients, regression, rice, sheath blight

INTRODUCTION

Rice (*Oryza sativa* L.), *Gramineae* family is one of the most importantfood crop in the world. With a combined production of 640 million tonnes, Asia is the world's top rice producer. India is the world's second largest producer of rice. Rice producers are continually confronted with biotic and abiotic pressures. Blast, sheath blight, and bacterial blight diseases are the most common biotic stresses of rice production (Kumar *et al*. 2009).

Rice sheath blight disease caused by the soil-borne necrotrophic fungus *Rhizoctonia solani* Kuhn [Teleomorph; *Thanatephorus cucumeris* (Frank) Donk], and is known to cause losses up to 50 per cent of rice yield under the favorable conditions (Molla *et al*. 2020). In India, maximum grain yield loss of roughly 58 per cent may occur depending on the severity of the disease and the variety (Chethana *et al*. 2016). It is a major productivity constraint in highly tilled, fertilizer-responsive, high-yielding rice varieties and hybrids in intensive rice production systems (Bhunkal *et al*. 2015).

Fungicides and cultural approaches are essential for the management of sheath blight due to lack of resistant cultivars. Since nutrients are important for the growth and development of plants and also for microorganisms, thus play important role in disease management. Mineral nutrition has been exploited as a supplement in the treatment of diseases. Preventing pathogen infection demands a thorough understanding of both the crop's and pathogen's nutrient requirements. Despite the fact that plant disease resistance is genetically controlled, disease is influenced by the environment, particularly nutrient deficits and toxins.

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Information on the nutrient status of different genotypes with varying degrees of disease resistance could be used to generate nutrient norms for boosting rice plant resistance to sheath blight disease. The objective of this research is to reveal the relationship between the plant nutrients, nutrient ratios on sheath blight severity in different rice genotypes.

MATERIALS AND METHODS

A field survey was conducted during *Kharif* 2020 and 2021 to record the severity of rice sheath blight in different rice genotypes grown in the fields of Zonal Agricultural Research Station (ZARS), V. C Farm, Mandya when the crop is at its maximum tillering to panicle initiation stage. The disease scoring of each genotype was done by following the standard evaluation system (SES) (IRRI,1996) for sheath blight of rice. Per cent disease severity was recorded by using the 0-9 scale. These scales were converted to per cent disease index (PDI) by using the formula given by Wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of the individual rating}}{\text{No. of tillers examined} \times \text{Maximum disease scale}} \text{X } 100$$

After grading for disease, a few top most leaves from two plants in each genotype were selected. One from a healthy plant, while the other from a plant with severe sheath blight in the field. Leaf samples were taken from genotypes, comprising hybrids and high yielding varieties from private companies, affected with sheath blight (Table 1).

The samples were brought to the laboratory for nutrient analysis. The methods followed for the plant nutrient analysis are listed in Table 2.

Values obtained from plant nutrients for sheath blight disease severity percentageswere subjected to correlation and regression analysis. The correlation, regression coefficients and p values thus obtained were used to interpret the relationship between nutrient content and disease severity percentage in different rice genotypes.

RESULTS AND DISCUSSION

Sheath blight severity with nitrogen (N)

The nutrient analysis revealed that the nitrogen content of leaf samples collected from the healthy and sheath blight infected genotypes are differed. The results revealed that there was a significant positive correlation between nitrogen content and sheathblight severity in the rice genotypes with a correlation coefficient (R) of 0.88. The regression coefficient (R^2) was 0.79, indicating that every unit change in nitrogen content within the plant influences a 79 percent change in sheath blight severity (Table 3 & Table 4, Fig.1).

Rice crops contained 0.5-0.8 per cent nitrogen at maturity stage, as per Dobermann and Fairhurst (2002) study report. Slaton *et al*. (2003) discovered that increased N rate increases sheath blight severity. Prasad *et al*. (2020) found that high nitrogen concentration can enhance disease severity by 60.4 per cent, when compared to plants cultivated with optimal nitrogen application. The findings were in consistent with those of Krauss (2001), who proved that sheath blight incidence and severity were higher on plants growing in soil with high nitrogen (N). Increased nitrogen content in excess of the plant's requirements may result in high disease severity. This could be because a high dose of nitrogen promotes more vegetative growth and increased succulency in plants, as well as interfering with the phenolic metabolic pathway and lowering total phenol (defense compound) in the plant (Huber and Thompson, 2007). Yang *et al*. (2022) also reported that with increase in N application sheath blight severity also increased due to reduced degree of silicification of epidermal plant cells and increased the content of amino acids which provide favorable conditions for the infection and occurrence of disease.

Sheath blight severity with Phosphorous (P)

The phosphorous content of leaf samples collected from healthy and sheath blight affected genotypes differed. With a correlation value (R) of 0.77, the results demonstrated a substantial positive association between phosphorus content

Table 1: List of rice genotypes collected for nutrient analysis

Genotypes	Sl. No	Genotypes
IR-64	9	MTU 1001
KRH-4	10	Amulya
Jyothi	11	Omkar
Hamsa	12	Godavari
Thanu	13	KRH-2
Rajmudi	14	RNR 15048
BPT- Sona	15	B R scale

Table 2. Methods followed for plant nutrient analysis

Parameter	Method	Reference
Nitrogen	Kjeldahl digestion and distillation method	Piper (1966)
Phosphorus	Diacid digestion and Colorimetry using vanadomolybdate reagent	Piper (1966)
Potassium	Flame Photometery	Piper (1966)
Calcium and Magnesium	Complexometry using versenate solution	Piper (1966)
Sulphur	Turbidometry	Bradsley and Lancester (1965)
Micronutrient's cations (Fe, Mn, Zn & Cu)	Atomic Absorption Spectrophotometery	Lindsay and Norwell (1978)

and sheath blight severity in the genotypes and the regression coefficient (R2) is 0.59 (Table 4, Fig. 2).

Based on the two years of study, Prasad *et al.* (2020) discovered that the maximum phosphorous fertilizer treated plants had the greatest sheath blight disease incidence (31.8 %). As phosphorous is an essential macronutrient for photosynthesis, respiration, cell division, energy transmission and various other functions in plants. Excess phosphorous, on theother hand, prevents micronutrient absorption. Both deficiency and excess of phosphorus have an impact on plants innate immunity (Prabhu *et al.* 2007).

Sheath blight severity with Potassium (K)

Genotypes with the highest disease severity *viz.*, BPT Sona (60.0 %), Omkar (42.6 %), Amulya (42.2 %) and Jyothi (40.0 %) genotypes had the lower potassium content of 1.11, 0.9, 1.29, and 1.13 per cent, respectively while, samples collected from healthy leaves of the same genotypes had comparatively higher K content of 1.45, 1.2, 1.42 and 1.32 per cent, respectively (Table 3). The factor's regression coefficient (R^2) with disease severity was 0.25 (Fig. 3).

The findings of potassium application on sheath blight matched with those of earlier workers who found that adding a substantial amount of potassium reduced disease incidence. Use of K as a fertilizer for rice plants may provide further protection against sheath blight infection. Rice varieties contained 0.40-2.0 per cent potassium at maturity stage (Dobermann and Fairhurst, 2002). Several researchers have reported on the mechanistic effects of K on plant disease resistance. Pathogens internal competition for nutritional resources was reduced by higher K+ concentrations. Plants with this nutritional status can devote more energy to construct stronger cell walls to ward off pathogens and insects, as well as obtaining more nutrients for plant defense and damage repair.

Influence of Calcium (Ca), Magnesium (Mg) and Sulphur (S) on sheath blight severity in rice genotypes

The data in Table 4 revealed a negative relationship (-0.4) between rice sheath blight severity and calcium content in straw which means that increasing calcium content reduces sheath blight severity.

Table. 3: Macro nutrient content derived from rice genotypes

Genotypes	ShB severity (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Omkar infected	42.22 (40.5)	1.01	0.22	0.99	0.35	0.17	0.051
Omkar healthy	0.00 (0.0)	0.45	0.12	1.2	0.40	0.192	0.071
B R Scale infected	13.33 (21.4)	0.85	0.19	0.79	0.42	0.18	0.062
B R Scale healthy	0.00 (0.0)	0.59	0.11	0.98	0.49	0.34	0.060
Hamsa infected	13.33 (21.4)	0.94	0.17	1.1	0.44	0.232	0.050
Hamsa healthy	0.00 (0.0)	0.65	0.11	1.33	0.48	0.168	0.070
I R 64 infected	26.67 (31.1)	0.99	0.21	1.23	0.24	0.216	0.050
I R 64 healthy	0.00 (0.0)	0.54	0.11	1.4	0.58	0.144	0.050
Jyothi infected	40.00 (39.3)	1.13	0.28	1.19	0.52	0.288	0.060
Jyothi healthy	0.00 (0.0)	0.79	0.17	1.32	0.55	0.312	0.070
Rajmudi infected	22.22 (28.1)	1.12	0.21	1.13	0.46	0.336	0.052
Rajmudi healthy	0.00 (0.0)	0.81	0.18	1.35	0.60	0.192	0.071
MTU 1001 infected	35.56 (36.6)	1.17	0.22	1.33	0.32	0.336	0.062
MTU 1001 healthy	0.00 (0.0)	0.76	0.19	1.46	0.58	0.225	0.071
Godavari infected	26.67 (31.1)	0.95	0.18	1.34	0.28	0.213	0.052
Godavari healthy	0.00 (0.0)	0.6	0.11	1.4	1.16	0.292	0.062
KRH 4 infected	22.22 (28.1)	1.09	0.2	1.39	0.36	0.384	0.062
KRH 4 healthy	0.00 (0.0)	0.73	0.18	1.401	0.45	0.204	0.072
Thanu infected	13.33 (21.4)	0.81	0.21	1.37	0.45	0.216	0.072
Thanu healthy	0.00 (0.0)	0.63	0.11	1.39	0.54	0.216	0.062
Amulya infected	42.22 (40.5)	1.89	0.245	1.29	0.36	0.24	0.071
Amulya healthy	0.00 (0.0)	0.56	0.11	1.42	0.42	0.12	0.041
BPT Sona infected	60.00 (50.8)	2.11	0.256	1.1	0.36	0.144	0.062
BPT Sona healthy	0.00 (0.0)	0.56	0.12	1.45	0.39	0.264	0.042
MTU 1010 infected	17.78 (25.0)	0.76	0.178	1.34	0.52	0.12	0.062
MTU healthy	0.00 (0.0)	0.11	0.13	1.41	0.56	0.216	0.062
RNR 15048 infected	19.78 (26.4)	0.87	0.211	1.35	0.38	0.13	0.072
RNR 15048 healthy	0.00 (0.0)	0.48	0.11	1.36	0.45	0.11	0.052
KRH -2 infected	15.56 (23.24)	1.11	0.19	1.26	0.15	0.311	0.072
KRH -2 healthy	0.00 (0.0)	0.7	0.11	1.35	0.56	0.21	0.062

* Figs in the parenthesis are arcsine transformed value, ShB- Sheath blight severity

The regression coefficient (R^2) of this component with disease severity was 0.16 (Fig.4). Positive relationship between magnesium content and sheath blight severity in the genotypes, with a correlation value (R) of 0.21. The regression coefficient (R^2) was 0.045, indicating that a 4.0 per cent variation in magnesium levels within the plant had an effect on sheath blight severity (Fig.5).

Negative association (-0.02) between sulphur concentration in straw and rice sheath blight severity, implying that increasing sulphur content reduces sheath blight severity and also regression coefficient (R^2) with disease severity was 0.0005 for sulphur (Fig. 6). But the difference in sheath blight disease severity with respect to magnesium and sulphur content was non-significant.

Calcium is vital for cell wall and membrane stability, as well as acting as a second messenger in a variety of developmental and physiological processes, including plant responses to biotic stress (Shcurt *et al.* 2014). High levels of Mg, on the other hand, can cause diseases like tomato and pepper bacterial spot and peanut pod rot by interfering with Ca uptake (Walters and Bhingam, 2007). Singh et al. (2010) observed that sulphur application enhanced the phenolic content, prolonged the incubation period and lowered the severity of sheath blight. Zn proteins play a dual role in plant defenses with potential to simultaneously aid and abet the plant and its invaders (Bodegom *et al.* 2005).

Nutrient content derived from healthy and sheath blight infected genotypes is depicted in Table 3 and the correlation and regression relation

Table 4: Correlation (R) and regression coefficient (R^2) between sheath blight severity and essential plant nutrients in rice genotypes

Nutrient content ingenotypes	Disease severity	
	R	R^2
Nitrogen (N)	0.88**	0.79
Phosphorous (P)	0.77**	0.59
Potassium (K)	-0.50*	0.25
Calcium (Ca)	-0.40*	0.16
Magnesium (Mg)	0.21	0.045
Sulphur (S)	-0.02	0.0005

Note: p value represents significance of correlation coefficient N=30, ** Correlation is significant at 0.01 level (2- tailed) *Correlation is significant at 0.05 level (2-tailed)

Table 5: Micro nutrient content derived from rice genotypes

Genotypes	ShB severity (%)	Cu (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)
Omkar infected	42.22 (40.5)	2	3420	43.42	444.1
Omkar healthy	0.00 (0.0)	3.3	420	34.20	469.8
B R Scale infected	13.33 (21.4)	2.2	410	34.10	120.8
B R Scale healthy	0.00 (0.0)	4.1	320	35.20	320.0
Hamsa infected	13.33 (21.4)	3.1	408	14.08	250.7
Hamsa healthy	0.00 (0.0)	2.1	417.6	34.18	228.6
I R 64 infected	26.67 (31.1)	2.7	424	23.42	195.7
I R 64 healthy	0.00 (0.0)	3.1	504	35.50	316.1
Jyothi infected	40.00 (39.3)	4	442	33.44	181.0
Jyothi healthy	0.00 (0.0)	1.2	376	31.38	133.6
Rajmudi infected	22.22 (28.1)	2.8	297.6	14.33	254.8
Rajmudi healthy	0.00 (0.0)	3.2	234	34.32	305.0
MTU 1001 infected	35.56 (36.6)	3.4	367	32.37	172.8
MTU 1001 healthy	0.00 (0.0)	2.2	415.6	32.42	143.0
Godavari infected	26.67 (31.1)	2.1	320	31.12	21.7
Godavari healthy	0.00 (0.0)	4.2	410	40.10	249.5
KRH 4 infected	22.22 (28.1)	3.3	350	33.50	167.7
KRH 4 healthy	0.00 (0.0)	3.2	400	34.44	338.8
Thanu infected	13.33 (21.4)	5.1	320	31.22	321.2
Thanu healthy	0.00 (0.0)	2.4	330	33.33	510.2
Amulya infected	42.22 (40.5)	4.4	350	34.25	154.8
Amulya healthy	0.00 (0.0)	3.6	345	31.45	124.4
BPT Sona infected	60.00 (50.8)	3.3	410	37.41	175.7
BPT Sona healthy	0.00 (0.0)	3.2	360	37.60	370.0
MTU 1010 infected	17.78 (25.0)	4.1	412	312.00	150.7
MTU healthy	0.00 (0.0)	3.2	363	36.30	188.2
RNR 15048 infected	19.78 (26.4)	4.2	410	34.10	140.1
RNR 15048 healthy	0.00 (0.0)	5.2	330	41.33	176.9
KRH -2 infected	15.56 (23.24)	4.2	360	43.60	135.6
KRH -2 healthy	0.00 (0.0)	3.6	290	42.90	121.2

* Fig.s in the parenthesis are arcsine transformed value

Table 6: Correlation (R) and regression coefficient (R2) between sheath blight severity and essential plant nutrients in rice genotypes

Nutrient content in genotypes	Disease severity	
	R	R^2
Copper (Cu)	-0.15	0.023
Iron (Fe)	0.25	0.062
Zinc (Zn)	0.012	0.00014
Manganese (Mn)	-0.26	0.068

Note: p value represents significance of correlation coefficient N=30, ** Correlation is significant at 0.01 level (2- tailed) *Correlation is significant at 0.05 level (2-tailed)

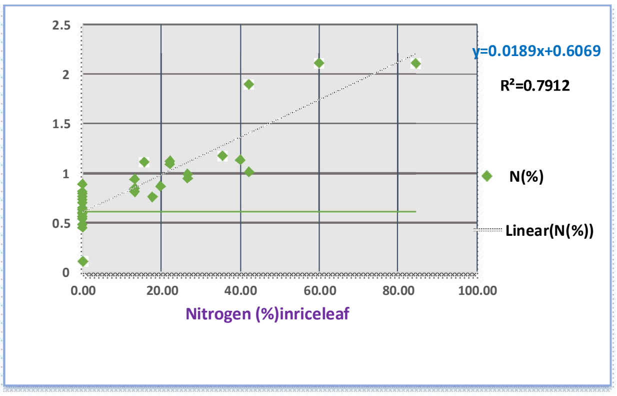

Fig.1: Correlation between nitrogen content and sheath blight severity

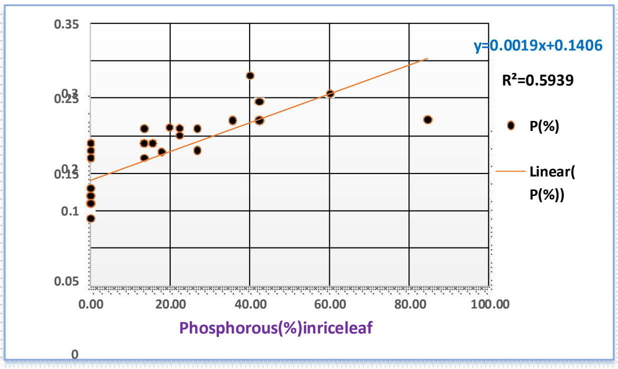

Fig.2: Correlation between phosphorous content and sheath blight severity

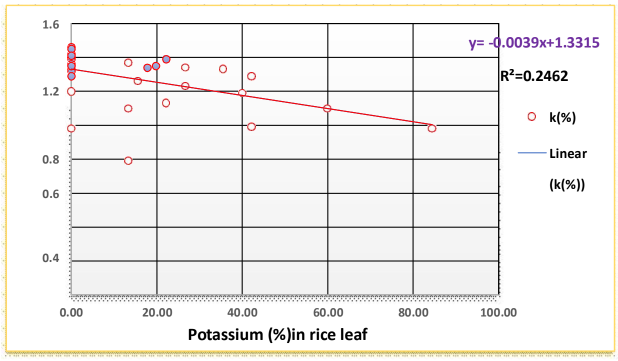

Fig.3: Correlation between potassium content and sheath blight severity

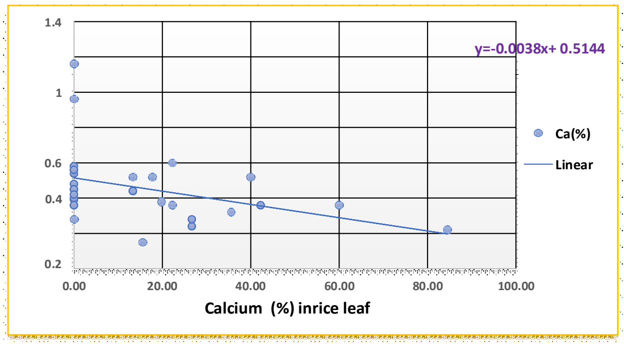

Fig.4: Correlation between calcium content and sheath blight severity

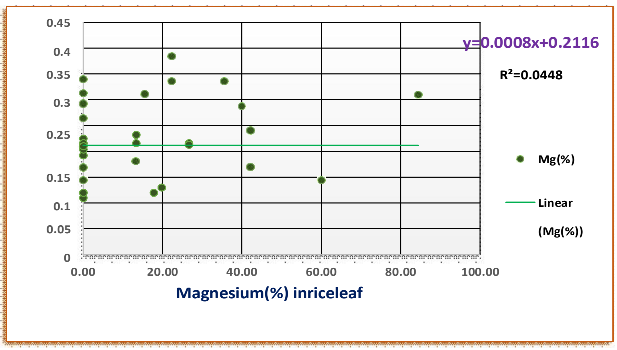

Fig 5: Correlation between magensium content and sheath blight severity

between nutrient contents derived from the plant sample and sheath blight severity is given in Table 4.

Influence of micro- nutrients Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) on sheath blight severity in rice genotypes

The results showed a positive relationship

Table 7: Effect of nutrient ratio on sheath blight severity in rice

Genotypes	Sheath blight severity(%)	N: S	P: S	K: S	N: P	N: K	P: K
Omkar infected	42.22 (40.5)	20: 1	5:1	17: 1	5: 1	5: 1	1: 5
Omkar healthy	0.00 (0.0)	6: 1	2:1	20: 1	4: 1	2: 1	1: 10
B R scale infected	13.33 (21.)	14:1	3:1	13: 1	5: 1	1:1	1: 4
B R scale healthy	0.00 (0.0)	10 :1	2: 1	16: 1	4: 1	0.6: 1	1: 9
Hamsa infected	13.33 (21.)	19 :1	3:1	22: 1	5: 1	0.9:1	1:6
Hamsa healthy	0.00 (0.0)	9: 1	2: 1	19: 1	4:1	0.5:1	1: 12
I R 64 infected	26.67 (31.)	20: 1	4: 1	24: 1	6: 1	1.7:1	1: 6
I R 64 healthy	0.00 (0.0)	11 :1	2:1	28: 1	4:1	0.8:1	1: 13
Jyothi infected	40.00 (39.)	19 :1	5:1	20: 1	4:1	0.9:1	1: 4
Jyothi healthy	0.00 (0.0)	11 :1	2:1	19: 1	5:1	0.6:1	1: 8
Rajmudi infected	22.22 (28.)	22:1	4:1	23: 1	6:1	1: 1	1: 7
Rajmudi healthy	0.00 (0.0)	12 :1	3:1	19: 1	5:1	2: 1	1: 8
MTU 1001 infected	35.56 (36.)	20 :1	4: 1	22: 1	5: 1	1.2: 1	1: 6
MTU 1001 healthy	0.00 (0.0)	11 :1	3: 1	21: 1	4:1	0.5: 1	1: 8
Godavari infected	26.67 (31.1)	19 :1	4: 1	24: 1	5: 1	0.7: 1	1:6
Godavari healthy	0.00 (0.0)	10 :1	2: 1	26: 1	5:1	0.4:1	1: 13
KRH 4 infected	22.22 (28.)	18 :1	4: 1	23:1	6:1	0.8: 1	1: 7
KRH 4 healthy	0.00 (0.0)	10 :1	3: 1	20: 1	4: 1	0.5: 1	1: 8
Thanu infected	13.33 (21.)	12:1	3: 1	19: 1	5:1	0.6: 1	1: 7
Thanu healthy	0.00 (0.0)	11:1	2: 1	23: 1	4: 1	0.5: 1	1: 13
Amulya infected	42.22 (40.)	27: 1	4: 1	18: 1	8:1	2: 1	1: 5
Amulya healthy	0.00 (0.0)	11 :1	3: 1	36: 1	5: 1	0.4: 1	1: 13
BPT sona infected	60.00 (50.)	35: 1	5: 1	17: 1	8: 1	2: 1	1: 4
BPT sona healthy	0.00 (0.0)	14: 1	3: 1	36: 1	5:1	0.4: 1	1: 12
MTU 1010 infected	17.78 (25.)	13: 1	3:1	22: 1	4: 1	0.6: 1	1: 7
MTU 1010 healthy	0.00 (0.0)	8 :1	2: 1	23: 1	1: 1	0.5: 1	1: 11
RNR 15048 infected	19.78 (26.)	13: 1	3: 1	19: 1	4: 1	0.7: 1	1: 7
RNR 15048 healthy	0.00 (0.0)	10: 1	2:1	27: 1	4: 1	0.4: 1	1: 12
KRH -2 infected	15.56 (23.4)	13 :1	3: 1	18: 1	5: 1	0.7: 1	1: 7
KRH -2 healthy	0.00 (0.0)	12: 1	2: 1	22: 1	4: 1	0.5: 1	1: 13

*Fig.s in the parenthesis are arcsine transformed value

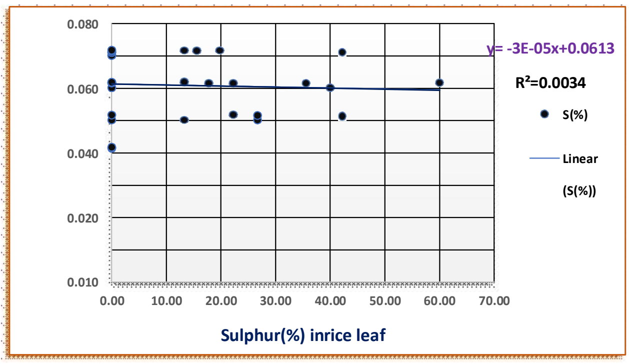

Fig.6: Correlation between sulphur content and sheath blight severity

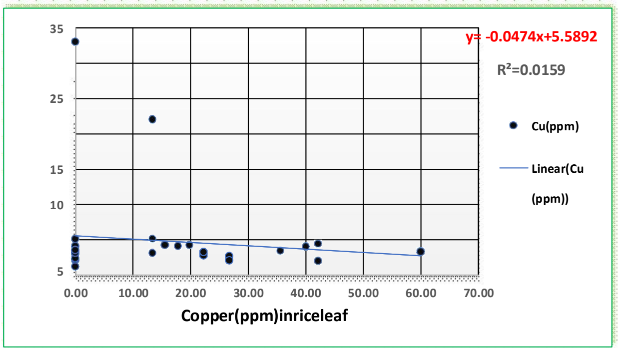

Fig. 7: Correlation between copper content and sheath blight severity

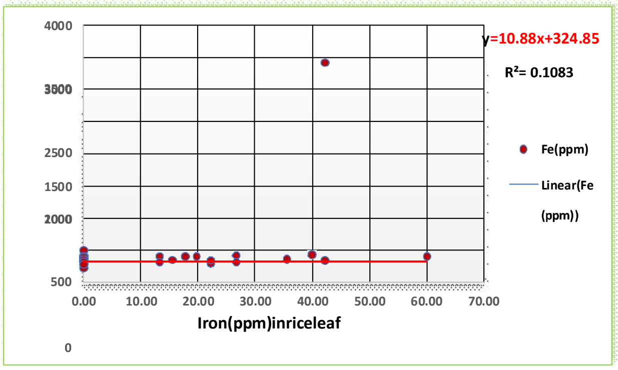

Fig.8: Correlation between iron content and sheath blight severity

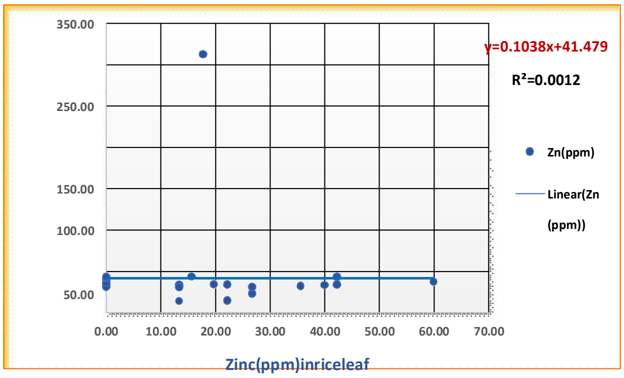

Fig. 9: Correlation between zinc content and sheath blight severity

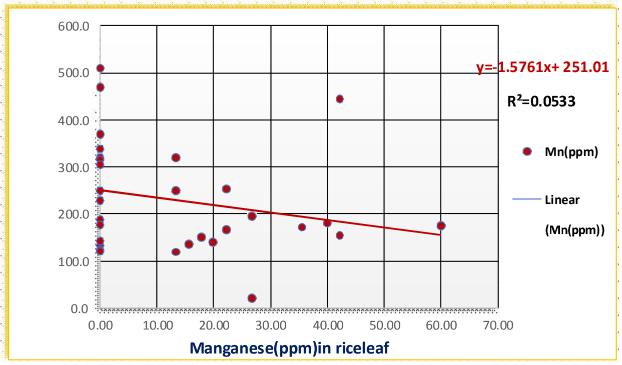

Fig.10: Correlation between Manganese content in plant and sheath blight severity

between iron concentration and sheath blight severity in the genotypes with a correlation value (R) of 0.25 and the regression coefficient (R2) was 0.062 as shown in Fig.7. This iron outflow generates an iron depletion inside the cell, which controls the transcription of pathogenesis-related genes in tandem with H_2O_2 (Walters and Bhingam, 2007). With a correlation value (R) of 0.012, a positive interaction exists between zinc concentration and sheath blight severity in the genotypes. The regression coefficient (R2) was 0.00014, indicating that a change in plant zinc levels of 0.015 per cent increases the severity of sheath blight (Table 6, Fig. 8).

Copper concentration in straw was found to have a negative relationship (-0.15) with rice sheath blight severity and the regression co efficient was 0.023 as shown in Fig.9. The amount of manganese (Mn) in straw was found to have a negative relationship (-0.26) with regression coefficient (R2) 0.068 which is depicted in Fig.10. The amount of manganese (Mn) in straw was found to have a negative relationship (-0.26) with regression coefficient (R2) 0.068 which is depicted in Fig.10.

Micro nutrient content derived from healthy and sheath blight infected genotypes is depicted in Table 5 and the correlation and regression relation between nutrient contents derived from the plant sample and sheath blight severity is given in Table 6.

Copper is involved in lignification, which is a plant's anti-pathogen defense mechanism. Its ions interfere with a range of enzymatic functions inside cells, inhibiting respiratory activity and, as a result, spore germination; copper at greater concentrations is toxic to plants (Laha *et al.* 2016). Mn is one of the 17 elements required for healthy growth and reproduction in plants which is required in only small quantity. Photosynthesis, respiration, scavenging of reactive oxygen species (ROS), pathogen defence and hormone signaling are important functions that Mn plays a role during a plant's life cycle (Andreson *et al.* 2018).

Effect of nutrient ratio on sheath blight severity in rice

Since each nutrient has an influence on either the availability, uptake or utilization of other nutrients, it is important to concentrate on the nutrient ratios in relation to the disease severity, which is given in Table 7. The effect of different ratio of nutrients is described below.

Effect of Nitrogen (N) to Sulphur (S) ratio on sheath blight severity in rice

High N: S ratio was observed in genotypes with high disease severity. The BPT Sona (60.0 %) had the highest N: S ratio (35: 1) followed by (27: 1) in Amulya (42.2 %), 20:1in Omkar (42.2 %), 20:1 in MTU 1001 (35.6 %), and (19: 1) in Jyothi (40.0 %). While, thehealthy leaves of the same genotypes had low N: S ratios (14: 1), (11: 1), (6:1), (11: 1) and (11:1), respectively. Genotypes with the least disease severity had low N: S ratio, B R scale genotype (13.0 %) had 14: 1, followed by Hamsa (13.3 %) had (19:1), KRH -2 (15.0 %) had (10:1) and MTU 1010 (17.8 %) had (13:1).

Effect of Phosphorous (P) to sulphur (S) ratio on sheath blight severity in rice

The high P: S ratio was identified in genotypes with high disease severity, as illustrated in Table 7. The highest P: S ratio (5: 1) was found in the BPT Sona (60.0 %) followed by (4: 1) in Amulya (42.2 %), (5: 1) in Omkar (42.2 %), (4: 1) in MTU1001 (35.6%), and (5: 1) in Jyothi (40.0 %), while healthy leaves of the same genotypes had low P: S rations (3: 1), (3: 1), (2: 1), (3: 1), and (2:1), respectively. B R scale (13.0 %), Hamsa (13.3 %), KRH -2 (15.0 %), and MTU 1010 (17.8 %) all exhibited poor P: S ratios.

Effect of Potassium (K) to Sulphur (S) ratio on sheath blight severity in rice

The analysis result of healthy leaves of BPT Sona and Amulya both had highest K: S ratio which is 36:1. Followed by, IR-64 (28:1), RNR 15048 (27:1), and Godavari (26:1) but the infected plants of the same genotype had low K: S ratio which is 17:1, 18:1, 24:1, 19:1 and 24:1 respectively, at the same time the genotypes having low disease severity had less K: S ratio.

Effect of Nitrogen (N) to Phosphorous (P) ratio on sheath blight severity in rice

In genotypes with severe disease, a high N: P ratio was reported. The highest N: P ratio (8: 1) was found in the BPT Sona (60.0 %), followed by (8: 1) in Amulya (42.2 %),(5:1) in Omkar (42.2 %), (6:1) in Rajmudi (22.2 %), and (6:1) in IR-64 (26.67 per cent), while healthy leaves of the same genotypes had low N: P rations (5: 1), (5: 1), (4:1), (5: 1) and (4:1), respectively. B R scale (13.33 %) had a N: P ratio of 5:1, followed by Hamsa (13.3 %) had (5:1), KRH-2 (15.0 %) had (5:1) and MTU 1010 (17.78 %) had (4:1).

Effect of Nitrogen (N) to Potassium (K) ratio on sheath blight severity in rice

The leaf samples of healthy genotypes had a low N: K ratio ranging from 0.4 to 0.8: 1,whereas, the leaf samples of infected genotypes had a high N: K ratio ranging from 0.9 to 5:1.

Effect of Phosphorous (P) to Potassium (K) ratio on sheath blight severity in rice

Healthy genotype leaf sample showed a low P: K ratio ranging from 1: 8-13, whereas infected genotype leaf samples had a high P: K ratio ranging from 1: 4 - 7. Thus, the nutrient ratios was higher in infected genotypes and *vice versa*.

CONCLUSION

Present study focused on the relationship between nutrient content and the sheath blight severity in different rice genotypes. It was observed that nitrogen, phosphorous, magnesium, iron and zinc were positively correlated with the severity of sheath blight, which depicted even a slight increase in the quantity of these nutrients has the potential to increase the disease severity, whereas potassium, calcium, sulphur, copper and manganese were negatively correlated, means that sheath blight severity can be lowered by proper and sufficient supply of these nutrients. The study also showed nutrient ratios and found that infected genotypes had greater N: S, N: P and P: S ratios than healthy genotypes.

However, the infected genotypes had lower K: S, N: K and P: K than the healthy genotypes. Since each and every nutrient is important for every crop and also for every pathogen, it is necessary to exploit the best precautionary and indirect methods of disease control through fertilization by studying the best method, dose and time of application of nutrients.

DECLARATION

Conflict of Interest. Authors declare no conflict of interest.

REFERENCES

Andreson, E., Peiter, E., Kupper, H. 2018. Trace metal metabolism in plants. *J. Exp. Bot.* **69**: 909–954.

Bhunkal, N., Singh, R., Mehta, N. 2015. Assessment of Losses and Identification of slow blighting genotypes against sheath blight of rice. *J. Mycol. Plant Pathol*. **45**: 231-239.

Bodegom, P.M.V., Brokeman, R., Dijk, J.V., Bakker, C., Rien, A. 2005. Ferrous iron stimulates phenol oxidase activity and organic matter decomposition in waterlogged wetlands. *Biogiochemistry*. **76**: 69-83.

Bradsley, C., Lancester, J. 1965. Sulphur, method of soil analysis. 1102.

Chethana, B.S., Deepak, C.A., Rajanna, M.P., Ramachandra, C., Shivakumar, N. 2016. Current scenario of rice diseases in Karnataka. *Int. J. Sci. Nat*. **7**: 405-412.

Dobermann, A., Fairhurst, T.H. 2002. Rice straw management by better crops. *Int. Spcl. Suppl.***16**: 212-215.

Huber, D.M., Thompson, I.A. 2007. Nitrogen and plant disease. In: Datnoff, Elmer and Mineral Nutrition and Plant Disease. *Phytopathol*ogy **158**: 160- 166.

IRRI. 1996. Standard Evaluation System Manual. International Rice Research Institute, Manila, Philippines: 35.

Krauss, A. 2001. Potassium and biotic stress. www. ipi@ipitotash.org.

Kumar, K.V., Reddy, M.S., Kloepper, J.W., Lawrence, K.S., Groth, D.S., Miller, M.E. 2009. Sheath blight disease of rice (*Oryza sativa* L.) - An overview . *Biosci. Biotechnol. Res. Asia.* **6**: 465-480.

Laha, G.S.V., Prasad, P., Muthuraman, M., Prasad, S., Brajendra, A., Yugander, Babu, R. 2016. Mineral nutrition for the management of rice diseases. *J. Plant Prot. Res*. **9**: 310-313.

Lindsay, W.L., Norwell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am J.* **42**: 421–28.

Molla, K.A., Karmakar, S., Molla, J., Bajaj, P., Rajeev, K., Varshney, Swapan Datta, K., Datta, K. 2020. Understanding sheath blight resistance in rice. *Plant Biotechnol. J*. **18**: 895–915.

Piper, C.S. 1966. Soil and Plant Analysis. *J. Am. Pharm. Assoc*. **35**: 192-193.

Prabhu, A.S., Fageria, N.D., Berni, R.F., Rodrigues, F.A. 2007. Phosphorus and plant disease. *Int. J. Mol. Sci*. **3**: 112-114.

Prasad, D., Singh, R., Tomer, A., Singh, R.N. 2020. Effect of different doses of plant nutrients on sheath blight and phenolic content of rice. *Int. J. Curr. Microbiol. App. Sci.* **9**: 4111-4122.

Schurt, D.A., Duarte, H.D., Lopes, U.P., Rodrigues, F.A. 2014. Influence of nitrogen content on rice leaf sheaths on sheath blight development. *Sci. Agrar*. **17**: 50.

Singh, P., Mazumdar, P., Harikrishna, J.A., Babu, S. 2010. Sheath blight of rice: a review and identification of priorities for future research. *Planta*. **250**:1387– 1407.

Slaton, N.A., Cartwright, R.D., Meng, J., Gbur, E.E., Norman, R.J. 2003. Sheath blight severity and rice yield as affected by Nitrogen fertilizer rate, application method, and fungicide. *Agron. J.* **95**: 1489–1496.

Walters, D.R., Bingham, I.J. 2007. Influence of nutrition on disease development caused by fungal pathogens: implications for plant disease control. *Ann. Appl. Biol*. **151**: 307- 324.

Wheeler, B.E.J. 1969. An Introduction to Plant Diseases, John Wiley and Sons Limited, London, 301.

Yang, G., Liu, R., Ma, P., Chen, H., Zhang, R., Wang, X., Hu, Y. 2022. Effects of nitrogen and phosphorus regulation on plant type, population ecology and sheath blight of hybrid Rice. *Plants* **11**:2306.