Original Research Article

Effect of Si with NPK Levels on Growth, Yield and Blast Disease of Aromatic Rice (*Oryza sativa* L.) in North-West Plain Zone of India

Abstract

Rice is an important cereal crop grown all over world. Blast, disease occurs in almost grown area causing significant yield losses. However, yield losses are prominent due to the improper fertilization and disease incidence in rice. Hence the study was carried out during *kharif* season at the Agricultural Research Farm of IFTM University, , Moradabad (U.P.) with the 10 treatment combinations in randomized block design (RBD) with three replications. The percent disease incidence (PDI) and percent disease control (PDC) of rice blast disease in aromatic rice field was significantly influenced with the application of RDF levels and Si spray. Lowest PDI (34.72%) and maximum PDC (39.4%) in aromatic rice was found in treatment T_{10} - (100 % RDF + two Si Spray @ 2 ml/ ltr of water at 15 and 40 DAT). Among all the treatments observed significantly increase in all growth and yield attributes *viz*., plant height (158.84 cm), no. of tillers plant^{-1} (18.67), fresh weight (290.13 g plant^{-1}), dry weight (103.33 g plant^{-1}), panicle length (31.04 cm), no. of grains panical^{-1} (180.78 cm), no. of unfilled grains panical^{-1} (16.70), no. of filled grains panical^{-1} (180.78), sterility percentage (10.36), 1000-seed weight (33.48 g), grain yield (67.16, q ha^{-1}), stover yield (79.60 q ha^{-1}), biological yield (146.77 q ha^{-1}), harvest index (45.76 %) and B: C ratio (2.85), respectively were recorded with the application of T_{10} -(150% RDF + two Si spray @ 2ml / liter of water at 15 DAT & 40 DAT).

Key words: Silicon, NPK levels, Blast disease, Rice, Economics

Introduction

Rice (*Oryza sativa* L.) is considered to be the most important cereal crop grown in different countries around the world. Asian region contributes about 92% of the global production. Rice crop suffer from a number of diseases but most severe disease of rice is rice blast (Naidu *et al*., 2016; Moletti *et al*., 1988; Mbodi *et al*., 1987). The teleomorphic stage of the blast disease causing fungus is *Magnaporthe grisea* whereas *P. oryzae* and *P. grisea* is anamorphic stage (Rossman *et al.,* 1990). The fungus can infect most parts of the plant, but the most destructive phase being nodal or panicle infection (Ou, 1985). The disease may kill the host plant or developments of seeds are prevented when the pathogen infects on neck or panicle.

Silicon exists in all plants grown in soil and its content in plant tissue ranges from 0.1 to 10% (Elmer and Datnoff, 2014). In modern agriculture, Si has already been recognized as a functional nutrient for a number of crops, particularly rice and sugarcane and plays an important role in the growth and development of crops; especially gramineae crops (Hodson *et al.,* 2005). Effects of silicon on yield are related to the deposition of the element under the leaf epidermis which results a physical mechanism of defense, reduces lodging, increases photosynthesis and decreases transpiration losses (Korndorfer *et al*., 2004). Rice is known to be the most effective Si-accumulator crop with the Si accumulation may exceed 10% of the shoot dry weight which is few-fold greater than the essential macronutrients particularly N, P and K (Ma and Takahashi, 2002). Silicon interacts favorably with other applied nutrients and improves their agronomic performance and efficiency in terms of yield response. Also it improves the tolerance of rice plants to abiotic and biotic stresses. Although silicon has not been considered important for vegetative growth but it aids the plant in healthy development under stresses in different grasses especially in rice. Plant tissue analysis has revealed that the optimum amount of silicon is necessary for cell development and differentiation (Liang, *et al.* 2005). Agarei *et al.,* (1993) indicates that silicon application was effective in increasing dry matter production of rice crop. In general, silicon increases leaf area and keeps leaves erect, which improve crop photosynthesis. Silicon deficiency in plants makes them more susceptible to insect feeding, fungal diseases, microorganisms attack and abiotic stresses that adversely affect crop yield and quality. Low silicon uptake has been proved to increase the susceptibility of rice to diseases such as rice blast (Kim, *et al.* 2002), leaf blight, brown spot, stem rot and grain discoloration (Kobayashi, *et al.* 2001; Rodrigues, *et al.* 2001; Massey and Hartley, 2006).

Among various essential plant nutrients, the macro nutrients NPK are crucial for determining the yield and quality. It has been noticed that farmers utilize imbalanced dose of N fertilizer which leads to higher insects/disease attack ultimately producing lower yield (Mannan *et al.,* 2009; Alam *et al.,* 2011). Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh *et al.* 2001). Application of inadequate and imbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.* 2003). The existing fertilizer recommendations for major nutrients in rice are proving to be sub-optimal for attaining higher productivity levels and need a fresh look to revise them to optimum and more balanced levels. Therefore, there is dire need to determine the best level of NPK fertilizers which may give maximum crop productivity with minimum losses. Nutrient management is gaining status and recognition as a possible method for practical control of diseases of crop plants. Keeping this in view, various efforts have been made to find out the effective and successful control and preventive measures for the efficient management of rice blast. Various Si and NPK dose have been effective for controlling rice blast throughout the world mostly in temperate or subtropical regions. Judicious uses of fertilizers are effective in controlling rice blast. Considering the above facts, this research aimed to determine comparative efficiency of different foliar fertilizers doses for the management and control of rice blast disease to enhance the grain yield.

Materials and Methods

A field experiment was conducted during *kharif* 2017-18 at the research farm of IFTM University Lodipur Rajput, Moradabad (U.P.). The experiment consist ten treatment combinations *viz.* (T_1- Control, T_2-100 % RDF, T_3-100 % RDF + one Si spray @ 2 ml/ ltr at 15 DAT, T_4-100 % RDF + two Si spray @ 2 ml/ ltr at 15 DAT and 40 DAT, T_5-125 % RDF, T_6- 125 % RDF + one Si spray @ 2 ml/ ltr at 15 DAT, T_7-125 % RDF + two Si spray @ 2 ml/ ltr at 15 and 40 DAT, T_8- 150 % RDF, T_9- 150 % RDF + one Si spray @ 2 ml/ ltr at 15 DAT and T_{10}-150 % RDF + two Si spray @ 2 ml ltr at15 and 40 DAT) which were tested in RBD and replicated three times. The recommended dose of fertilizers was applied @ 120: 60: 40. The graded levels of NPK were applied through Urea, Diammonium phosphate and Murate of potash. Half dose of urea and full doses of Diammonium phosphate and Murate of potash were applied basally at sowing time. Remaining half dose of Nitrogen was given in two equal splits at 25 DAT and 50 DAT. Healthy seedlings of rice *cv. IMR 002* (aromatic group) were transplanted in main field on dated 14/07/2017. First thinning and weeding was done during the first fortnight of August, 2017.

Observation on disease incidence and disease control were recorded from randomly selected five tagged plants from each net plot and calculate with the help of following formula:

1.1 Percent Disease Incidence (PDI)

The disease was scored from randomly selected five plants from each plot, one week after the last application of Si and NPK by using 0 – 9 disease rating scale given by International Rice Research Institute (IRRI, 1996) as shown in table below and then converting into percent disease incidence and severity by using the following formula.

$$\text{Percent Disease Incidance} = \frac{\text{Number of Infected plant}}{\text{Total number of plant observed}} \times 100$$

Table 1. Disease scoring scale for leaf blast of rice caused by *Pyricularia oryzae* (IRRI System, 1996)

Scale	Description	Host Behaviour
0	No lesion observed	Highly Resistant
1	Small brown specks of pin point size	Resistant
2	Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in with a distinct brown margin. Lesions found on the lower leaves	Moderately Resistant
3	Lesion type same as in 2, but significant number of lesions on the upper Leaves	Moderately Resistant
4	Typical susceptible blast lesions, 3 mm or longer infecting less than 4% of leaf area	Moderately Susceptible
5	Typical susceptible blast lesions of 3 mm or longer infecting 4-10% of the leaf area	Moderately Susceptible
6	Typical susceptible blast lesions of 3 mm or longer infecting 11-25% of the leaf area	Susceptible
7	Typical susceptible blast lesions of 3 mm	Susceptible
8	Typical susceptible blast lesions of 3 mm or longer infecting 51-75% of the leaf area, many leaves are dead	Highly Susceptible
9	Typical susceptible blast lesions of 3 mm or longer infecting more than 75% leaf area affected	Highly Susceptible

(Source: IRRI, 1996)

1.2 Percent Disease Control (PDC)

$$\text{Disease Control (\%)} = \frac{C - T}{C} \times 100$$

Where,

C = Per cent disease incidence in untreated plot

T = Per cent disease incidence in treated plot

Observations on growth and yield attributes were recorded from five plants selected randomly from the net plots, while the grain and straw yield was recorded from the net plots at harvest and recorded as kg ha^{-1}. It was converted into q ha^{-1} to multiplying the conversion factor. The data was analyzed statistically following the procedure of Gomez and Gomez (1984). The critical differences (CD) at 5% level were worked out for comparing the treatment means wherever 'F' test was found significant.

2. Results and Discussion

2.1 Disease study:

The percent disease incidence of rice blast disease in aromatic rice field was significantly influenced with application of RDF levels and Si spray (Table - 2). Lowest incidence of blast disease (34.72%) in aromatic rice was found with treatment T_4 (100 % RDF + two Si spray @ 2 ml/ltr of water at 15 and 40 DAT). It is attributed due to the Si confers rigidity and strength, resistance against pests and diseases, improves water economy by reducing transpiration rate, alleviates the ill effects of a biotic stresses and enhances crop yield. The same findings also reported by Vasanthi *et al.,* (2014).

The per cent disease control of rice blast disease in aromatic rice field was significantly influenced with application of RDF levels and Si spray (Table - 2). The maximum per cent of disease control (39.4%) in aromatic rice was found with the application of T_4 (100 % RDF + two Si Spray @ 2 ml/ ltr at 15 and 40 DAT). It is attributed due to the Si confers rigidity and strength, resistance against pests and diseases, improves water economy by reducing transpiration rate, alleviates the ill effects of a biotic stresses and enhances crop yield. The same findings also reported by Vasanthi *et al.*, (2014).

2.2 Growth attributes:

The plant height of rice up to harvesting stage significantly influenced with the application of 150 % RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT). Maximum plant height (cm) was noted under this treatment up to harvesting of crop (Table - 2). It may be attributed due to the sufficient availability of plant nutrients as like nitrogen, phosphorus, potassium and silicon to aromatic rice plant. These results are conformity with those already reported by Ahmad *et al*., (2013), Javeed *et al.,* (2017) and Singh *et al.,* (2020).

The number of tillers plant^{-1}of aromatic rice significantly influenced with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}). In this combination maximum number of tillers plant^{-1} were recorded (Table – 2). It may be attributed due to the maximum availability of plant nutrients as like nitrogen, phosphorus, potassium with Si to aromatic rice plant. Same findings are also reported by Mahyar *et al.,* (2013) and Singh *et al.,* (2020).

Dry weight (g plant^{-1}) of aromatic rice were gradually increased up to the harvesting of crop with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-}

^{1}) (Table - 2). It may be attributed due to the sufficient availability of plant nutrients as like nitrogen, phosphorus, potassium with Si to aromatic rice plant up to the maturity of crop. The same findings also reported by Javeed, *et al*., (2017) and Singh *et al.,* (2020).

2.3 Yield attributes:

The panicle length was recorded maximum (31.04 cm) with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}) (Table - 3). It may be attributed due the more availability of nutrients to plant. The number of grains $panical^{-1}$ was significantly influenced and with application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}) was observed maximum number of grains (203.38) $panical^{-1}$ and the number of unfilled grains $panical^{-1}$ was significantly influenced with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}) and it was observed minimum number of unfilled grains (16.70) $panical^{-1}$ (Table - 3). Sterility percentage was observed minimum (10.36) with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}). It is attributed due to the more availability of nutrients for photosynthesis to aromatic rice plant. The results are in conformity with those already reported by Ataollah *et al.,* (2014), Jugal and Ramani (2016) and Singh *et al.,* (2020).

1000 - Seed weight (g) was failed to touch the level of significance (Table - 3). But numerically highest 1000- seed weight (21.79 g) was recorded with 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}). It might be due to the genetically character of any crop. The results are in conformity with those already reported by Singh *et al.*, (2020).

Grain yield and biological yield (q ha^{-1}) were significantly influenced with the application of 150% RDF + two Si spray @ 2 ml/ltr at (15 and 40 DAT ha^{-1}) and recorded highest grain and biological yield (67.17 q ha^{-1} and 146.77 q ha^{-1}) respectively, in this treatment this may be increased due to the maximum availability of plant nutrients. The same findings are also reported by Amin *et al.,* (2004), Srivastava *et al*., (2013), Srivastava *et al.,* (2016), Jugal and Ramani (2016), Singh *et al.,* (2017), Javeed *et al*., (2017) and Singh *et al.,* (2020).

Harvest index (%) was significantly influenced and with the application of T_{10} (150% RDF + Si spray @ 2 ml/ltr at 15 and 40 DAT ha^{-1}) and it was registered highest HI (45.76 %). (Table – 3). These results are in conformity with those already reported by Guntamukkala *et al*., (2017), Jugal and Ramani (2016).

2.4 Economics:

The cost of cultivation (Rs 38332) ha^{-1}], gross returns (Rs 1,47,752) ha^{-1}], net returns Rs 109,420 ha^{-1} and benefit: cost ratio, 2.85 ha^{-1} was increased with T_{10} [150 % NPK + two

Si spray over control (Table – 4). It was increased due to the 50% extra NPK + Si spray in rice crop used over the rest treatments. These results are in accordance with those of Mahmood *et al.,* (2015) and *Meena et al.,* (2014) also revealed that cost of cultivation, gross returns, net returns and benefit: cost increased with increasing levels of phosphorus up to 90 kg P_2O_5 ha^{-1}. The silicon application 120 kg Si ha^{-1} recorded highest gross returns (136.1 × 103 and `139.8 × 103 ha^{-1}).

Conclusion:

Rice blast has caused severe loss in the yield of grains over the years leading to scarcity of food. Since rice is the staple crop of Indian people, it is necessary to adopt appropriate strategy for the control of blast. From the research, it was found that the judicious use of fertilizers were effective against blast disease as compared to control one. T_{10} was the most significant among other doses of fertilizers with least disease incidence % and high grain yield. Thus, from above findings, it can be concluded that Si and judicious use of NPK can be recommended for farmers to use against blast as it is very effective and easily available in market.

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Table - 2: Growth attributes (plant height, number of tillers plant^{-1} and dry weight (g plant^{-1}), PDI and PDC at harvesting stage as influenced by Si with different NPK levels.

Treatments	Plant height (cm)	Number of tillers plant^{-1}	Dry weight (g plant^{-1})	Percent Disease Incidence (PDI)	Percent Disease Control (PDC)
T_1- Control	122.96	9.90	59.33	47.05 (43.28)	00 (0.0)
T_2- 100 % RDF	140.27	11.70	71.67	40.15 (39.29)	29.76 (22.4)
T_3- 100 % RDF + one Si spray @ 2 ml/ltr at 15 DAT	144.10	12.87	75.00	39.12 (38.70)	35.95 (25.7)
T_4-100 % RDF + two Si spray @ 2 ml/ltr at 15 DAT and 40 DAT	147.20	11.8	76.67	34.72(36.09)	47.43 (39.4)
T_5-125 % RDF	148.31	13.89	76.67	40.48 (39.41)	27.51 (21.3)
T_6-125 % RDF + one Si spray @ 2 ml/ltr at 15 DAT	150.53	13.85	79.00	39.80 (39.11)	30.78 (23.5)
T_7-125 % RDF + two Si spray @ 2 ml/ltr at 15 DAT and 40 DAT	151.98	14.11	84.67	37.05 (37.47)	45.97 (32.2)
T_8-150 % RDF	152.95	15.17	87.00	41.04 (39.82)	25.04 (19.5)
T_9-150 % RDF + one Si spray @ 2 ml/ltr at 15 DAT	154.13	15.22	88.00	40.54 (39.52)	30.05 (21.1)
T_{10}-150 % RDF + two Si spray @ 2 ml/ltr at15 DAT and 40 DAT	158.84	15.29	103.33	37.38 (37.64)	43.16 (31.0)
SEm±	0.428	0.584	0.608	0.394	0.587
CD at 5%	1.280	1.749	1.819	1.179	1.76

*RDF = Recommended dose of fertilizers,
*DAT = Days after transplanting,
*PDI = Percent disease incidence,
*PDC = Percent disease control
*Si = Silicon

Table - 3: Yield attributes and yields of aromatic rice as influenced by Si with different NPK levels.

Treatments	Panicle length (cm)	No. of grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Sterility (%)	1000 seed weight (g)	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	HI (%)
T_1- Control	21.37	115.19	37.67	48.57	17.55	30.17	69.66	43.30
T_2- 100 % RDF	28.72	192.74	33.88	21.35	18.60	49.13	108.46	45.30
T_3- 100 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	28.78	200.17	33.40	20.07	19.96	50.72	112.67	45.02
T_4-100 % RDF + two Si Spray @ 2 ml ltr at15 and 40 DAT	29.13	200.59	32.71	19.16	20.50	52.16	115.33	45.22
T_5-125 % RDF	29.17	201.60	30.57	17.79	20.56	52.53	117.41	44.74
T_6-125 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	29.33	202.80	29.33	16.80	20.68	53.67	119.35	44.96
T_7-125 % RDF + two Si Spray @ 2 ml ltr at15 and 40 DAT	29.44	203.11	28.22	16.10	21.17	54.54	121.33	44.95
T_8-150 % RDF	29.94	203.31	26.10	14.77	21.37	58.10	128.33	45.27
T_9-150 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	30.24	203.32	23.73	13.34	21.69	61.00	136.80	44.59
T_{10}-150 % RDF + two Si Spray @ 2 ml ltr at15 and 40 DAT	31.00	203.38	16.70	10.36	21.79	67.17	146.77	45.76
SEm±	0.654	0.64	0.747	0.267	1.43	0.386	0.451	0.262
CD at 5%	1.959	1.91	2.237	0.801	NS	1.156	1.350	0.786

*RDF = Recommended dose of fertilizers,
*DAT = Days after transplanting,
*Si = Silicon

Table - 4: Economics of rice cultivation as influenced by Si with different NPK levels

Treatment	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio
T_1 – Control	26300	66352	40052	1.52
T_2 -100 % RDF	31588	108086	76498	2.42
T_3 -100 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	33588	111584	77996	2.32
T_4 -100 % RDF + two Si Spray @ 2 ml/ ltr at 15 and 40 DAT	35588	114730	79142	2.22
T_5 -125 % RDF	32910	115566	82656	2.51
T_6 -125 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	34910	118052	83142	2.38
T_7 -125 % RDF + two Si Spray @ 2 ml/ ltr at 15 and 40 DAT	36910	119988	93368	2.25
T_8 -150 % RDF	34232	127600	100068	2.71
T_9 -150 % RDF + one Si Spray @ 2 ml/ ltr at 15 DAT	36332	136400	109420	2.75
T_{10} –150 % RDF + two Si Spray @ 2 ml/ ltr at 15 and 40 DAT	38332	147752	109400	2.85

*RDF = Recommended dose of fertilizers,
*DAT = Days after transplanting,
*Si = Silicon