Oryza Vol. 51 No.4, 2014 (297-301)

Effect of diatomacious earth on yield and disease infestation of rice

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ABSTRACT

A study was undertaken to determine the effect of diatomaceous earth (DE a source of Silicon) on yield and disease infestation of rice. The experiments were carried out in old alluvial zone of West Bengal during 2012 - 2013. All the treatments were performed in a completely randomized block design. Results showed a significant increase in grain yield with Si application. Highest grain yield was found in the treatment of DE @ 600 kg ha^{-1} along with POP (package of practice). The POP contained FYM @ 5 t ha^{-1}, $ZnSO_4$. $7H_2O$ @ 25 kg $ha^{-1}$and N: P: K :: 100:50:50 kg ha^{-1}. All the treatments of Si were found to have a significant effect in promoting and disease resistance while higher doses of DE had a better effect than lower one. The investigation concludes that application of diatomaceous earth @ 600 kg ha^{-1} along with POP was effective to increase the grain yield of rice. Whereas, regarding reduction of pest and disease infestation DE application (@600 kg ha^{-1}) showed significant effect when amalgamated with half the package of practice.

Key words: *diatomaceous earth, rice, silicon, grain yield, pest, disease*

Silicon (Si) is the second most abundant element in the soil after oxygen (Epstein, 1999). Although Si is abundant in the earth crust, its availability in soil is very low due to its low solubility (Lindsay, 1979). Plants can only absorb Si in the form of soluble monosilicic acid (H_2SiO_4) a non-charged molecule that has a significant role in imparting biotic and abiotic stress resistance, and enhancing crop productivity (Ma *et al.,* 1989). Silicon as a most abundant mineral element in plant tissues and shoot concentrations in excess of 0.1 to 10% dry weights have been reported (Epstein, 1999). However, Si-containing fertilizers are routinely applied to several crops including rice (Pereira *et al*., 2004) and sugarcane (Savant *et al*., 1999) to obtain good crop yield. Increase in silicon supply improves the structural integrity of crops and also improves plant tolerance to diseases, drought and metal toxicities (Epstein, 1999; Ma *et al*., 2004).

The beneficial effect of Si has been thought due to the precipitation of amorphous silica in plants which acts as a mechanical barrier (Cheng, 1982). It has been observed that Si also protects the plant by other processes which can heighten the guard mechanisms, including the accumulation of lignin, phenolic compounds, and phytoalexins (Epstein, 1999; Ma and Yamaji, 2006). In case of an attack by pathogenic fungi, Si triggers a rapid and widespread deployment of the natural defenses of the plant (Fauteux *et al*. 2005) either indirectly by sequestering cations or directly by increasing some protein activity. Different researcher reported that for plant defense, the epidermal cells in Si-fertilized plants produce phenolic compounds, callose, or methylaconitate (phytoalexin) (Belanger *et al*. 2003). Gascho, 2001 reported that diatomaceous earth should meet a number of criteria, such as solubility, availability, sui physical properties and have acceptably low levels of contaminants. Silicon supply improves plant tolerance to diseases, drought and metal toxicities (Epstein, 1999; Ma *et al*., 2004). The intensity of rice diseases in regions with poor level of silicates (Si) in the soil, together with high control costs, can make the cultivation of rice unfeasible. Therefore, the aim of this study was undertaken to determine the effect of diatomaceous earth (DE) on yield and disease infestation of rice.

MATERIALS AND METHODS

The study was carried out at old alluvial zone (Madandanga) of West Bengal, India during 2012 and 2013. The soil texture of the experimental location was silty clay loam with slightly alkali in nature (pH-7.41), organic carbon (1.02 %), available N,P & K content was 138.60, 31.18 & 301.45 kg ha^{-1}, respectively and available silicon content was 43.00 µg g^{-1}. Experiment was laid out in randomized block design with nine treatments *viz*., untreated control ; package of practice (POP); ½ POP; POP + DE @ 150 kg ha^{-1}; POP + DE @ 300 kg ha^{-1}; POP + DE @ 600 kg ha^{-1}; ½ POP + DE 150 kg ha^{-1} ; ½ POP + DE @ 300 kg ha^{-1} and ½ POP + DE @ 600 kg ha^{-1} with three replications in rice cv Swarna Masuri. Twenty five-day old seedlings were planted with a spacing of 20 × 10 cm. Recommended dose of P_2O_5 (as single super phosphate) were applied in full , K_2O (as muriate of potash) were applied in full. Nitrogen was N (as Urea) was applied as basal in half and remaining half nitrogen was given as two splits at 30th and 45thday after planting. The POP contained FYM @ 5 t ha^{-1}, $ZnSO_4$. $7H_2O$ @ 25 kg $ha^{-1}$and N: P: K :: 100:50:50 kg ha^{-1}. Meteorological data of the experimental location during rice crop growth period of two years were recorded (Table 1).

Initial physico-chemical properties of the experimental soil were analyzed by standard procedures outlined by (Jackson, 1973). Available Si in soil samples were determined by using 0.01M $CaCl_2$extractant (soil: extractant :: 1:10) following the method of Haysom and Chapman (1975).

0.1 g sample was digested in a tri-acid mixture (7 mL of 62% HNO_3, 2 mL 30% of $H_2O_2$and 1 mL of 46% HF) and kept it for 10–15 min for pre-digestion. The samples were digested using microwave digester. The digested samples were diluted to 50 mL with 4% boric acid (Ma *et al*. 2002). 0.1 mL of digested aliquot was placed into a plastic centrifuge tube and mixture of reagents (3.75 mL of 0.2 N Hydro Chloric acid, 0.5 mL of 10% Ammonium Molybdate and 0.5 mL of 20% Tartaric acid and 0.5 mL of Reducing agent (ANSA)) was added sequentially. For Si determination, the aliquot volume was made up to 12.5mL with distilled water and kept it for one hour. The reading was taken in an UV-visible spectrophotometer at 600 nm wavelength. Similarly, standards (0, 0.2, 0.4, 0.8, and 1.2 ppm) were prepared by the same procedure.

Observations were taken at maximum tillering stage (45-55 DAT) and dough stage (90-100 DAT) to record disease incidence based on 0-9 scale (IRRI, 2002). The experimental data were analyzed as per the procedure outlined by Gomez and Gomez (1994).

The Diatomaceous Earth (DE) commercially manufactured by Agripower Australia and was used in the field experiment. Composition in percentage of DE is (63.70 (SiO_2), 0.02 (P_2O_5), 0.40 (K_2O), 2.70 (CaO), 3.25 (MgO), 2.00 (Fe_2O_3), 0.02 (MnO_2), 15.30 (Al_2O_3) and 0.55 (Na_2O).

RESULTS AND DISCUSSIONS

Among the different treatments, application of POP + 600 kg DE ha^{-1} recorded maximum grain and straw yield of rice (Table 2). Higher grain and straw yield due to Si may be attributed to increased growth and yield characters of rice, reducing biotic and abiotic stress, better plant growth, greater photosynthetic efficiency and increased number of productive tillers. Gholami *et al*., 2013 concluded that siliceous fertilizers significantly increased stems and leaves silicon concentration, tiller number, leaves dry weight, 1000 grain weight and yield.

Table 1. Meteorological data of experimental station during rice crop growth period of 2012 and 2013

Months	Rainfall (mm)		No. of Rainy days		Maximum Temperature (°C)		Minimum Temperature (°C)	
	(2012-13)	(2013-14)	(2012-13)	(2013-14)	(2012-13)	(2013-14)	(2012-13)	(2013-14)
July	264.00	180.30	24.00	21.00	32.28	33.44	26.54	26.46
August	203.30	305.30	22.00	18.00	32.31	32.78	26.44	26.00
September	278.80	475.30	18.00	29.00	32.58	32.76	26.02	25.10
October	29.00	0.00	5.00	0.00	33.48	30.14	22.52	16.60
November	50.20	0.00	4.00	0.00	29.49	30.04	17.33	16.44
December	7.30	0.00	1.00	0.00	25.35	24.30	11.74	10.39

The maximum grain yield of rice (5.26 and 5.17 t ha^{-1}) was observed by the application of 600 kg DE ha^{-1} and along with full POP during 2012 and 2013, respectively. This may be attributed to the increased rate of photosynthesis, increased percentage of filled grains, increase in test weight and reduction in per cent spikelet sterility and disease infestation. Similar result were also found in straw yield of rice. These findings are in accordance with earlier reports by Prakash *et al*., 2011. Average increase in grain and straw yield of rice over control were 67.96, 50.33 and 61.33, 43.11 in, (Table 2).

DE as a source of silicon has a good impact to increase the silicon content in different parts of rice viz. grain and straw (Table 3). Application of POP along with DE @600 kg ha^{-1} showed higher efficiency for Si uptake in rice plant parts. 50.00% over control in growth and straw (52.85% over control). Prakash *et al*., 2011 reported that application of silicon increase grain and straw silicon content.

Addition of diatomaceous earth as a source of silicon had influenced incidence of pest and diseases. Results indicated that disease was significantly decreased due to application of higher dose of DE (DE @ 600 kg ha^{-1}) treatment. Application of POP + DE @ 600 kg ha^{-1} also significantly reduces the incidence of diseases in comparison to other treatments. Application DE also reduced the disease infestation of rice at maximum tillering and dough stage (Fig 1 and 2). It decreases 2.1% of blast, 49.17% of brown spot and 42.58% of sheath blight infestation over POP during maximum tillering stage of rice. Treatment 100 % POP + DE @600 kg ha^{-1} has pronounced report to reduce discoloration % (29.71%, 2.95% and 15.32% over

Table 2. Effect of diatomaceous earth Si on grain and straw yield (kg ha^{-1}) of rice

Treatments	2012				2013			
	Grain yield	Straw yield	Percent increase of grain yield over control	Percent increase of Straw yield over control	Grain yield	Straw yield	Percent increase of grain yield over control	Percent increase of grain yield over control
Control	2700	4787	-	-	2800	5000	-	-
Package of practice (POP)	4763	7119	76.41	48.72	4610	6900	64.64	38.00
½ POP	4005	6767	48.33	41.36	3969	6490	41.75	29.80
POP + DE @ 150 kg ha^{-1}	4929	7602	82.56	58.81	4797	7398	71.32	47.96
POP + DE @ 300 kg ha^{-1}	4862	7268	80.07	51.83	4952	7400	76.86	48.00
½POP + DE @ 300 kg ha^{-1}	4125	6968	94.93	64.05	4323	7300	84.82	53.64
½POP + DE @ 600 kg ha^{-1}	4228	7060	52.04	44.85	4111	6972	50.00	42.04
CD (P<0.05)	259.832	418.665	56.59	47.48	223.993	362.080	46.82	39.44

Table 3. Effect of diatomaceous earth Si on silicon concentration (%) and uptake (kg ha^{-1}) of rice in 2012 and 2013

Treatments	Concentration (%)		Uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw
T_1: Control	0.40	2.46	11.0	120.3
T_2: 100 % POP	0.50	2.66	23.5	186.1
T_3: 50 % POP	0.47	2.55	18.0	169.0
T_4: T_2 + DE @150 kg ha^{-1}	0.53	2.93	25.8	219.4
T_5: T_2 + DE @300 kg ha^{-1}	0.57	3.36	27.7	246.3
T_6: T_2 + DE @600 kg ha^{-1}	0.60	3.76	31.1	292.2
T_7: T_3 + DE @150 kg ha^{-1}	0.48	3.02	19.7	211.7
T_8: T_3 + DE @300 kg ha^{-1}	0.50	3.08	20.9	219.5
T_9: T_3+ DE @600 kg ha^{-1}	0.52	3.11	21.7	218.0
CD (P<0.05))	0.031	0.129	1.369	8.758

POP,POP + DE @ 150 kg ha^{-1} and POP + DE @ 300 kg ha^{-1}) and disease infection of rice at dough stage than other treatments of full POP. It has been observed that treatment 100 % POP+ DE @600 kg ha^{-1} and 50 % POP+ DE @600 kg ha^{-1} has given good result to reduce pest-insect and disease infestation. But in comparison to yield and Si availability in plant, treatment 100 % POP + DE @600 kg ha^{-1} found better than 50 % POP+ DE @600 kg ha^{-1} and other treatments. Regarding other treatments particularly for introducing 100% package of practice showed most susceptible to increase disease and pest

Notes: T_1= Control, T_2= 100 % POP, T_3= 50 % POP, T_4= T_2 + DE @150 kg ha^{-1}, T_5= T_2 + DE @300 kg ha^{-1}, T_6= T_2 + DE @600 kg ha^{-1}, T_7= T_3 + DE @150 kg ha^{-1}, T_8= T_3 + DE @300 kg ha^{-1}, T_9= T_3+ DE @600 kg ha^{-1}

Fig 1. Effect of diatomaceous earth on the disease infestation at maximum tillering stage of rice

Notes: T_1= Control, T_2= 100 % POP, T_3= 50 % POP, T_4= T_2 + DE @150 kg ha^{-1}, T_5= T_2 + DE @300 kg ha^{-1}, T_6= T_2 + DE @600 kg ha^{-1}, T_7= T_3 + DE @150 kg ha^{-1}, T_8= T_3 + DE @300 kg ha^{-1}, T_9= T_3+ DE @600 kg ha^{-1}

Fig 2. Effect of diatomaceous earth on the disease infestation at maximum tillering stage of rice

infestation due to having more succulence in plants because higher dose of N and may be due to avoid any pesticide, insecticide. But incorporation of Si with POP can reduce the pest-disease infestation and can increase yield of rice significantly. Ma *et al*., 2004 reported that application of silicon decrease the pest and disease infestation of rice. In Si deficient soils it has been shown that Si reduces the severity of rice blast (Seebold *et al.,* 2000). Application of Wollastonite as a silicon source increased total grain weights, leaf Si content increased as well as total accumulated of Si in the plant with Si added to the soil. Silicon also dramatically reduced grain discoloration (Korndorfer et al 1999). Wattanapayapkul *et al*., 2011 concluded that application of higher dose silicon 100kg ha^{-1}, leaf and neck blast severity were reduced by 83 and 75%.

In conclusion, the results of the study highlight the role diatomaceous earth silicon in improving rice yield in all the treatments over control as well as 100 % POP. We suggest that application of Si through DE@ 600kg ha^{-1} along with POP to obtained significantly higher rice grain yield. It is also recommended that application of Si through DE@ 600 kg ha^{-1} along with ½POP could reduce the disease infestation of rice.

ACKNOWLEDGEMENT

Authors are thankful to Agripower Australia for funding and Dr. S. Das, Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya for evaluation of disease incidence.

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