EFFECT OF SILICON THROUGH DIATOMACEOUS EARTH ON GROWTH, YIELD AND ECONOMICS OF AEROBIC RICE IN CAUVERY DELTA ZONE

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Abstract: Field investigation was conducted during Kuruvai, 2013 to study the effect of silicon through diatomaceous earth on growth, yield and economics of aerobic rice in Cauvery delta zone. The field experiment consisted of four rice varieties (ADT 47, ASD 16, CO 47 and IR 64) and four levels of silicon (0,120, 240 and 360 kg Si ha-^{1} through Diatomaceous Earth). The experiment was laid out in randomized block design with factorial arrangements and replicated thrice. Among the different rice varieties tried, ASD 16 recorded higher growth attributes viz., plant height, number of tillers hill^{-1}, leaf area index and dry matter production, yield attributes viz. number of panicles m^{-2}, number of grains panicles^{-1} and test weight, which in turn accelerated the higher grain and straw yield under aerobic condition. Regarding different levels of silicon, application of silicon at 360 kg ha^{-1} favorably enhanced the growth attributes viz, plant height, number of tillers hill^{-1}, leaf area index and dry matter production, yield attributes viz., number of panicles m^{-2}, number of grains panicles^{-1} and test weight. It also significantly recorded higher grain and straw yield under aerobic condition. The interaction between different rice varieties and silicon levels had significant effect of growth, yield attributes and yield of rice. Among the different treatment combination, ASD 16 with 360 kg Si ha^{-1} recorded higher value for growth, yield attributes and yields under aerobic condition. In economics returns, ASD 16 with 240 kg Si ha^{-1} through diatomaceous earth registered higher net return and return rupee-^{1} invested in aerobic rice. Hence it can be concluded that rice variety ASD 16 fertilized with 240 kg Si ha^{-1} diatomaceous earth holds promise as agronomically safe and economically viable practice to the rice farmer under water scarcity condition especially at Cauvery delta zone of Tamilnadu.

Key words: silicon, aerobic rice, growth, yield, economics

I.INTRODUCTION

Food and water are the two most important necessities for survival, but with an increasing demand for food and a looming water crisis, a shortage of food and water may be on the horizon unless innovative technologies are developed. Water is becoming a precious commodity as more and more number of people using it for the household, industry and agriculture. Therefore scientists are now concentrating on developing rice production system that can cope with water scarcity. Around 75% of the rice production comes from 79 million ha of irrigated low land. Over 17 million ha of Asia's irrigated rice may experience "physical water scarcity" and 22 million ha may experience "economic water scarcity'' by 2025. Due to increasing water scarcity, there is a need to develop alternate methods of rice cultivation that require less water. One such strategy is cultivation of rice under aerobic situation (Venkataravana, 1991).

Aerobic rice is a production system where rice is grown in well-drained and non-saturated soils. Water requirement of rice can be lowered by reducing water losses due to seepage, percolation and evaporation. This method of cultivation involves direct sowing with surface irrigations when needed and is characterized by aerated soil environment during the entire growth period of crop comparable to other crops like maize and finger millet. Suitable varieties under aerobic cultivation save about 50-60 per cent of irrigation water. It is also reduces the emission of methane and contributes to lowering of greenhouse gas emission (Ananymous, 2008). To make aerobic rice successful, new varieties and management practices should be developed. Since this is a new concept, there is need to screen more fertilizer responsive and high yielding cultivars adapted to aerobic condition especially in Cauvery Delta Zone where water scarcity is a very big problem during Kuruvai season.

Silicon (Si) is the second most abundant element of the earth's surface. It plays an important role in imparting biotic, abiotic stress resistance and enhancing crop productivity (Jawahar and Vaiyapuri, 2010 and 2013). Silicon is the only element known that does not damage the crop plants with excess accumulation. Recently Si has been reported as quasi-essential element which enhances pest and disease resistance in plants and mitigates metal toxicities (Epstein, 2002). It also offer resistant to drought and minimize lodging in the cereal crops (Munir *et al*., 2003). Diatomaceous earth or DE is a naturally occurring, soft, siliceous sedimentary rock contains 80–90 % silica, 2–4 % alumina and 0.5–2 % iron oxide. Now a day it is used as a source of silicon nutrition for crop production. The available literature on the effect of DE on rice crop is limited particularly under aerobic condition. Keeping the aforesaid facts in consideration, the present investigation was carried out to study the effect of silicon through diatomaceous earth on growth, yield and economics of aerobic rice in Cauvery delta zone.

II.MATERIALS AND METHODS

Field investigation was conducted during Kuruvai, 2013 to study the effect of silicon through diatomaceous earth on growth, yield and economics of aerobic rice in Cauvery delta zone. The field experiment consisted of four rice varieties (ADT 47, ASD 16, CO 47 and IR 64) and four levels of silicon (0,120, 240 and 360 kg Si ha-^{1} through Diatomaceous Earth). The experiment was laid out in randomized block design with factorial arrangements and replicated thrice. The soil of the experimental field is clay loam with low in available N, medium in available P_2O_5, high in available K_2O and low available in silicon. The rice crop was fertilized with 120:38:38 kg of N, P_2O_5 and K_2O ha^{-1} The entire dose of

P_2O_5 and K_2O and half of the dose 'N' was applied as basal along with different level of silicon through Diatomaceous earth. The remaining half of N was top dressed in two equal splits each at active tillering and panicle primordial initiation stages. The data on various characters studied during the investigation were statistically analyzed as suggested by Gomez and Gomez (1984) and wherever the treatment differences were found significant (F test); critical differences were worked out at five per cent probability level.

III.RESULTS AND DISCUSSION

Growth attributes

The growth attributes such as plant height, number of tillers hill^{-1}, LAI, and DMP were significantly influenced with rice varieties and silicon application under aerobic condition (Table 1). Among the different varieties, ASD 16 recorded, increased plant height, number of tillers^{-1}, LAI and DMP compared to other rice varieties. The increased growth attributes might be due to enhanced root system, better utilization of sun light, applied nutrient and also growth rate of the plant. This is accordance with the finding of James Martin (2007) who reported that increase in plant height, LAI, number of tillers hill $^{-1}$ and DMP could be due to increased root activities of rice crop. The least growth attributes were recorded by IR 64 which might be due to decreased root growth and poor adaption to aerobic condition (Boonjung *et al*., 1993). Among the different levels of silicon tried, Si at 360 kg ha^{-1} recorded higher plant height, number of tillers hill^{-1}, LAI and DMP of rice. Increase in plant could be due to increased cell division, elongation and expansion influenced by silicon. This was in agreement with the findings of Yavarzadeh *et al*. (2008) who reported that higher deposition of silica on the plant tissues causing erectness of leaves and stem resulted in increased plant height. Silicon application enhanced the supply of carbohydrate and nutrients to the mother clump which influenced on expanding auxiliary resulted in higher number of tillers plant^{-1}. This was agreement with the finding of Liang *et al*. (1994).The highest LAI at tillering and flowering stage was due to erectness of leaves and more number of leaves. The maximum DMP under Si at 360 kg ha^{-1} could be due to the maintenance of high photosynthetic activity, efficient utilization of light and translocation of photosynthates to sink (Rani *et al*., 1997). In addition, Si improves light interception by keeping leaves erect, thereby stimulating canopy photosynthesis in rice. Similar report was earlier outlined by Chandrashekar (2008). However, combination of rice varieties and silicon recorded highest growth attributes of rice over their individual effect. The highest values for plant height, number of tillers hill^{-1}, LAI and DMP was noticed with ASD 16 plus Si at 360 kg ha$^{-1.}$ Thus the favorable influence of rice varieties and silicon on shoot and root growth resulted in higher growth attributes (Kalyan Singh,2010).

Yield attributes and Yield

Varieties and silicon application significantly influenced the yield attributes and yield of rice under aerobic condition (Table 1). Among the different rice varieties, ASD 16 recorded higher number of panicles m^{-2}, number of filled grains panicle^{-1}, test weight, grain and straw yield under aerobic condition which was closely followed by ADT 47. The increase in yield attributes might to be due to better shoot and root growth effective utilization of light and genetic character of the plant which ultimately leads to higher grain yield. This is accordance with the finding of James Martin (2007) stated that the root length, dry matter production panicle number per unit area and filled grains panicle^{-1} were higher in PMK 3 under aerobic condition. Similar finding was earlier reported by Venkataravana and Hittalamani (2003) who reported that contributing factor for the higher yield could be increased number of tiller, long panicle length, filled grains per panicle^{-1} and grain weight. The lower yield in IR 64 could be due to reduced leaf area index and increased diffusive resistance. Increased diffusive resistance might have reduced photosynthesis and leading to reduce assimilates supply (Boonjung, 1993). Increasing levels of silicon increased the yield attributes and yield of rice. With varying levels of silicon, Si at 360 kg ha^{-1} registered its superiority over lower levels and recorded higher number of panicles m^{-2}, filled grain panicles^{-1}, test weight, grain and straw yield in rice. Panicle formation is directly related to number of productive tillers plant^{-1}, which resulted in higher number of panicle per unit area. Increased filled grain number was due to better assimilation of carbohydrate in panicles (Jawahar and Vaiyapuri, 2010). Higher test weight was attributed to better availability and translocation of nutrients as well as photosynthates from source to sink. These factors together with efficient translocation resulted in more numbers of filled grains, which ultimately led to higher grain and straw yield (Rani and Narayanan, 1994). These findings were in agreement with the reports of Vishwanath (2004) who stated that application of silicon through rice hull ash significantly increased the yield attributes and yields of rice. Jawahar and Vaiyapuri (2013) also reported that application of silicon along with sulphur increased the yield attributes and yield of rice. Among the different combinations, ASD 16 with silicon at 360 kg ha^{-1} significantly increased the yield attributes and yield of rice. This might be due to sustained nutrient supply by Si applied plots which ultimately lead to increased photosynthetic activity by the crop and resulted in higher yield attributes and yield. These results are in conformity with the findings of Chaudhary and Bodiuzzaman (1992) and Sudhakar *et al*. (2004).

Economics

The highest net return and return rupee^{-1} invested of Rs.35530 and 3.08 was associated with the treatment ASD 16 with 240 kg Si ha^{-1} in aerobic rice due to lesser input cost for silicon fertilizer (Diatomaceous Earth) (Table 2). The treatment, ASD 16 with 120 kg Si ha^{-1} was almost on par, registered a return rupee^{-1} invested of Rs. 3.03. The treatment IR 64 with 360 kg Si ha^{-1} registered the least net return of Rs.85 ha^{-1} and return rupee^{-1} invested of 1.0 under aerobic condition due to poor economic yield and higher cost of Diatomaceous Earth.

IV CONCLUSION

Based on the above results, it can be concluded that rice variety ASD 16 fertilized with 240 kg Si ha^{-1} diatomaceous earth holds promise as agronomically safe and economically viable practice to the rice farmer under water scarcity condition especially at Cauvery delta zone of Tamilnadu.

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Table 1 . Effect of Silicon through Diatomaceous Earth on Growth and Yield Attributes of Aerobic Rice

Treatments	Growth attributes				Yield attributes			Yield (kg ha^{-1})	
	Plant height at harvest (cm)	No. of tillers hill^{-1}	LAI at tillering	DMP at harvest (kg ha^{-1})	No. of panicles m^{-2}	No. of grains panicle $^{-1}$	Test weight (g)	Grain	Straw
Factor I- Rice Varieties (V)									
V_1-ADT 47	101.43	14.82	5.89	7554	258.83	120.41	13.46	2732	4962
V_2- ASD 16	104.87	16.96	6.12	7962	266.10	123.45	24.19	3187	5451
V_3-CO 47	97.96	14.82	5.34	6321	249.63	115.54	20.55	1765	3923
V_4-IR 64	88.56	12.20	4.71	5537	232.35	105.39	23.15	1202	3163
S.Ed	1.02	0.32	0.10	65.68	2.94	0.97	0.61	96.34	149.25
CD(P=0.05)	2.06	0.66	0.21	132.0	5.91	1.96	1.27	193.66	300.0
Factor II- Silicon levels (Si) (kg ha^{-1})									
Si_1 - 0	91.09	13.01	5.07	6240	238.47	108.66	20.15	1745	3888
Si_1 -120	97.23	14.63	5.44	6755	248.63	114.90	20.34	2158	4312
Si_1 -240	100.89	15.73	5.69	7067	256.65	119.19	20.43	2409	4538
Si_1 -360	103.62	16.56	5.86	7311	263.17	122.03	20.49	2574	4762
S.Ed	0.89	0.25	0.07	79.7	2.15	0.8	0.50	64	127
CD(P=0.05)	1.8	0.52	0.15	160.20	4.33	1.62	NS	121	255
Interaction (V X Si)									
S.Ed	1.18	0.41	0.15	84.2	3.34	1.15	NS	127	226
CD(P=0.05)	2.38	0.83	0.31	169.42	6.71	2.32	**NS**	255	455

Table 2. Effect of Silicon through Diatomaceous Earth on Economics of Aerobic Rice

Treatment Combinations	Cost of cultivation (Rs.)	Gross income (Rs.)	Net income (Rs.)	Return rupee^{-1} invested
V_1Si_1	12520	33274	20754	2.65
V_1Si_2	14770	40737	25967	2.75
V_1Si_3	17020	43399	26379	2.54
V_1Si_4	21520	45549	24029	2.11
V_2Si_1	12520	35450	22930	2.83
V_2Si_2	14770	44850	30080	3.03
V_2Si_3	17020	52550	35530	3.08
V_2Si_4	21520	56524	35004	2.62
V_3Si_1	12520	22100	9580	1.76
V_3Si_2	14770	23409	8939	1.58
V_3Si_3	17020	25587	8567	1.50
V_3Si_4	21520	25875	4355	1.20
V_4Si_1	12520	14700	2180	1.17
V_4Si_2	14770	17675	2905	1.19
V_4Si_3	17020	19687	2667	1.15
V_4Si_4	21520	21605	85	1.0