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Effect of silica nutrition on growth and yield of aerobic rice (*Oryza sativa* L.)

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Abstract

Field experiment was conducted at Department of Agronomy, Agricultural College and Research Institute, Killikulam during *kharif* season (2019) to study the effect of silica nutrition on growth and yield of aerobic rice (*Oryza sativa* L.). The experiment was carried out in randomized block design (RBD) with thirteen treatments and replicated thrice. Various sources and levels of silica along with potassium were taken as treatments. Growth and yield attributes were significantly influenced by silica application over control. The maximum grain and straw yield were recorded in 100% K + Rice husk ash 4 tons/ha + SSB (T_9) (4212 and 4703 kg ha^{-1}). However, it was on par with100% K + Rice husk ash 2 tons/ha + SSB (T_8). The lowest grain yield was recorded in absolute control (T_{13}).

Keywords: Aerobic rice, rice husk ash, silica solubilizing bacteria, ortho silicic acid

Introduction

Rice (*Oryza sativa* L.) is the most important crop among staple food crops which sustains about two thirds of the world's population (Kahani and Hittalmani, 2015) [5]. In India, it is extensively grown crop occupying an area of 43.78 million hectares with a production of 112.76 million tonnes and with a productivity of 2.58 t ha^{-1}. In Tamil Nadu, the cropping pattern of Thoothukudi district mainly depends on North East monsoon rains. Although the North Eastern monsoon has a significant impact on the state's rainfall distribution and cropping pattern, drought occurs mostly during the southwestern monsoon or *kharif* season (Nanjundiah and Selvaraj, 2014) [6]. Since South West monsoon is lower in Thoothukudi district, the entire season is being left without even a short duration crop. Thus water scarcity is becoming a global concern which is already evident in Indian agricultural sector. Since rice has very low water-use efficiency and consumes 3000 to 5000 l of water to produce one kg of rice, ways to increase water use efficiency under irrigated rice ecosystems were studied by various researchers. Aerobic rice cultivation offers scope with less water requirement, wherein rice can be cultivated as of garden land crops without puddling the soil (Bouman *et al.*, 2015) [1].

Though aerobic rice requires less water as compared to transplanted rice, under scanty water availability coupled with extreme weather may pose water stress to the crop. In this regard, Silica (Si) is a potential nutrient to cope up the effect of water stress in aerobic rice and enhance its productivity. Silica is the second most available element in the soil and it is taken up by the plant as mono silicic acid which acts as an anti-stress agent and reduces transpiration rate up to 30 per cent in rice. One of the ways to minimize the yield gap may be through addition of silica in nutrient management as it is an essential component of rice plants and its accumulation is helpful in maintaining sustainable production of aerobic rice (Jinger *et al.*, 2018) [4]. Considering the above in view, the present study was conducted to determine the effect of silica nutrition on growth and yield of aerobic rice.

Materials and Methods

Field experiment was conducted at the 'B' block farm of Department of Agronomy, Agricultural College and Research Institute, Killikulam during *kharif* season of 2019. The soil of the experimental site was sandy clay loam in texture and neutral in pH. The soil was low in available nitrogen (237 kg ha^{-1}), medium in available phosphorus (18 kg ha^{-1}), and medium in available potassium (228 kg ha^{-1}) and medium in available silica (162.05 kg ha^{-1}). The experiment was laid out in randomized block design, replicated thrice with thirteen treatments in combinations of levels of K (75 and 100 per cent), levels of ortho silicic acid (0.1 and 0.2 per cent), rice husk ash with silica solubilizing bacteria (2 tons and 4 tons ha^{-1}) and absolute control. The seeds were soaked overnight and sown directly in the well-prepared dry seed bed in lines at a spacing of 20 × 10 cm. Fertilizers were applied at a recommended rate of 150:50:50 kg N, P and K ha^{-1}.

The entire P was applied as basal in the form of diammonium phosphate and N and K were applied in the form of urea and muriate of potash at four equal splits during seedling, active tillering, panicle initiation and flowering stages and silicic acid was foliar applied atcritical growth stages. Ortho silicic acid (OSA) was obtained as a proprietary formulation from Neeru Privi Firms.

Results and Discussion

Growth parameters

Growth parameters, *viz*., plant height, leaf area index (LAI) and dry matter production (DMP) were recorded at panicle initiation and flowering stages and found to have significant variation among the treatments.

Plant height is a measure of crop's growth success, as determined by environment and management factors. The plant height increased with the progress of crop growth and it attained maximum at harvest stage. At panicle initiation stage, 100% K + Rice husk ash (RHA) 4 tons/ha + SSB (T_9) registered maximum plant height (66.6 cm) which was on par with application of 100% K + RHA 2 tons/ha + SSB (T_8) (65.5 cm). It was followed by application of 75% K + RHA 2 tons/ha + SSB (T_3) (62.7 cm) and 75% K + RHA 4 tons/ha + SSB (T_4) (62.3 cm), whereas the minimum plant height was recorded in absolute control (T_{13}) (38.0 cm). At flowering stage, maximum plant height was recorded with, 100% K + Rice husk ash 4 tons/ha + SSB (T_9) (109.6 cm) which was on par with application of 75% K + Rice husk ash 4 tons/ha + SSB (T_4) (107.7 cm). Next to this treatment 100% K + RHA 2 tons/ha + SSB (T_8) (105.9 cm) and application of 75% K + RHA 2 tons/ha + SSB (T_3) (103.9 cm) recorded the maximum plant height. The minimum plant height was observed in absolute control (T_{13}) (63.9 cm). Adoption of different treatments had significant influence on rice leaf area index. The leaf area index was steadily increased in its initial stage and reduction was experienced at flowering stage. At panicle initiation stage, application of 100% K + RHA 4 tons/ha along with SSB (T_9) produced plants with largest canopy size of 5.96. This was followed by75% K + RHA 4 tons/ha + SSB (T_4) and application of 100% K + Rice husk ash 2 tons/ha + SSB (T_8) registered higher leaf area index of 5.58 and 5.66. The same trend was followed during flowering stage also. Adoption of different treatments appreciably influenced the DMP at panicle initiation and flowering stages. At panicle initiation stage, application of 100% K + RHA 4 tons/ha along with SSB (T_9) recorded the highest dry matter of 5060 kg ha^{-1}. Next to this, application of 100% K + RHA 2 tons/ha + SSB (T_8) and the treatment 75% K + RHA 4 tons/ha + SSB (T_4) produced more dry matter of 4740 kg ha^{-1} and 4503 kg ha^{-1} and the least dry matter was recorded in control plot (T_{13}) at 1421 kg ha^{-1}. Same trend was observed in flowering stage. Silica as an important nutrient, is responsible for the control of stomata activity, photosynthesis and water use efficiency which ultimately results in better plant height and vegetative growth. Similar finding was also reported by Gong *et al.* (2003) [3] who found that Si supply increased plant height, leaf area and dry mass in wheat under drought. Silica induced erectness of leaves results in increased photosynthesis since more plant parts are exposed to sunlight, improved water use efficiency, decreased transpiration and enhanced photosynthetic activity ultimately leading to better growth and development of crop accumulated more dry matter (Singh *et al*., 2006) [9]. Similarly, Gerami *et al*. (2012) [2] reported that with the increase of Si levels, leaf area of the plant will increase by enhancing photosynthetic rate and dry matter of rice.

Grain and straw yield

The grain and straw yield were significantly influenced by adoption of different treatments (Fig. 1). Among the different treatments, application of 100% K + RHA 4 tons/ha + SSB (T_9) registered highest grain and straw yield (4212 and 4703 kg ha^{-1} respectively) which was on par with application of 100% K + RHA 2 tons/ha + SSB (T_8) (4068 and 4565 kg ha^{-1} respectively). Next to this treatment application of 75% K + RHA 4 tons/ha + SSB (T_4) (3625 and 4083 kg ha^{-1}), application of 100% K + Ortho silicic acid 0.2% foliar spray (T_7) (3502 and 3957 kg ha^{-1}) and application of 75% K + RHA 2 tons/ha + SSB (T_3) (3486 and 3973 kg ha^{-1}), recorded the maximum grain and straw yield and were on par. The absolute control (T_{13}) registered the lowest grain and straw yield of 1618 and 1958 kg ha^{-1}. The increase in grain and straw yield was possibly due to better vegetative growth, effective tillersm-^{2}, higher number of grains panicle-^{1} and 1000-grain weight due to silica application in the form of rice husk ash. Similar results of increase in rice grain yield due to silica application were reported by Prakash *et al.* (2011) [7] and Yogendra *et al.* (2014) [10]. These results are corroborated with the findings by Seebold *et al.* (2010) [8] in wheat and rice and by Malav *et al*. (2015) [5] in rice. From this experiment, it could be concluded that application of silica is indispensable for sustainable production of aerobic rice. Application of 100% K + Rice husk ash 4 tons/ha + SSB was found to be superior with respect to growth and yield of aerobic rice.

Table 1: Effect of levels of ortho silicic acid, rice husk ash and potassium on growth characters of aerobic rice

Treatments		Plant height (cm)		LAI		DMP(kg ha^{-1})	
		Panicle Initiation	Flowering	Panicle Initiation	Flowering	Panicle Initiation	Flowering
T_1	75% K + Ortho silicic acid 0.1% foliar spray	53.0	89.5	2.69	1.78	2506	3650
T_2	75% K + Ortho silicic acid 0.2% foliar spray	58.6	95.9	4.37	3.09	3127	5655
T_3	75% K + Rice husk ash 2 tons/ha + SSB	62.7	103.9	5.40	3.99	4288	7194
T_4	75% K + Rice husk ash 4 tons/ha + SSB	62.3	107.7	5.58	4.12	4503	7394
T_5	75% K + SOP 1% foliar spray	52.7	89.6	1.89	1.84	1666	3433
T_6	100% K + Ortho silicic acid 0.1% foliar spray	57.9	96.4	4.47	3.37	3797	6277
T_7	100% K + Ortho silicic acid 0.2% foliar spray	59.5	97.9	4.61	3.21	4042	6644
T_8	100% K + Rice husk ash 2 tons/ha + SSB	65.5	105.9	5.66	4.22	4740	7911
T_9	100% K + Rice husk ash 4 tons/ha + SSB	66.6	109.6	5.96	4.64	5060	8416
T_{10}	100% K + SOP 1% foliar spray	53.8	95.0	2.92	2.55	2722	4688
T_{11}	75% K alone	52.4	92.2	2.88	1.80	2522	4155
T_{12}	100% K alone	58.1	95.1	3.80	2.94	3212	4950
T_{13}	Absolute control	38.0	63.9	1.59	1.53	1421	3072
	SEd	1.34	1.45	0.08	0.12	134	159
	CD (P=0.05)	2.67	3.00	0.17	0.25	278	344

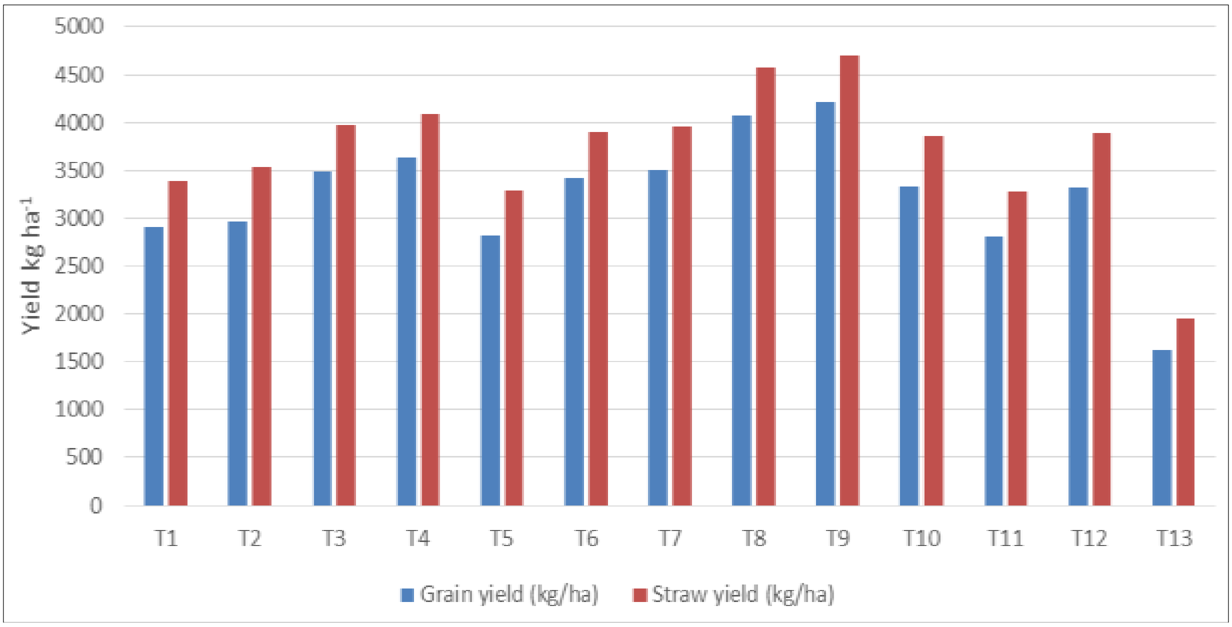

Fig 1: Effect of levels of ortho silicic acid, rice husk ash and potassium on grain and straw yield of Aerobic rice

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