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Productivity of rice as influenced by soil and foliar application of silicon

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Abstract
A field experiment was undertaken to study the effect of soil and foliar application of silicon on crop growth and yield of rice at Krishi Vigyan Kendra (KVK) Sirsi, University of Agricultural Sciences, Dharwad during *Kharif* 2018-19 and 2019-20. The experiment was laid out in a randomized complete block design (RCBD) with three replications and nine treatments. The pooled results concluded that, significantly higher dry matter production (97.76 g hill), number of grains per panicles (121.33), test weight (23.64 g), grain yield (5750 kg ha^{-1}) and straw yield (6960 kg ha^{-1}) of rice was recorded with soil application of silicon @ 200 kg ha^{-1} along with foliar application of silicon @ 0.5 per cent (T_9). However, treatments T_8 and T_7 were on par with T_9. Whereas, lower dry matter production (87.84 g hill-1), number of grains per panicles (97.67), test weight (19.49 g), grain yield (4581 kg ha^{-1}) and straw yield (5621 kg ha^{-1}) was observed in the control (T_1). The yield increase to an the extent of 25.51 and 23.82 per cent, respectively over control.

Keywords: Rice, yield, silicic acid, calcium silicate, foliar application

Introduction

In India, rice occupies an area of 44.72 million hectare with a production of 117.5 million tonnes with an average productivity of 2659 kg per hectare which is almost half of the global average. In Karnataka state rice is grown over an area of 1.50 million hectare with an annual production of about 3.71 million tonnes with an average productivity of 2540 kg per hectare (Anonymous, 2019) [1].

The demand for rice cultivation is steadily increasing due to an increase in Indian population. But, the productivity of rice is almost half of the global average due to some productivity constraints *such as.*, imbalanced nutrition, water scarcity, lodging, pest and diseases and low yielding varieties (Datta *et al.*, 2017) [3]. Among the production constraints nutrient management plays an important role in enhancing and sustaining rice production (Gruhn *et al*., 2000) [5]. Majority of researchers had worked on mostly nutrients like nitrogen, phosphorous and potassium, sulphur, iron and zinc and their usage is already in practice at higher level but still there exist a yield gap in rice. Therefore, interestingly, the only non-essential nutrient that can be included in the fertilization proportion for highest productivity is silicon (Dobermann and Fairhurst, 2000) [4]. Silicon is the one of the second most abundant element in the earth crust. It is not an essential but is a beneficial element for crop growth and development, especially to the members of *Poaceae* family. Application of silicon promotes growth, strengthens culms and favours early panicle formation, increases the number of spikelets per panicle and percentage of matured rice grains and helps maintain erect leaves which are important for higher rate of photosynthesis, production of phenols which stimulates phytoalexin production, reduces lodging, decreases transpiration losses and increases photosynthesis capacity of crop plants and a significant role in hull formation in rice and in turn seems to influence on grain quality (Bhaskaran, 2014) [2]. The present study aimed to assess the effect of calcium silicate as a silicon source and silicic acid (Mono silicic acid) sources on crop growth and yield of rice plants.

Materials and Methods

An experiment was carried out at D block of the Krishi Vigyan Kendra, Sirsi, University of Agricultural Sciences, Dharwad which lies between 14.61'95" North latitude, a longitude of

74.83’54” East and at an altitude of 790 m above MSL. It is situated in the Hilly Zone (Zone IX) of agro-climatic zones of Karnataka. The experimental soil was acidic pH 5.42, EC 0.14 dS/m non saline and low in organic carbon (4.10 mg kg^{-1}), available N, P_2O_5, K_2O (192.2, 19.50 and 120.9 kg ha^{-1}, respectively) and Ca and Mg, 4.10 (cmol (p+) kg^{-1}) and 1.35 (cmol (p+) kg^{-1}) S (17.6 ppm) respectively). Among the available micronutrients, Cu, Fe, Mn and B were above critical level (3.13, 67.20, 60.12, 0.51 and 0.69 mg kg^{-1}, respectively) and Zinc was deficient in the soil (0.51 mg kg^{-1}). Available silicon (73.46 mg kg^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications and nine treatments *such as.*, T_1: Control (RPP), T_2: Soil application of silicon @ 100 kg ha^{-1}, T_3: Soil application of silicon @ 200 kg ha^{-1}, T_4: Foliar application of silicic acid @ 0.25%, T_5: Foliar application of silicic acid @ 0.50%, T_6: Soil application of silicon @ 100 kg ha^{-1} + Foliar application of silicic acid @ 0.25%, T_7: Soil application of silicon @ 100 kg ha^{-1} + Foliar application of silicic acid @ 0.50%, T_8: Soil application of silicon @ 200 kg ha^{-1} + Foliar application of silicic acid @ 0.25% and T_9: Soil application of silicon @ 200 kg ha^{-1} + Foliar application of silicic acid @ 0.50%, RPP: Recommended package of practice (FYM @ 7 t ha^{-1} + 75:75:90 N, P_2O_5, K_2O kg ha^1 + 20 kg $ZnSO_4$ .7 H_2O ha^{-1}) was common to all the treatments. Paddy cv Abhilash was raised as test crop during 2018 and 2019. As per treatments, soil application of calcium silicate and foliar application of silicic acid at different interval was carried out.

Results and Discussion

Significantly higher dry matter production (19.10, 69.88 and 97.76 g ha^{-1}, at 60, 90, DAT and harvest, respectively) was observed with soil application of silicon @ 200 kg ha^{-1} + foliar @ 0.5 per cent (T_9). However, treatments T_8, T_7 and T_6 were on par with T_9. Whereas, lower dry matter production (15.12, 59.43 and 87.84 g $hill^{-1}$, at 60, 90 DAT and harvest, respectively) was noticed in the control (T_1). Foliar application of silicon due to efficient utilization of sunlight by making plant leaves more erect. Such ideal crop stand enhanced photosynthetic activity and translocation of assimilated product from source to sink. This ultimately resulted in higher dry matter accumulation per hill.

Higher yield attributes *such as.*, number of grains per panicles (121.33) and test weight (23.64 g) was recorded with soil application of silicon @ 200 kg ha^{-1} + foliar @ 0.5 per cent (Table 1). There was significant increase in all the yield attributes was observed with combined application of silicon as compared to individual soil/foliar application of silicon.

Significantly higher grain yield (5750 kg ha^{-1}) and straw yield (6960 kg ha^{-1}) was recorded with soil application of silicon @ 200 kg ha^{-1} and along with foliar application of silicon @ 0.5 per cent (T_9). However, treatments T_8 and T_7 were on par with T_9. Whereas, lowest grain yield (4581 kg ha^{-1}) and straw yield (5621 kg ha^{-1}) was observed in the control (T_1). The yield increase to an extent of 25.51 and 23.82 per cent, respectively over control (Table 2 and Fig 1). Application of silicon helped in reduction of spikelet sterility, increased number of tillers, increased rate of photosynthesis, reduction of incidence of insect pest and disease, decreasing mutual shading by improving leaf erectness, increased water use efficiency observed with application of silicon, probably might be due to prevention of excessive transpiration and also preventing manganese and iron toxicity under water logged condition (Ma *et al.* 2011) [6]. During reproductive stage, silicon is preferentially transported in to the flag leaves and interruption for spikelet fertility and better translocation of photosynthates from source to sink which ultimately leads to higher productivity of paddy. These similar results were in close accordance with the findings of Prakash *et al.* (2011) [9] in rice and Malav *et al.* (2018) [7] in rice, higher application of silicon up to 600 kg ha^{-1} resulted in higher grain and straw yield of paddy. Further reported by (Pati *et al.* 2016) [8] application of diatomaceous earth @ 600 kg ha^{-1} along with recommended fertilizer practices recorded significantly higher rice grain (5,219 kg ha^{-1}) and straw (7,768 kg ha^{-1}) yields.

Table 1: Growth and yield parameters of paddy as influenced by soil and foliar application of silicon

Treatments 0062	Growth and yield parameters								
	Dry matter production (g $hill^{-1}$)			Number of grains per panicles			Test weight (g)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1: Control (RPP)	87.51d	88.16d	87.84d	93.33c	102.00d	97.67d	19.03c	19.95c	19.49c
T_2: SA of silicon @ 100 kg ha^{-1}	90.90b-d	94.57b-d	92.73b-d	104.67a-c	113.33a-d	109.00bc	20.95b	21.61a-c	21.28b
T_3: SA of silicon @ 200 kg ha^{-1}	91.49a-c	96.32a-c	93.91a-c	108.33ab	115.00a-d	111.67a-c	21.31b	22.12ab	21.72b
T_4: FA of silicic acid @ 0.25%	88.78cd	92.71cd	90.74cd	102.33bc	105.00cd	103.67cd	20.61bc	21.06bc	20.84bc
T_5: FA of silicic acid @ 0.50%	89.38b-d	94.39b-d	91.89b-d	106.33a-c	108.67b-d	107.50b-d	20.83bc	21.20bc	21.01bc
T_6: SA of silicon @ 100 kg ha^{-1} + FA of silicic acid @ 0.25%	92.81a-c	97.18a-c	95.00a-c	109.00ab	117.33a-c	113.17a-c	21.43b	22.60ab	22.01ab
T_7: SA of silicon @ 100 kg ha^{-1} + FA of silicic acid @ 0.50%	93.32a-c	98.26a-c	95.79a-c	112.67ab	118.67a-c	115.67ab	21.90ab	22.77ab	22.34ab
T_8: SA of silicon @ 200 kg ha^{-1} + FA of silicic acid @ 0.25%	93.42ab	99.27ab	96.34ab	114.33ab	119.67ab	117.00ab	22.02ab	22.96ab	22.49ab
T_9: SA of silicon @ 200 kg ha^{-1} + FA of silicic acid @ 0.50%	94.33a	101.19a	97.76a	117.00a	125.67a	121.33a	23.56a	23.71a	23.64a
S. Em ±	2.98	2.14	2.02	4.35	4.68	3.72	0.63	0.71	0.59
C.D. at 5%	8.94	6.42	6.07	13.06	14.04	11.16	1.90	2.13	1.77
CV	6.6	7.8	6.7	7.0	7.1	6.8	5.2	5.6	4.7

Note:

- RPP: Recommended package of practice (RPP) was common to all treatments
- DAT: Days after transplanting
- SA: Soil application of silicon at the time transplanting
- FA: Foliar application @ 30,60 and 90 DAT
- Means followed by the same letter (s) within a column are not significantly differed by DMRT (P= 0.05)

Table 2: Grain and straw yield of paddy as influenced by soil and foliar application of silicon

	Yield (kg ha^{-1})							
	Grain yield			% increase yield over control	Straw yield			% increase over control
	2018	2019	Pooled		2018	2019	Pooled	
T_1: Control (RPP)	4545c	4617d	4581e	-	5554d	5689c	5621e	-
T_2: SA of silicon @ 100 kg ha^{-1}	4906bc	4985b-d	4945b-e	7.94	5914b-d	6191a-c	6052c-e	7.66
T_3: SA of silicon @ 200 kg ha^{-1}	5013bc	5164a-d	5089b-e	11.08	6167a-d	6260a-c	6214b-e	10.54
T_4: FA of silicic acid @ 0.25%	4581bc	4819cd	4700de	2.59	5763cd	5948bc	5855de	4.16
T_5: FA of silicic acid @ 0.50%	4727bc	4926b-d	4827c-e	5.37	5821cd	5992bc	5906c-e	5.07
T_6: SA of silicon @ 100 kg ha^{-1} + FA of silicic acid @ 0.25%	5128a-c	5310a-d	5219b-d	13.92	6230a-d	6512a-c	6371a-d	13.34
T_7: SA of silicon @ 100 kg ha^{-1} + FA of silicic acid @ 0.50%	5176a-c	5513a-c	5345a-c	16.67	6366a-c	6733ab	6550a-c	16.52
T_8: SA of silicon @ 200 kg ha^{-1} + FA of silicic acid @ 0.25%	5227ab	5568ab	5397ab	17.81	6643ab	6851a	6747ab	20.03
T_9: SA of silicon @ 200 kg ha^{-1} + FA of silicic acid @ 0.50%	5673a	5827a	5750a	25.51	6889a	7030a	6960a	23.82
S. Em $\pm$	218.1	243.0	175.9	-	268.8	280.5	231.5	-
C.D. at 5%	653.1	728.7	527.5	-	805.8	842.3	694.1	-
CV	7.6	8.2	6.9	-	7.6	7.7	6.5	-

Note:

- RPP: Recommended package of practice (RPP) was common to all treatments
- DAT:Days after transplanting,
- SA: Soil application of silicon at the time transplanting
- FA: Foliar application @ 30,60 and 90 DAT
- Means followed by the same letter (s) within a column are not significantly differed by DMRT (P= 0.05)

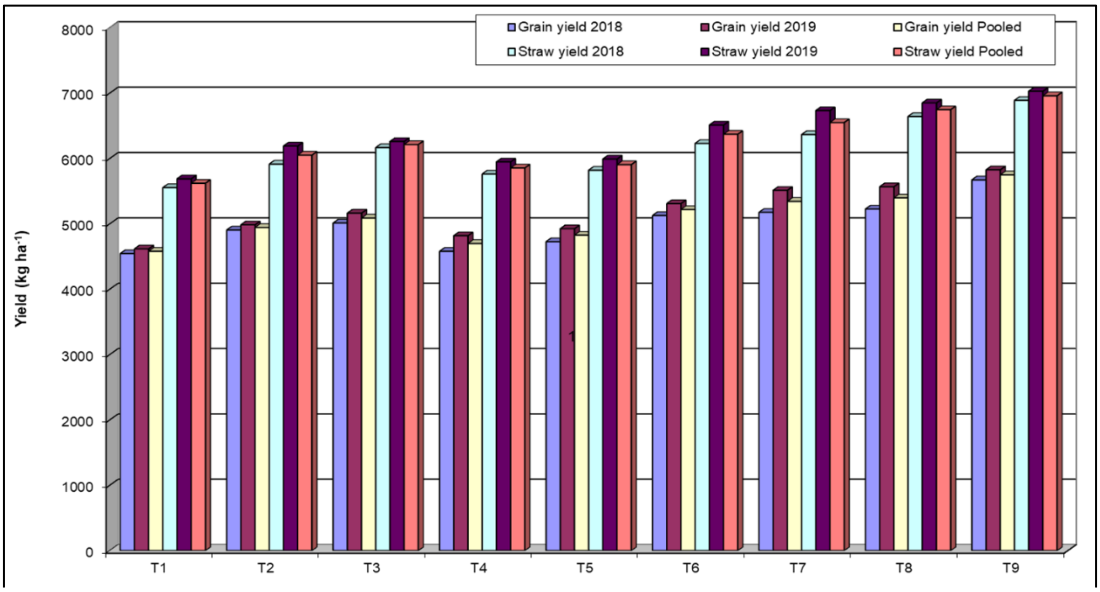

Fig 1: Grain and straw yield of paddy as influenced by soil and foliar application of silicon

Conclusion

Its concluded that, significantly higher growth and yield of rice was recorded with soil application of silicon @ 200 kg ha^{-1} along with foliar application of silicon @ 0.5 per cent (T_9). Finally highlight of this study was found significant role of silicon in improving growth and yield of rice.

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