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Effect of Gypsum and Boron Application on Growth and Yield of Rice Under Acid Soils of High Rainfall Area of Hilly Zone

S. Channakeshava, G. S. Krishnareddy, B. S. Basavaraju and H. K. Pankaja
Krishi Vigyan Kendra, Hassan, UAS, Bengaluru,

Abstract

The results of pooled data revealed that application of Recommended Dose of Fertilizer along with soil test based lime and foliar spray of 0.1 per cent boron has recorded significantly higher grain yield of 61.02 q / ha as against 46.97q / ha in farmers practice. Significantly higher number of filled grain per panicle (66.5), test weight (37.3 g) and number of panicles per hill (24.5) recorded in recommended dose of fertilizer + soil test based lime + foliar spray of 0.1 per cent boron as against farmers practice (46.97, 52.62, 27.0, and 17.87, respectively) and was on par with RDF + Gypsum @ 200 kg / ha and 0.1 per cent of boron (57.2, 64.25 , 37.3 and 18.07, respectively). The increase in yield due to application RDF + soil test based lime along with 0.1 per cent boron was 29.91 per cent over farmers practice, 18.39 per cent over recommended practice, 5.37 per cent over soil application of gypsum and boron along with RDF and 6.67 per cent over soil application of gypsum @ 200 kg / ha and foliar spray of 0.1 per cent boron along with RDF. Application of RDF + Soil test based lime along with foliar spray of 0.1 per cent boron recorded significantly higher total boron content and uptake of 2.94 ppm and 21.07 g / ha in grain and straw, respectively followed by soil application of boron @ 2.0 kg / ha and gypsum @ 200 kg / ha along with RDF (2.68 ppm and18.83g / ha) and RDF + Gypsum @ 200 kg / ha + 0.1 per cent foliar spray of boron (2.71 and 19.15 g / ha). However, significantly lower content and uptake of 2.38 ppm and 13.61g / ha was recorded in farmers practice. Application of gypsum @ 200 kg / ha as a source of calcium decreased soil pH from 4.9 to 4.8, whereas, application of calcium as lime on soil test base has increased pH from 5.4 to 5.9 and 6.15 during 2013 and 2014, respectively.

Rice is the most important food crop of India covering about one-fourth of the total cropped area and providing food to about half of the Indian population.

Rice is the staple food of the people living in the eastern and the southern parts of the country, particularly in the areas having over 150 cm annual rainfall. There are about 10,000 varieties of rice in the world, out of which about 4,000 are grown in India (Guyer *et al.,*1998).

In Karnataka, rice cultivation in hilly region covers Coorg, Chikmagalur and parts of Hassan district (Sakaleshpura and Belur taluk) having total rice area of 0.26 million hectares with productivity of 1900 kg/ ha under the regime of monsoon.Recently productivity of rice in the hilly zone was decreasing due to deficiency of secondary (Calcium) and micronutrient (Boron) which resulted in spikelet infertility of panicle and poor seed setting which resulted in lower grain yield in paddy (Khattak and Parveen 1988).

Calcium plays a important role in paddy for the better root growth and development apart from reducing the aluminium toxicity and iron toxicity in soil. Research reviews reveals that gypsum application on the soil surface followed by its leaching to acidic sub soils results in the improvement of root growth and higher absorption of water and nutrients by root plants and improves quality of grain in paddy (Sumner *et al.,* 1986).

Boron (B) is responsible for better pollination, seed setting and grain formation in different rice varieties (Aslam *et al.,* 2002; Rehman *et al.,* 2012), making it more important during the reproductive stage as compared to the vegetative stage of the crop.

Boron is needed in small amount, but, proved to be an essential micronutrient for plant growth. Its deficiency symptoms and nutritional disorder characteristics appear when application is neglected which proved several scientist for last many years. Its role in plant growth has been extensively studied in as many as 20 agricultural crops. Boron impacts transport of carbohydrates, cell division, cell wall strength and development, onset of fruits and seed development and hamonal production. Its severe deficiency causes

abnormal development reproductive organs, and ultimately results in reduction of plant yield.

Boron availability to plants decreases under high rainfall and strongly acid soils (pH less than 5.0) because of B sorption to iron and aluminum oxide surfaces of soil minerals. However, over liming acid soils often has resulted in temporary B deficiencies, especially when liming to pH levels above 7.0.

Boron application improve the plant functioning at cellular level including cell division, flower and fruit formation and development, Carbohydrate and nitrogen metabolism retention and disease resistance. Application of Boron gave 41.8 per cent yield increase. Different levels of Boron application have been reported and different levels in yield increase have been observed. Boron can be used as soil application as well as foliar application on growing crops. Foliar application of Boron is believed to retain significant Carbohydrate Phloem mobility to flowering meristematic cell from either senescing leaves and / or bark. Thus, foliar spray of boron not only a source to apply boron at a particular growth stage but also permits a rapid action to mitigate the problem soon after deficiency diagnosis. Keeping these points in view the present investigation was undertaken to study the effect of gypsum and boron on growth and yield of rice in acid soils under high rainfall area.

Material and Methods

An on farm testing on effect of calcium and boron in paddy under acid soils of high rainfall area during kharif season of 2013 - 14 and 2014 - 15 at Halebelur, Sakaleshpura taluk, Hassan district, Karnataka through Krishi Vigyan Kendra, University of Agricultural Sciences, Bengaluru. The experimental area was quite uniform and the soil was sandy clay loam. Initial physico-chemical properties of soil of experimental plot was analysed using standard procedure (Jackson, 1958) and details are presented in Table I. Experiment was laidout in randomized block design with five treatments having plot size of 6 m × 5 m and replicated four times. Plant samples were digested and were analysed for boron content using AAS by following standard procedure (Lindsay, 1991). Soil test based lime applied once in two years as per recommendations.The biometric observations (plant height, number of tillers per hill, number of panicles per hill, number of filled grains per panicle and number of unfilled grains per panicle and test weight (1000 grain seed weight) were recorded at harvest. The boron uptake was computed using data on boron content in grain, straw and grain yield and straw yield of paddy. Data were statistically analysed using standard procedure (Steel *et al.*, 1997). Five soil and plant samples were drawn from each treatment with replications after harvest of crop and analysed using standard procedures.

Table I

Initial Physico chemical properties of experimental site

Parameters	Value
pH	5.4
EC (dS/m)	0.12
Organic Carbon (%)	0.74
Available N (Kg/ha)	289.4
Available P (Kg/ha)	32.0
Available K(Kg/ha)	128.6
Available Zinc(ppm)	0.70
Available boron (ppm)	0.15

No.	Treatments
T_1	Farmers practice (50:50:60 kg / ha NPK)
T_2	Soil test based lime application (1.35t/ha) kg / acre + RDF (75:75:90 kg / ha NPK) + Zn SO4 @ 10.0 kg/ha
T_3	RDF (75:75:90 kg / ha NPK) + gypsum @ 200 kg/ha + borax @ 2.0 kg/ha)
T_4	RDF (75:75:90 kg / ha NPK) + zinc sulphate @ 10.0 kg / ha + gypsum @ 200 kg / ha + 0.1 % foliar spray of boron (0.1%)
T_5	Soil test based lime application (1.35 t/ha) + RDF (75:75:90 kg / ha NPK) + Zn SO4 @ 0.0 kg / ha + 0.1 % foliar spray of boron

Treatment Details : Lime applied once in two years based on soil test value and gypsum applied every year.

Results and Discussion

Results on effect of application of calcium and boron in paddy under acid soils of high rainfall area on growth, yield and yield parameters and nutrient status of soil are presented below.

Effect of gypsum and lime application on soil properties : Results from (Table II) the pooled data revealed that application of gypsum @ 200 kg / ha decreased soil pH marginally from 4.8 and 4.9 wherever gypsum applied as source of calcium compared to application of lime to correct soil pH @ 1.35 t / ha. Application of lime was found to be more beneficial than application of gypsum as it decreases soil acidity marginally. However, yield reduction was not observed due to application of gypsum for a short period of two years. Application of lime @ 1.35 t / ha increased soil pH from 5.4 to 5.9 during 2013 and 2014, respectively which was favourable for availability of nutrients for plant uptake. Application of lime in soil having advantage of slowly soluble in nature and can bring changes in soil pH in surface layer of soil than gypsum which is quickly soluble in soil and leaches to subsurface layer of soil where it reduces soil acidity marginally rather than surface soil acidity under paddy cultivation.

The available nutrient status of soil after harvest of crop : The results (Table II) revealed that available nitrogen, phosphorus and potassium was medium in range and marginally higher wherever lime applied. This was attributed to change in soil pH which favoured increase in availability of nutrient in soil compared to application of gypsum wherein pH does not changed.

The maximum available zinc content in soil was recorded in all the treatments was normal in range (0.52 to 0.60 ppm and 0.60 to 0.66 ppm during 2013 and 2014, respectively) except in farmers practice (0.43 & 0.52 ppm) where farmers have not applied zinc sulphate to soil. Available boron content in soil was higher where boron applied through soil application (0.41 and 0.34 ppm) during 2013 and 2014, respectively. Lower content of boron in soil in the treatments where lime applied was due to fixation of boron as calcium borate which resulted in low availability in soil.

Influence of calcium and boron on growth parameters of paddy : Results (Table III) from the pooled data (2013 and 14) revealed that significantly higher plant height (91.45 cm) and number of tillers per hill were recorded with RDF + 0.1 per cent foliar spray of Boron + soil test based lime application (1.35

Table II

Effect of application of gypsum and lime on soil pH and available nutrient status of soil after harvest of crop

Treatments	pH		EC (dS / m)		Available Nitrogen (kg / ha)		Available Phosphorus (kg / ha)		Available Potassium (kg / ha)		Available Zinc (ppm)		Available Boron (ppm)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
T_1	5.2	5.4	0.12	0.14	262.0	271.0	30.5	28.8	125.6	128.8	0.43	0.52	0.12	0.16
T_2	5.4	5.9	0.23	0.32	265.0	279.0	28.5	32.5	122.8	126.3	0.58	0.62	0.22	0.24
T_3	4.9	4.8	0.35	0.34	258.0	257.2	27.4	29.1	124.7	125.4	0.52	0.65	0.41	0.34
T_4	4.8	4.9	0.42	0.48	257.0	260.2	26.3	27.5	122.3	124.2	0.57	0.62	0.28	0.23
T_5	5.8	6.15	0.36	0.41	285.0	288.5	27.8	35.4	128.4	231.6	0.60	0.66	0.24	0.23
SEm±	0.12	0.14	0.09	0.10	0.09	1.12	0.75	0.65	0.62	0.52	0.12	0.17	0.09	0.08
CD (5%)	0.36	0.41	0.27	0.32	NS	2.25	2.12	1.84	1.75	1.32	0.35	0.51	0.27	0.25

TABLE III

Effect of application of gypsum and boron on growth parameters of paddy

Treat--ments	Plant height (cm)			No. of tillers		
	2013	2014	Pooled	2013	2014	Pooled
T_1	81.60	90.00	85.8	20.75	17.25	19.00
T_2	81.16	90.75	85.955	24.25	19.75	22.00
T_3	84.00	93.75	88.875	26.25	23.50	24.87
T_4	85.66	94.15	89.905	25.50	23.75	24.62
T_5	86.66	96.25	91.455	26.00	24.25	25.12
SEm ±	1.05	0.52	0.785	0.56	0.58	0.57
CD (5%)	3.24	1.59	2.415	1.75	1.78	1.765

t / ha). And however was on par with RDF + Gypsum @ 200 kg / ha + 0.1 per cent foliar spray of Boron (89.90). The lowest plant height (85.8 cm) and number of tillers per hill (19.0) was recorded in farmers practice and recommended practice (85.9 and 22.0 cm). Soil application of gypsum and boron along with recommended dosage of fertilizers recorded plant height of 88.8 cm and 24.8 number of tillers per hill which on par with soil application of gypsum @ 200 kg / ha and 0.1 per cent boron along with RDF (75:75:90 kg / ha NPK). The higher growth parameters in treatment where boron applied as foliar spray was attributed to sufficient concentration of boron in plant than soil application, where boron was not taken up by plant. Similar results were also recorded by Zayed etal (2011)

The higher growth parameters like plant height and number of tillers per hill was attributed to sufficient supply of calcium in the treatments where lime and gypsum applied which in turn helps in growth and development of growth parameters. These results were in agreement with findings of Aslam *et al.,* (2002)

Yield and yield parameters of paddy : Yield and yield attributes of paddy was differed significantly due to application of calcium and boron. Results from the pooled data (Table - IV) revealed that significantly higher number of panicles per hill (24.5), panicle length (18.81cm) and number of filled grains per panicle (66.5) was recorded in the treatment where RDF + Soil test based lime + 0.1 per cent boron sprayed. However, its on par with RDF + soil application of gypsum + 0.1 per cent foliar spray of boron which recorded 23.62 number of panicles per hill, 18.07 cm panicle length and 64.25 filled grains per panicle.

Lowest number of filled grains per panicle was recorded in farmers practice (52.62) and recommended practice (58.75) where boron applied either through soil application or through foliar spray.

The higher number of filled grain per panicle was

TABLE IV

Yield parameters of rice crop as influenced by application of gypsum and boron

Treatments	No. of panicles per hill at harvest			Length of panicle (cm) at harvest			No. filled grain per panicle			No. of unfilled grain per panicle		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1	19.25	16.50	17.87	16.75	17.5	17.12	49.75	55.50	52.625	16.25	15.5	15.875
T_2	22.25	19.0	20.62	17.13	18.0	17.56	55.50	62.00	58.75	15.25	18.0	16.625
T_3	25.50	22.25	23.87	17.30	18.8	18.05	57.50	64.75	61.125	15.00	19.5	17.25
T_4	24.25	23.0	23.62	16.95	19.20	18.07	62.75	65.75	64.25	2.0	20.25	11.125
T_5	25.25	23.75	24.5	17.63	20.00	18.815	64.50	68.50	66.5	10.25	20.75	15.5
S. Em ±	0.57	0.60	0.58	0.44	0.58	0.51	1.04	0.83	0.93	0.89	0.92	0.90
CD @ 5 %	1.75	1.81	1.78	1.34	1.80	1.57	3.20	2.55	2.87	2.73	2.84	2.78

attained due to sufficient supply of boron through foliar spray of 0.1 per cent Boron which helps in growth and development of floral parts of plant and enhances better pollination, fertilization and grain filling in panicle which in turn increased grain yield of paddy.

Grain and straw yield of paddy : Grain and straw yield of paddy differed significantly due to application of calcium and boron under high rainfall acid soil. Results from the pooled data (Table V) revealed that application of RDF + soil test based lime along with foliar spray of 0.1 per cent boron increased grain and straw yield significantly (61.02 q / ha and 76.88 q / ha) than other treatments . Application of gypsum @ 200 kg / ha + RDF (75:75:90 NPK Kg / ha) + 0.1 per cent foliar spray (57.20 and 73.0) and soil application of gypsum and boron along with RDF (57.9 q / ha and 73.38 q / ha) recorded similar results and were on par with each other. Application of only NPK @ 50:50:40 kg / ha in farmers practice (46.97 and 61.17q / ha) and RDF: 75:75:90 NPK kg / ha in recommended practice recorded significantly lower grain and straw yield (51.54 and 65.39 q / ha). The increase in yield due to application RDF + soil test based lime along woth 0.1 per cent boron was 29.91 per cent over farmers practice, 18.39 per cent over recommended practice, 5.37 per cent over soil application of gypsum and boron along with RDF and 6.67 per cent over soil application of gypsum @ 200 kg / ha and foliar spray of 0.1 per cent boron along with RDF. The increase in yield was attributed to foliar spray of 0.1 per cent boron along with RDF + soil test based lime which favored nutrient availability to crop in turn influenced on increase in grain and straw yield of paddy. These results were also in agreement with findings of Aslam *et al.* (2002)

1000 grain weight : Application of RDF + soil test based lime (1.35 t / ha) along with foliar spray of boron recorded maximum and significantly higher grain weight (36.8g) followed by soil application of gypsum @ 200 kg / ha + RDF + 0.1 per cent boron spray (37.30 g) and however were on par with each other. Lowest weight was recorded with farmers practice (27.0 g) and recommended practice (35.35 g). Maximum grain weight was attributed to foliar spray of boron which enhanced spikelet fertility which inturn increased grain weight. Similar results were also recorded by Yu and Bell (1998).

Effect of application of calcium and boron on content and uptake of B by paddy grain and straw : Results of pooled data revealed (Table VI and Table VII) that maximum total boron content and its uptake by paddy recorded as 2.94 ppm and 13.61 g / ha in the treatment where RDF + Soil test based lime + 0.1 per cent B sprayed and was on par with RDF + Gypsum @ 200 kg / ha + 0.1 per cent B spray. The total B content and its uptake was significantly lower in case of farmers practice (2.38 ppm and 13.61 gm / ha) and recommended practice (2.52 ppm and 15.8 gm / ha). The higher boron content and its uptake was attributed to foliar spray of B which can quickly compensate total B requirement of plant than soil

TABLE V

Effect of application of gypsum and boron on grain and straw yield of paddy

Treatments	Grain yield (q / ha)			Straw yield (q / ha)			1000 Seed weight (gm)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1	46.42	47.50	46.97	60.57	61.78	61.17	27.20	26.80	27.00
T_2	51.06	52.00	51.54	64.33	67.63	65.98	35.20	35.50	35.35
T_3	57.79	58.00	57.91	71.33	75.43	73.38	35.90	35.70	35.80
T_4	56.92	57.40	57.20	71.29	74.72	73.00	37.40	37.20	37.30
T_5	60.47	61.50	61.02	75.83	76.88	76.35	36.89	36.52	36.70
SEm	0.60	0.50	0.55	0.70	0.84	0.77	0.14	0.18	0.17
CD (0.5%)	1.86	1.55	1.68	2.15	2.48	2.31	0.45	0.58	0.51

TABLE VI

Effect of application of gypsum and boron on boron content (ppm) in grain and straw of paddy

Treatments	Grain			Straw			Total content		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1	0.64	0.65	0.64	1.75	1.73	1.74	2.39	2.38	2.38
T_2	0.70	0.69	0.69	1.82	1.84	1.83	2.52	2.52	2.52
T_3	0.82	0.87	0.84	1.85	1.86	1.85	2.67	2.69	2.68
T4	0.89	0.91	0.90	1.80	1.87	1.83	2.69	2.73	2.71
T5	1.02	0.99	1.00	1.92	1.96	1.94	2.94	2.94	2.94
SEm	0.04	0.05	0.045	0.05	0.06	0.05	0.12	0.09	0.11
CD(5%)	NS	0.15	0.13	0.16	0.19	0.17	0.36	0.28	0.34

TABLE VII

Effect of application of gypsum and boron on uptake of boron by paddy grain and straw

Treatments	Uptake by Grain			Uptake by Straw			Total uptake (Grain + Straw)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1	3.18	3.08	3.13	10.29	10.68	10.48	13.47	13.76	13.61
T_2	3.88	3.59	3.73	11.70	12.44	12.07	15.58	16.03	15.80
T_3	4.71	5.04	4.87	13.19	14.72	13.99	17.9	19.76	18.83
T4	6.27	5.23	5.75	12.83	13.97	13.40	19.1	19.20	19.15
T5	6.45	6.09	6.27	14.55	15.06	14.78	21.0	21.15	21.07
SEm	0.45	0.51	0.48	0.78	0.82	0.80	0.88	0.92	0.90
CD(5%)	1.03	1.54	1.28	2.28	2.48	2.38	2.50	2.75	2.68

application wherein greater losses of B through leaching under high rainfall and fixation in soil takes place. Similar results were also recorded by Dunn *et al.* (2005).

Application of RDF (75:75:90 NPK kg / ha + Zinc sulphate @ 20 kg / ha + soil test based lime (1.35 t / ha) along with foliar spray of 0.1 per cent boron recorded significantly superior yield and yield parameters, boron content and uptake over farmers practice, recommended practice and soil application of gypsum and boron along with RDF, soil application of gypsum and RDF along with foliar spray of 0.1 per cent boron . The foliar application of 0.1 per cent boron found to superior than soil application of boron @ 2.0 kg / ha where boron fixed in soil with inorganic constituents inturn reduce availability for plant absorption. Application of calcium as source of nutrient does not change the soil pH under acidic soils and further it leach down to lower soil horizon which will affect the availability of nutrient for plant root absorption. Hence, application of soil test based lime found to be more advantageous in raising soil pH and enhances availability of nutrients for growth and

development of crop. Application of gypsum reduces soil pH slightly due to presence of soluble sulphates and hydrogen ions reacts together and resulted in to formation of sulphuric acid in soil which further aggravates soil acidity.

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