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EFFECT OF CALCIUM SILICATE ON YIELD AND NITROGEN USE EFFICIENCY (NUE) OF WETLAND RICE

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Abstract

Field experiment was conducted to investigate the effect of calcium silicate application on the growth, yield and nitrogen use efficiency (NUE) of wetland rice at eastern dry zone soils of Karnataka, using *Cv*. BI-34, a medium duration rice genotype. Results revealed that the significantly highest grain and straw yield was noticed with 100 kg N ha^{-1} (RDF) along with the application of calcium silicate @ 2t ha^{-1} over all other treatments. Application of calcium silicate @ 2t ha^{-1} along with LCC based N application of 75 kg N ha^{-1} (Basal 30 kg N ha^{-1} + LCC) recorded on par grain and straw yield over RDF alone. Higher nitrogen use efficiency *i.e*. AE_N, RE_N, PEP_N values were noticed with LCC based application along with calcium silicate @ 2t ha^{-1}.

Key words : Wetland rice, calcium silicate, nitrogen use efficiency, leaf colour chart.

Introduction

Nitrogen is necessary for all forms of life and is a crucial component in increased production of food to feed the continuously increasing population. It is most important nutrient for crop production, as it is a constraint of the building blocks of almost all plant structure. Nitrogen occupies a unique position as a plant nutrient, because rather higher amounts are required compared to other essential nutrients. Thus it is deliberately added to agro-ecosystem. The degree to which added within the agro ecosystem is critical. Fertilizer N is one of the major inputs in rice production. Being highly mobile in soil, N is subjected to several types of losses consequently the nutrient use efficiency is low in rice. Soil nitrogen supply, fertilizer efficiency and productivity vary widely across small distances of rice ecosystem. However, blanket fertilizer nitrogen recommendation are often applied in large areas without taking into account the wide variability and site and season specific crop N requirements within the each recommendation domain. Therefore, site specific approach is warranted (Nagarajan *et al.*, 1999) applying N as per crop demand and soil N supply will enhance N use efficiency (NUE) in rice.

In this context, the leaf colour chart (LCC) helps farmer to determine *in situ* crop requirements for N in the field and apply N as and when necessary, taking into account the variation in soil N supply.

The search for new technologies that will enable the expansion of producing area as well as productivity has featured the use of silicon fertilization in rice crop as a promising alternative. Silicon has a synergistic effect with N no nutrient uptake and yield of rice (Singh *et al*., 2006). Nitrogen is essential for plant growth and development, and is often a limiting factor for high productivity. However, when applied in excess it may limit yield because of lodging, especially for cultivars of the traditional and intermediate groups and promote shading and disease problems. These effects could be minimized by the use of silicon. Therefore, the study was under taken to evaluate the effect of calcium silicate on growth, yield and nitrogen use efficiency of wetland rice.

Materials and Methods

A field experiment was conducted to study the effect of Effect of Calcium Silicate on yield and nitrogen use efficiency (NUE) in wetland rice during *kharif* - 2009 at eastern dry zone soils of Bengaluru, Karnataka (12°10' N, 76°35' E, 650m above msl). The soil of experimental field was sandy loam in texture; soil reaction was slightly acidic, with medium organic carbon and available N. Similarly, available soil P_2O_5 and K_2O values were medium (54.1 kg ha^{-1}) and low (136.6 kg ha^{-1}),

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respectively. The experiment comprise of five treatments (**T_1** : control, **T_2** : Recommended Dose of Fertilizer (RDF, 100 : 50 : 50 N, P_2O_5, K_2O kg ha^{-1}), **T_3** : **T_2** + Calcium silicate @ 2t ha^{-1}, **T_4** : **T_1** + Basal 30 kg N ha^{-1} + LCC-4, **T_5** : **T_4** + Calcium silicate @ 2t ha^{-1}) replicated with three times in randomized block design. The calculated quantity of calcium silicate was applied a week before transplanting. 25 days old rice seedlings were transplanted to main field at a spacing of 20 × 10 cm. For the LCC treatments, 30 kg N ha^{-1} was applied at the time of transplanting and remaining amount of N supplied based on leaf color chart (LCC-4) critical values. Grain and straw yield and yield components were recorded in each treatment at harvest and grain yields were adjusted to 14 percent of moisture level. Grain and straw samples were analyzed by using CHNS (LECO, USA) analyzer for total N content. Nitrogen use efficiency (NUE) was calculated by using different efficiency formulae *viz*., agronomic efficiency (AE_N), apparent recovery efficiency (RE_N) and Partial factor productivity (PFE_N).

Results and Discussion

The data pertaining to the study are given in table 1. The results of experiments showed that the growth attributes *viz*., plant height and number of productive tillers and yield attributes *viz*., number of grains per panicles, test weight, grain and straw yield were significantly influenced by application of calcium silicate @ 2t ha^{-1}.

Among the treatments, application of calcium silicate along with 100 kg n ha^{-1} recorded highest values for growth attributes plant height (92 cm), number of productive tillers $hill^{-1}$ (10) and yield attributes *viz*., number of grains per panicle (137), grain yield (5425 kg ha^{-1}) and straw yield (6842 kg ha^{-1}). The increase in growth and yield attributes might be due to the supplement of calcium silicate as silicon source.

Increase in the number of grains per panicle was mainly attributed increased application of N from 0 to 100 kg ha^{-1} along with the application of calcium silicate, which might have enhanced the accumulation of photosynthates.

Application of silicon sources along with RDF and LCC based nitrogen application significantly increased the test weight over control. It may be due to higher N rates, which primarily increased the chlorophyll concentration in leaves and thereby higher photosynthetic rate and ultimately plenty of photosynthates available during grain development (Mahzoor *et al*., 2006). Increase in test weight could also be due to greater deposition of Si on paleae and lemma (Balastra *et al.*, 1989).

Application of calcium silicate @ 2t ha^{-1} significantly increased grain and straw yield of wetland rice when applied along with 100 kg N ha^{-1} as compared to RDF alone and control. The grain yield response to silicon application may be due to increased leaf erectness, decreased mutual shading caused by dense planting and high N application, Nitrogen increases susceptibility to various disease in rice but silicon decreases the occurrence of disease in rice (Yoshida *et al*., 1969). Increased yields in flooded rice with Si fertilization have been already reported in India. Prakash *et al*. (2002) reported that application of calcium silicate @ 3-4 t ha^{-1} as silicon source significantly increased grain yield over control and other treatments, Takahashi *et al*. (1990) reported particularly striking rice yield responses to Si application especially when application rates of other conventional fertilizers were rather high. Snyder *et al.*, (1986) showed that calcium silicate application increased rice yield on Histosols mainly due to the supply of plant available Si and not due to supply of other nutrients.

Increase in straw yield was mainly attributed to higher tiller numbers, biomass observed in the treatment with calcium silicate @ 2t ha^{-1}. The enhanced straw yield with calcium silicate at higher N levels may be attributed to leaf erectness which facilitated better penetration of sunlight leading to higher photosynthetic activity of plant and higher production of carbohydrates (Korndorfer *et al.*, 2001).

Application of N based on LCC in combination with calcium silicate as a silicon source significantly affected the NUE of wetland rice. The AE_N, RE_N and PFP_N values were higher for LCC based N application along with calcium silicate @ 2t ha^{-1}.

The AE_N and RE_N values ranged from 9.1 - 17 and 9.3 - 26.7 wetland rice, respectively. The AE_N is a function of both physiological efficiency and RE_N of applied N. Application of N using LCC resulted in increased leaf N concentration. The AE_N was greater when less N fertilizer was applied, but this was achieved with LCC without sacrificing the yield. Basal application of 30 kg N ha^{-1} compared to 50 kg N ha^{-1} (RDF) efficiently utilized the applied N, whereas at later stages of the crop growth N was applied based on the crop requirement which was measured through LCC based on critical values. Spilt application of N @ 15 kg N ha^{-1} was applied at each time against the recommended fixed dose of 25 kg N ha^{-1}. Cassman and Pingali (1985) reported AE_N values of 24-30 in rice by improved timing and further revealed that crop demand of applied N could improve the AE_N to some extent.

Table 1 : Effect of calcium silicate on growth, yield and nitrogen use efficiency of wetland rice.

Treatment	Plant height (cm)	No. of tillers	No. of productive tillers	No. of grains per panicle	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	AE_N	RE_N	PFP_N
T_1 : Recommended P & K (control)	82	8	7	120	20.1	3723	4705	-	-	-
T_2 : Recommended NPK (RDF)	90	10	9	125	24.8	4805	6041	10.8	17.0	48.1
T_3 : T_2 + $Casio_3$ @ 2t ha^{-1}	93	12	10	137	25.4	5425	6842	17.0	25.0	54.3
T_4 : T_1 + Basal 30 kg N ha^{-1} + LCC-4	87	9	8	128	24.7	4409	5265	9.1	9.3	58.8
T_5 : T_4 + $Casio_3$ @ 2t ha^{-1}	88	11	10	129	25.1	4692	5649	12.9	26.7	62.6
S. Em ±	3	1	1	3	1	141	116	0.8	1.1	0.9
CD (5%)	9	3	3	9	3	424	438	1.2	3.4	2.9

Application of N based on LCC achieved higher PEP_N (62.6) values against RDF of fixed N spilt application. Half of the 100 kg N ha^{-1} (RDF) was recommended as basal application, as rice seedlings need about 7-10 days to recover from transplanting shock and hence, N uptake within two weeks of transplanting could be very small. The usefulness of applying a lower dose of N is sufficient or at later stages of crop *i.e.* 14 days after transplanting in wetland rice need to be examined. Alam *et al*. (2005) observed not only higher NUE, but also higher yields through LCC based management.

Application of calcium silicate @ 2t ha^{-1} as a source of silicon significantly increased grain and straw yield of wetland rice. Application nitrogen based on leaf colour chart with or without calcium silicate @ 2t ha^{-1} recorded on par grain yield over RDF. Thus, the leaf colour chart would be helpful to avoid the under or over fertilizing besides applying at appropriate time when the crop needs nitrogen so as to increase the productivity in rice. Leaf colour chart based N management could adequately take care of location to location and temporal variation in N supply and holds promise in increasing fertilizer N use efficiency in wetland rice.

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