Short communication

Effect of combined application of nutrients on growth and yield of irrigated rice

Sreedhu P. Preman*, Mercy George and P. S. John

Department of Agronomy, College of Horticulture, Kerala Agricultural University, Thrissur-680 656., Kerala, India.

Received 21 November 2015; received in revised form 22 December 2015; accepted 29 December 2015

Abstract

A field experiment was conducted during the second crop season of 2014 to study the efficiency of joint foliar or soil application of nutrients (Mg, Zn and B) on the growth parameters, yield attributes, and yield of rice. Plant height, tiller number, dry matter yield, yield attributes and straw and grain yield were influenced by the application of nutrients. Combined soil application of Mg, Zn and B produced highest grain yield of 6.28 Mg ha^{-1}.The combined application of nutrients (Mg, Zn and B) either in soil or on foliage had similar effect on all the growth parameters, yield attributes and yield compared to the individual application of the same. The quantity of micronutrients required was less when applied on foliage compared to soil application. Thus it reduced the toxic level accumulation of micronutrients in soil and saved cost.

Key words: Rice, Joint application, Secondary nutrients, Micronutrients, Individual application

Rice, the staple food of Kerala, contributes a major share towards the economy. While the estimated requirement of rice for the state is 35-40 lakh tonnes per year, it produces less than one-fifth of its requirement (GOK, 2013).The deficit in rice production is increasing year after year due to reduction in rice area and stagnant productivity of rice. Inadequate and unbalanced nutrient input coupled with very limited use of organic manures leading to the incidence and expansion of multi-nutrient deficiencies in the soils are considered to be major reasons for declined productivity associated with fertilizer use (Singh et al., 2009). Soils of Kerala are deficient in secondary nutrients viz., Ca, Mg and S and micronutrients such as Zn, B and Cu. The soil samples taken from 14 districts in Kerala showed that there was a very high deficiency of magnesium, boron and calcium: around 80 per cent soil samples had magnesium deficiency, 70 per cent had boron deficiency and 50 per cent had calcium deficiency (Viju, 2012). 2-40 per cent of Kerala soils are deficient in Zn (Ponnusamy, 2006). The use efficiency of macro and micronutrients is very low and it is hardly 2 to 4 per cent for the latter (Yadav, 2012). The fertilizer use efficiency can be increased and losses can be reduced by matching supply with crop demand, optimizing split application, correct method of application, and site specific and soil test based nutrient management. Continuous soil application of micronutrients may lead to their accumulation in soils. Foliar application has been found to be favourable where the soil applied fertilizer may not become fully available before maturity of crop (Ganapathy et al., 2008). Individual application of each of the macro and micro nutrient fertilizers either in soil or as foliar is time consuming, labour intensive and thereby increases the cost of production. Combined application of nutrients either in soil or as foliar seems to be an alternative. A field experiment was conducted to assess the efficiency of joint foliar or soil application of

*Author for correspondences: Phone-0487-2438322; E-mail: sreedhuppreman@gmail.com

nutrients on growth parameters, yield attributes and yield of rice.

The experiment was conducted in the farmer's field, Thathamangalam, Palakkad during the 2nd crop season (*Mundakan*) from October 2014 to February 2015.Geographically, the area is situated at $10^{0}68'$ N latitude and $76^{0}70'$ E longitude and at an altitude of 67.2 m above MSL. The experiment was laid out in randomized block design and replicated thrice. The soil was sandy clay loam with pH 6.2 and high organic carbon (1.43%), low N (127.56 kg ha^{-1}), P (6.53 kg ha^{-1}) and high K (470.77 kg ha^{-1}). The secondary and micronutrient status of the soil was sufficient for Mg (367.08 mg kg^{-1}), Zn (1.17mg kg^{-1}) and B (1.62 mg kg^{-1}). The plot size was 5.0 m x 4.0 m with spacing of 20 cm x 10 cm. There were 14 treatments and in the first three treatments, N, P and K were applied based on soil test results. The treatments included T_1) soil test based N, P and K inclusive of farmyard manure, T_2) soil test based P and K, but N 90 kg ha^{-1} + farmyard manure, T_3) soil test based P and K but N based on C:N ratio, T_4) existing POP inclusive of farmyard manure, T_5) POP NPK, T_6) T_5+ $MgSO_4$(80 kg ha^{-1}), T_7) T_5+ $ZnSO_4$ (20 kg ha^{-1}), T_8) T_5+Borax (10 kg ha^{-1}), T_9) T_5+ $MgSO_4$ (1%), T_{10}) T_5+ $ZnSO_4$ (0.5%), T_{11}) T_5+ Borax (0.25%), T_{12}) T_5+ $MgSO_4$ (80 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) + Borax (10 kg ha^{-1}), T_{13}) T_5+ $MgSO_4$ (1%) + $ZnSO_4$ (0.5%) + Borax (0.25%), and T_{14}) absolute control. Farmyard manure was applied @ 5 t ha^{-1}. NPK as per package of practices (POP) were applied at 90: 45:45 kg N, P_2O_5 and K_2O ha^{-1} (KAU, 2011). Medium duration rice variety Uma (MO-16) was used for the experiment. Observations on growth parameters, yield attributes and yield of rice was recorded and statistically analyzed.

At 30 DAT the plant height ranged from 58.94 to 62.49 cm, while it was ranged from 71.29 to 82.01

Table 1. Plant height, Tiller number, Dry matter production and LAI influenced by joint application of nutrients (Mg, Zn and B)

Treatments		Plant height (cm)			Tiller number			Dry matter production (Mg ha^{-1})			LAI
		30 DAT	60 DAT	Harvest	30 DAT	60 DAT	Harvest	30 DAT	60 DAT	Harvest	(60 DAT)
T_1	Soil test based all nutrient package inclusive of FYM	62.49^{a}	80.04^{ab}	99.54^{a}	19.80^{a}	20.07^{ab}	14.33^{a}	2.62^{a}	6.43^{a}	12.30^{a}	4.54^{ab}
T_2	Soil test based all nutrient package except N + FYM + N 90 kg ha^{-1}	59.78^{a}	80.14^{ab}	98.62^{a}	18.03^{cd}	18.37^{ab}	14.53^{a}	2.22^{a}	6.18^{a}	12.50^{a}	4.27^{abc}
T_3	Soil test based all nutrient package except N, N based on C:N ratio	61.06^{a}	81.97^{a}	100.26^{a}	17.80^{cd}	19.83^{ab}	14.97^{a}	2.31^{a}	6.77^{a}	11.78^{a}	4.62^{ab}
T_4	Existing POP inclusive of FYM	61.15^{a}	82.01^{a}	99.73^{a}	19.63^{ab}	20.47^{a}	14.07^{a}	2.08^{a}	6.17^{a}	11.53^{a}	3.95^{bc}
T_5	POP NPK	59.58^{a}	77.94^{b}	96.76^{a}	18.93^{abc}	18.07^{ab}	14.30^{a}	2.51^{a}	5.93^{a}	9.76^{b}	3.78^{cd}
T_6	POP NPK + $MgSO_4$ at 80 kg ha^{-1}	58.94^{a}	82.38^{a}	98.47^{a}	18.40^{abcd}	18.40^{b}	14.20^{a}	2.18^{a}	5.05^{a}	12.17^{a}	4.51^{ab}
T_7	POP NPK + $ZnSO_4$ at 20 kg ha^{-1}	60.38^{a}	78.78^{b}	100.02^{a}	18.63^{abcd}	18.63^{ab}	14.77^{a}	2.48^{a}	5.96^{a}	11.16^{ab}	4.45^{abc}
T_8	POP NPK + Borax at 10 kg ha^{-1}	60.81^{a}	80.35^{ab}	97.57^{a}	19.70^{a}	19.27^{ab}	14.23^{a}	2.37^{a}	6.31^{a}	12.57^{a}	4.00^{bc}
T_9	POP NPK + $MgSO_4$ foliar – 1%	60.04^{a}	79.74^{ab}	97.58^{a}	19.67^{ab}	19.37^{ab}	14.23^{a}	2.02^{a}	6.13^{a}	12.32^{a}	4.21^{abc}
T_{10}	POP NPK + $ZnSO_4$ foliar – 0.5%	60.64^{a}	82.50^{a}	96.87^{a}	18.43^{abcd}	19.27^{ab}	14.50^{a}	2.56^{a}	6.30^{a}	11.25^{a}	4.62^{ab}
T_{11}	POP NPK + Borax foliar – 0.25%	59.76^{a}	79.64^{ab}	95.94^{a}	19.67^{ab}	18.37^{ab}	15.30^{a}	2.24^{a}	6.51^{a}	12.47^{a}	4.36^{abc}
T_{12}	POP NPK + Soil application of $MgSO_4$(80 kg ha^{-1}) + $ZnSO_4$(20 kg ha^{-1}) + Borax (10 kg ha^{-1})	59.81^{a}	79.94^{ab}	97.83^{a}	18.27^{bcd}	18.33^{ab}	14.40^{a}	2.28^{a}	6.14^{a}	12.29^{a}	4.70^{a}
T_{13}	POP NPK + Foliar application of $MgSO_4$(1%) + $ZnSO_4$ (0.5%) + Borax (0.25%)	60.08^{a}	78.66^{b}	96.88^{a}	19.60^{ab}	18.40^{ab}	15.53^{a}	2.45^{a}	6.74^{a}	12.08^{a}	4.69^{a}
T_{14}	Absolute control	59.23^{a}	71.29^{c}	88.03^{b}	17.43^{d}	13.30^{c}	10.87^{b}	1.58^{a}	5.60^{a}	7.92^{c}	3.13^{d}

cm at 60 DAT and from 88.03 to 100.26 cm at harvest. The height of plants among treatments did not vary significantly at 30 DAT but it varied later at 60 DAT. Foliar application of Mg produced tallest plants at 60 DAT which was at par with all the other foliar applications. At harvest, the plant height was statistically similar in all the treatments except control. Tiller number significantly varied at all the stages of growth. At 30 DAT, soil supplication of B produced higher number of tillers and it was at par with all the foliar nutrient applied treatments. Similar trend was observed at 60 DAT also. But at harvest, the tiller count was statistically similar in all the treatments except control. The LAI was significantly higher for joint application of Mg, Zn and B either applied in soil and on foliage or was at par for all the foliar applications of nutrients. The enhancement of photosynthesis in presence of B due to the activation of synthesis of tryptophan and precursor of IAA leads to the stimulation of plant growth and consequently increases the leaf width and area (Patil et al., 2008). Soil application of B resulted in higher dry matter yield and it was at par with all the nutrient applied treatments irrespective of method of application. Application of B increased the yield and dry matter production. These findings are in conformity with those of Ehsan-Ul-Haq et al. (2009) and Dunn et al. (2005).

Whenever FYM was applied (T_1, T_2 and T_4), plant height, tiller number and LAI at 60 DAT were higher, and consequently the yield of rice. Individual soil application of Mg (T_6) and foliar application of Zn (T_{10}) resulted in significantly increased height over NPK alone (T_5) or absolute control, while individual soil application of borax significantly increased the tiller count at 60 DAT.

All the treatments irrespective of the method of application of nutrients, showed noticeable increase in yield and yield attributes than in control. The yield attributes of rice includes number of productive tillers or panicles/hill, spikelets/panicle, fertility or filled grain percentage and test weight of grain. There were no marked differences in number of panicle/hill due to treatments except for control.

Table 2. Yield attributes and yield of rice influenced by joint application of nutrients (Mg, Zn and B)

	Treatments	Yield Attributes				Yield (Mg ha^{-1})	
		Panicle/ hill	Spikelets/ panicle	Fertility %	Test weight (g)	Grain	Straw
T_1	Soil test based all nutrient package inclusive of FYM	14.33^a	132.00^{ab}	77.85^d	26.67^{ab}	6.05^a	6.25^a
T_2	Soil test based all nutrient package except N + FYM + N 90 kg ha^{-1}	14.53^a	149.00^a	84.18^{abcd}	26.39^{ab}	6.18^a	6.32^a
T_3	Soil test based all nutrient package except N, N based on C:N ratio	14.97^a	146.33^{ab}	81.05^{cd}	26.87^a	5.73^{ab}	6.05^a
T_4	Existing POP inclusive of FYM	14.07^a	134.00^{ab}	80.31^{cd}	26.02^b	5.67^{ab}	5.87^{ab}
T_5	POP NPK	14.30^a	143.33^{ab}	79.36^{cd}	26.66^{ab}	4.69^{bc}	5.07^b
T_6	POP NPK + $MgSO_4$ at 80 kg ha^{-1}	14.20^a	146.67^{ab}	86.06^{abc}	27.14^a	5.89^a	6.29^a
T_7	POP NPK + $ZnSO_4$ at 20 kg ha^{-1}	14.77^a	145.00^{ab}	89.50^{ab}	27.18^a	5.19^{ab}	5.97^a
T_8	POP NPK + Borax at 10 kg ha^{-1}	14.23^a	129.67^{ab}	81.52^{cd}	26.37^{ab}	6.18^a	6.38^a
T_9	POP NPK + $MgSO_4$ foliar – 1%	14.23^a	130.67^{ab}	82.14^{bcd}	26.45^{ab}	6.10^a	6.22^a
T_{10}	POP NPK + $ZnSO_4$ foliar – 0.5%	14.50^a	131.67^{ab}	90.42^a	26.40^{ab}	5.59^{ab}	5.66^{ab}
T_{11}	POP NPK + Borax foliar – 0.25%	15.30^a	125.67^b	81.91^{cd}	26.71^{ab}	6.12^a	6.35^a
T_{12}	POP NPK + Soil application of $MgSO_4$ (80 kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) + Borax (10 kg ha^{-1})	14.40^a	134.00^{ab}	84.55^{abcd}	26.73^{ab}	6.28^a	6.12^a
T_{13}	POP NPK + Foliar application of $MgSO_4$ (1%) + $ZnSO_4$ (0.5%) + Borax (0.25%)	15.53^a	149.00^a	81.16^{cd}	26.49^{ab}	6.13^a	6.15^a
T_{14}	Absolute control	10.87^b	99.33^c	77.80^d	25.09^c	3.89^c	4.03^c

However, joint foliar application of Mg, Zn and B showed highest tiller number. According to Arif et al. (2012) foliar application of Zn and B at the rate of 6 kg acre^{-1} and 3 kg acre^{-1} recorded 38.40 percent increase in productive tillers/plant compared to the control. The highest number of spikelets/panicle was produced by the joint foliar application of Mg, Zn and B. These findings are in conformity with those of Uddin et al. (2002). Irrespective of the method of application, Zn application enhanced the fertility percentage compared to other treatments. The individual application of Zn and Mg along with POP NPK recorded highest thousand grain weight, probably due to the increased transportation of photosynthates from source to sink due to Zn application as reported by Sriramachandra and Mathan (1988). The application of $MgSO_4$ increased tillering, hastened the process of heading, increased the filled grains and grain size leading to yield enhancement significantly (Singh and Singh, 2005). Mg application leads to early completion of flowering which helps in uniform ripening of grains, thereby increasing the grain weight. The B application helps to produce bold grains. Test weight also increased over control when the nutrients Mg, Zn and B were individually or jointly applied either in soil or on foliage. The application of nutrients increased the grain yield compared to the control. Combined soil application of Mg, Zn and B produced highest grain yield of 6.28 t ha^{-1} and it was at par with all the nutrient applied treatments irrespective of method of application. Soil organic carbon is considered as the index of soil fertility and its relation with soil organic matter is well established. Relatively high soil organic carbon content of 1.43 as observed in this study is expected to provide good nutrient support to the crop. However, the control plot resulted in noticeably low yield. The recommended fertilizer application (T_4) also failed to improve the grain yield considerably due to reduced growth (plant height and LAI) and consequently the total dry matter and yield. FYM application at 5 t ha^{-1}irrespective of the N dose applied as per package of practices recommendation or soil test, improved the situation. Organic manure supply almost all the essential nutrients for growth and development of plants thereby helping in production of new tissues and development of new shoots ultimately increasing the plant height and tiller number (Chaudhary et al., 2014). The straw yield was better in all the treatments except treatments which received POP NPK alone and in control. Highest straw yield of 6.38 t ha^{-1} was recorded with soil application of B along with POP NPK. A significant increase in straw yield was reported by the application of B in Kerala soils by Sreedharan and George (1969). Combined soil and foliar application of Mg, Zn and B along with POP NPK resulted in statistically similar straw yields possibly due to the combined effect of all the three nutrients in rice growth. Combined application of S, Zn and B along with NPK fertilizers increased plant height and number of tillers/hill which resulted in higher straw yield at harvest (Uddin et al., 2002). The yield attributes such as fertility per cent and test weight were also significantly improved by the treatments and a significant yield increase was also effected. When these nutrients were jointly applied, either in soil or as foliar application, the yield was substantially increased to 6.28 and 6.13 Mg ha^{-1} over the NPK alone (4.69 Mg ha^{-1}) or control treatment (3.89 Mg ha^{-1}).

The experiment brings out the results favouring application of Mg, Zn and B jointly either in soil at the rate of $MgSO_4$ (80kg ha^{-1}) + $ZnSO_4$ (20 kg ha^{-1}) + Borax (10 kg ha^{-1}) or as foliar application at the rate of $MgSO_4$ (1%) + $ZnSO_4$ (0.5%) + Borax (0.25%). Application of Mg, Zn and B in soil requires higher quantity of nutrients compared to its foliar application and the latter reduces the toxic level soil accumulation of these nutrients and cost.

References

Arif, M., Shehzad, M. A., Bashir, F., Tasneem, M.,Yasin, G. and M. Iqbal. 2012. Boron, zinc and microtone effects on growth, chlorophyll contents and yield attributes in rice (*Oryza sativa*L.) cultivar. Afr. J. Biotechnol., 11(48):10851-10858.

Chaudhary, S.K., Singh, S. P., Singh, Y. and Dharminder.

2014.Influence of integrated use of fertilizers and manures on SRI grown rice (*Oryza sativa*) and their residual effect on succeeding wheat (*Triticum aestivum*) in calcareous soil. Indian J. Agron.,59(4): 527-533.

Dunn, D., Stevens, G. and Kendig, A. 2005. Boron Fertilization of Rice with Soil and Foliar Applications [On line]. Available at http: // plantsci.missouri. edu/ deltacrops/pdfs/ Rice Boron.pdf. [12 March 2014].

Ehsan-Ul-Haq, M., Kausar, R., Akram, M. and Shahzad, S. M. 2009. Is boron required to improve rice growth and yield in saline environment? Pak. J. Bot., 41: 1339-1350.

Ganapathy, M., Baradhan, G. and Ramesh, N. 2008. Effect of foliar nutrition on reproductive efficiency and grain yield of rice fallow pulses. Legume Res., 31(2): 142-144.

GOK [Government of Kerala]. 2013. Economic Review 2013 [on-line]. Available: http://spb.kerala.gov.in/ images/pdf/er2013/pdf/Chapter06.pdf[29 July 2015].

KAU (Kerala Agricultural University). 2011. Package of Practices Recommendations Crops (14thEd.). Kerala Agricultural University, Thrissur, 360 p.

Patil, B. C., Hosamani, R. M. and Ajjappalavaran, P. S. 2008. Effect of foliar application of micronutrients on growth and yield components of tomato (*Lycopersicon esculentum* Mill.) Karnataka J. Agric. Sci., 21: 428-430.

Ponnusamy, K. 2006. Farmers' participatory assessment of zinc in increasing yield. Indian Fmg., 56(6): 9-10.

Singh, H. P. and Singh, T. N. 2005. Enhancement in zinc response of rice by magnesium in alkali soil. Indian J. Plant Physiol., 10(2): 158-161.

Singh, V. K., Tiwari, R., Sharma, S. K., Dwivedi, B. S., Tiwari, K. N. and Gill, M. S. 2009. Economic viability of rice-rice cropping as influenced by site-specific nutrient management. Bett. Crops, 93 (2): 6-9.

Sreedharan, C. and George, C. M. 1969. Effect of micronutrients on paddy in red loam soil of Kerala. Agric. Res. J. Kerala, 7(2): 61-66.

Sriramchandra, M. V. S. and Mathan, K. K. 1988. Influence of zinc sources on the yield components, dry matter production and yield of rice. Madras Agric. J., 75: 200-203.

Uddin, M. K., Islam, M. R., Rahman, M. M. and Alam, S. M. K. 2002. Effect of sulphur, zinc and boron supplied from chemical fertilizers and poultry manure to wetland rice (Cv. BRRI Dhan 30). J. Biol. Sci., 2(3): 165-167.

Viju, B. 2012. Acidic soil stunts Kerala's growth, reveals study, *Times of India*, 26 May. 2012, p. 13.

Yadav, D.S. 2012. Fertilizer marketing in changing environment. Indian J. Fert., 8(11): 60-77.