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Effect of nutrients on growth and yield attributes of rice in two different methods of cultivation under *Terai* situation of West Bengal

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Abstract
An experiment was carried out at the agricultural farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar during the year 2012-2013 and 2013-2014 to study the effect of zinc on growth and yield attributes of Boro rice, (Cv. Annoda MW-10) at Conventional and SRI (System of Rice intensification) methods. It was observed that grain and straw yield was higher at the SRI method compared to that at the conventional one. The application of NPK @ 75 per cent RDF (80 : 40 : 40 kg/ha), biofertilizers (150 g per sq.mt) and 25 kg $ZnSO_4$ per ha resulted significant increase in plant height (82.76 cm), number of tillers per hill (25.6), panicle length (26 cm), 1000 grain weight (29.06 g), straw yield (16.97 t ha^{-1}) and yield of rice (10.07 t ha^{-1}) under SRI method whereas, the same treatment combination gave 9.64 t/ha grain yield and 16.26 t ha^{-1} straw yield of rice under the conventional method of cultivation. It could be concluded that application of zinc @ 25 kg/ha in addition to the recommended dose of N, P and K along with biofertilizer may be applied for increasing the grain yield of rice.

Keywords: Boro rice, yield, zinc, sri, conventional

Introduction
Zinc (Zn) is considered as one of the essential micronutrients for plants, especially for rice growing under submerged conditions. Although it requires in a very small amount but plays an important role in the growth and development of crop plants, hence, essential for plant growth. Rice is the important cereal crop grown mostly on Indian soils irrespective of soil types and conditions (Naik and Das, 2008) [12]. Rice cultivation under non-flooded conditions (aerobic) is an alternative to the conventional rice cultivation system in regions where rainfall and fresh water resources are limited (Ali and Pandey, 2015) [1].

In India, West Bengal is one of the leading states for rice cultivation. Productivity of rice depends upon balance application of nutrients. The soils of West Bengal are relatively poor in micronutrients due to continuous growing of high yielding varieties (Mahata *et al.*, 2012) [10] and for the only incorporation of macronutrients in cropping systems. The deficiencies of micronutrients are of critical importance for sustaining high productivity of rice in India.

Conventional method of rice production has been done under continuously flooded conditions and the hypoxic condition limits the ability of the roots to respire, creates low solubility of some nutrient ions and high solubility of some other nutrient ions and also regulates the ion transport, growth and yield of the crop.

It has become difficult to increase production from traditional rice farming. It needs extra labour and a lot of compost. Farming with modern methods is also expensive in outside inputs. With conventional methods, only by using expensive chemical fertilizers, pesticides and hybrid seed can increase the production. Hence, the SRI method of growing rice with local seed and organic compost, may increase rice production by reducing the demand of water. The better performance of the crop under SRI was the outcome of enhanced growth measured in terms of significantly higher plant height, number of tillers/hill, dry matter accumulation and leaf area index at different growth stages as compare to other methods of planting rice (Bokaria, 2015) [2].

Tzudir and Ghosh (2014) [19] revealed that there were positive and significant effects of organic and inorganic combination of fertilizers on System of rice Intensification (SRI).

SRI methods had favorable and significant impacts on plant height and panicle length and also showed significant differences in the yield components of grain number in panicles and percent sterility. Kabeya and Shankar (2013) [8] reported that application of Zn was found to have significant positive influence on growth of rice compared to untreated (zinc) control. Chapagain and Yamaji (2010) [3] also reported that SRI management promoted better root growth, greater number of effective tillers in a hill, longer panicle length, and greater number of filled grains per panicle over conventional management.

Keeping these in perspectives, the present research was undertaken to study the response of zinc on growth and yield attributes of rice under the *Terai* situation of West Bengal under the two methods of cultivation (i.e., SRI and Conventional).

Materials and Methods

A field experiment was conducted at the agricultural farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar during the year 2012-2013 and 2013-2014. The agricultural farm is located within the *Terai* Agro-climatic zone and its geographic location is 26°39′94.62″ N latitude and 89°38′94.66″ E longitude. The elevation of the farm is 43 meters above the mean sea level. The experimental design adopted was RBD (Randomised Block Design) in which there were two methods i.e., i) conventional and ii) SRI and twelve treatments with three-fold replications making a total of 36 (thirty six) plots for each method and the total of 72 (seventy two) plots, each measuring 4m x 4m. The variety Annoda (MW-10) was used in both the conventional and SRI methods. The N : P : K as 80 : 40 : 40 kg/ha was considered as the Recommended Dose of Fertilizer (RDF) in the form of Urea, SSP and MOP respectively. The treatments comprised of 100% RDF + 10 kg Znha^{-1} **(**T_1**)**, 100% RDF + 25 kg Znha^{-1} **(**T_2**)**, 100% RDF **(**T_3**)**, 75% RDF + Biofertilizer (Azotobacter and PSB) + 10 kg Znha^{-1} **(**T_4**)**, 75% RDF + Biofertilizer (Azotobacter and PSB) + 25 kg Zn ha^{-1} (T_5), 75% RDF + Biofertilizer (Azotobacter and PSB) (T_6**)**, 75% RDF + FYM + 10 kg Zn ha^{-1} **(**T_7**)**, 75% RDF + FYM + 25 kg Znha^{-1} **(**T_8**)**, 75% RDF + FYM **(**T_9**)**, 10 kg Znha^{-1} **(**T_{10}), 25 kg Zn ha^{-1} **(**T_{11}) and Control (T_{12}). The plants of outer row and the extreme ends of the middle rows were excluded to avoid border effect. Five hills were randomly selected from each treatment for recording observations on plant height, total tillers/hill, panicle length and 1000-grain weight (Yadav, 2007) [21]. Grain yield and straw yield, were recorded at harvest. For entire analyses, there were three independent replication for each treatment. Prior to parametric statistical analyses, data were transformed as and when applicable. Transformed data were analyzed by one-way, two-way and or three-way analyses of variance (ANOVAs). Means were separated by post-hoc least significant difference (LSD) test or Fisher's Protected LSD test. The term significant has been used to indicate differences for which $P \leq 0.05$. GenStat Version 11.1.0.1504 (VSN International Ltd., Oxford, UK) was used for statistical analyses (Hsu, 1996) [6].

Results and Discussion

Plant height (cm) of rice

The pooled data (1st and 2nd year) pertaining to plant height of rice under conventional method (Table 1) revealed that, significantly higher plant height (83.52 cm) was recorded in the treatment T_5, i.e., 75 percent RDF + Biofertilizer + 25 kg Zn per ha and the lower (60.92cm) was in the treatment T_{12} (control). In SRI method (Table 2), at the treatment T_5, the maximum plant height (82.76 cm) was observed compared to the rest of the treatments. (Table 2). The highest plant height in treatment receiving 75 percent RDF + Biofertilizer + 25 kg Zn per ha was because of the continuous supply of nutrients throughout its growth stage from biofertilizers. Singh *et al.* (2013) [14] reported that growth, i.e., plant height of rice increased significantly due to the system of rice intensification (SRI) practices as compared to conventional method. The plant height was progressively increased with advancement of the age of crop reported by Dwivedi *et al.* (2015) [5].

Number of leaves per hill

The maximum number of leaves per hill (127.96 and 128.90) was observed in the application of 75 percent RDF + Biofertilizer + 25 kg Zn per ha (T_5) in both the methods of cultivation, i.e., Conventional and SRI (Table 1 and Table 2) methods respectively. Kabeya and Shankar (2013) [8] reported that application of Zn was found to have a significant positive influence on growth of rice in comparison to non-application of zinc as nutrient in soils.

Number of tillers per hill

The number of tillers per hill in conventional method varied from 9.53 to 25.07 (Table 1) whereas, in SRI method it varied from 10.75 to 25.60 (Table 2). However, the SRI method of cultivation had higher number of tillers per hill (25.60) compared to conventional method (25.07). Rice seedlings when planted earlier need to be provided enough space to express their full potential in terms of growth of leaves, tillers and roots. Enough space, along with other favorable conditions, allows the plants' roots to grow profusely both vertically in deeper parts of the soil and horizontally to cover a larger area, and when roots are spread to a large volume of soil, they tap more nutrients, which results in the development of larger plants with larger number of tillers. The similar findings was reported by Mohanty *et al.* (2014) [11] in SRI method, where, the yield attributes like plant height, effective tillers per hill, panicle length, number of grains per panicle and test weight were significantly higher as compared to traditional random planting (TRP) method. The hills under SRI had nearly double the number of tillers per plant than Traditional flooding (TF) hills but there was no significant difference in tillers per unit area reported by Thakur *et al.* (2010) [17].

Panicle length (cm)

The application of 75 percent RDF along with biofertilizer and 25 kg of Zn as zinc sulphate in T_5 recorded higher panicle length of 26.75 cm and 26.00 cm in conventional (Table 1) and SRI (Table 2) method of cultivation respectively. Prabha *et al.* (2011) [13] reported that SRI produced significantly highest number of tillers, panicle length, grain yield compared to conventional method.

Number of panicle per plant

The number of panicles per plant was maximum in T_5 in both the methods of cultivation (Table 1 and Table 2). The application of 100 percent RDF + 25 kg Zn per ha in treatment T_2 was found to be the second best treatment for panicle number per plant of 13.75 (Table 1) and 14.08 (Table 2) at conventional and SRI method respectively.

Grains per plant
The significantly higher grains per plant was noticed in SRI method (861.50) than that of the conventional method (802.34) in the treatment T_5 in both the methods of cultivation. Sridevi and Chellamuthu (2012) [15] reported that the SRI method profoundly enhanced the growth and nutrient uptakes which in turn improved the yield attributes of rice. Singh *et al.* (2013) [14] also reported that the number of grains per panicle was significantly higher as compared to conventional method.

1000-grain weight (g)
The 1000-grain weight of rice (28.54 g) in treatment T_5 (Table 1) in conventional method, was somewhat less than the SRI method (29.06 g) was found in the same treatment (Table 2). The increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in 1000 grain weight (Thawait *et al.*, 2014) [18].

Grain yield (t ha^{-1}) of rice
The effect of treatments had significant influence on grain yield of rice. Similar observation was recorded (Thakur *et al.*, 2019) [16] on *boro* rice at different combinations of nutrients under *Terai* situation of West Bengal. The change in grain yield from 4.36 to 9.64 t ha^{-1} in conventional method (Table 1) and from 4.74 to 10.07 tha^{-1} in SRI method (Table 2) was observed. However, the application of 75 percent RDF + Biofertilizer + 25 kg Zn per ha in treatment (T_5) was observed to be the best treatment in both the methods of cultivation and the least was in the untreated control. This might be due to the azotobacter which helps in improving the plant growth, increase the nitrogen in soil through nitrogen fixation by utilizing carbon for its metabolism and the PSB could increase the uptake of P by the plants, thus helps in increasing the crop yield (Jnawali *et al.*, 2015) [7]. The SRI method had higher grain yield in comparison to that of conventional method (Fig. 1). The use of young seedlings, addition of an organic manures, wider spacing and greater aeration from intermittent irrigation might have produced high yields under SRI method, as was reported by Dass and Dhar (2014) [4]. Similarly, Wijebandara *et al.* (2011) [20] reported that the highest grain yield was found under the SRI method of cultivation with 75% RDF + biofertilizer + 25 kg ha^{-1} $ZnSO_4$.

The grain yield at conventional method was found relatively lower than the yield under the SRI method. This might be due to the lower number of filled grains per panicle, lower number of grains per panicle and panicle length. Similar finding was reported by Singh *et al.* (2013) [14]. The maximum grain yield of rice was achieved by the application of 20 kg $ZnSO_4$ ha^{-1} with recommended NPK as compared to the control, which was reported by Keram *et al.* (2012) [9].

Straw yield (t ha^{-1})
The treatment T_5 receiving 75 percent of RDF + Biofertilizer + 25 kg Zn per ha had higher straw yield in conventional and SRI methods of cultivation (Table 1 and Table 2) and the lower (8.87 t ha^{-1} and 9.25 t ha^{-1}) was in the untreated plot (T_{12}). The application of 75 percent of RDF + Biofertilizer + 25 kg $ZnSO_4$ ha^{-1} had straw yield of 16.26 t ha^{-1} and 16.97 t ha^{-1} in conventional and SRI methods of cultivation respectively. The differences in straw yield between SRI method and conventional method may be related to the variations in number of tillers, leaf area and total dry matter production in plant at the fertilizer levels. The per cent increase in the straw yield by 12 days old seedlings (SRI) was 21.56 per cent over 25 days old seedlings i.e., Conventional method (Thawait *et al.* 2014) [18].

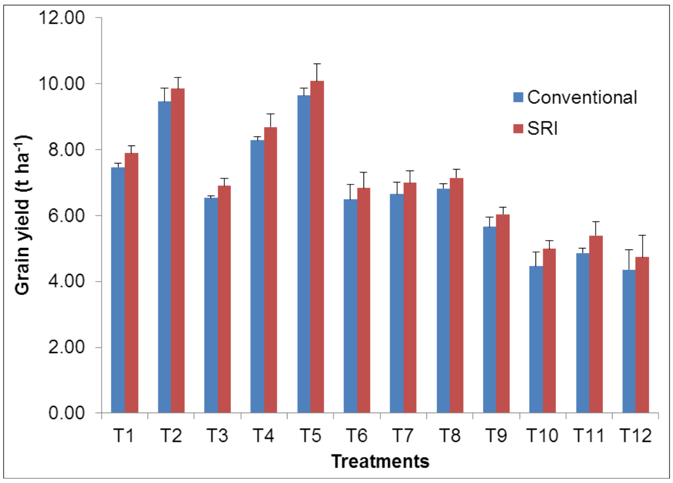

Fig 1: Effect of treatments on grain yield of rice under conventional and SRI methods ofcultivation. The error bar indicates the standard deviation at 5% level of significance

Table 1: Effect of treatments on growth and yield attributes of rice under conventional method

Treatments	Conventional (pooled data)								
	Plant height (cm)	Number of leaves hill^{-1}	Number of tillers hill^{-1}	Panicle length (cm)	No. of Panicle/plant	Grains/plant	1000 grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})
T_1	76.02de	124.10fg	23.80c	22.42fgh	11.58ef	717.25ef	27.60ef	7.47ef	13.09gh
T_2	81.67fg	126.11gh	24.62c	24.00h	13.75gh	749.34ef	27.80f	9.45g	15.28
T_3	74.92d	119.31e	19.92b	19.67de	10.09cde	574.34cd	25.40cd	6.54cd	12.10ef
T_4	78.93ef	124.72g	24.20c	22.50gh	12.25fg	743.17ef	27.67f	8.28f	13.41h
T_5	83.52g	127.96h	25.07c	26.75	15.08h	802.34f	28.54f	9.64g	16.26
T_6	74.43cd	118.26de	19.51b	19.50de	9.00bcd	528.17bc	24.97cd	6.49cd	11.47de
T_7	76.79d	122.13f	20.26b	20.67ef	10.34de	659.84de	26.04de	6.65de	12.08ef
T_8	76.62de	123.69fg	21.05b	21.75fg	11.09ef	652.17de	27.27ef	6.82de	12.42fg
T_9	72.00c	116.70cd	17.01a	18.50cd	8.59bc	544.33bc	24.38bc	5.66bc	10.87cd
T_{10}	64.67b	112.91ab	13.18	16.67ab	7.42ab	463.50b	22.53a	4.46a	10.03b
T_{11}	66.79b	114.53bc	15.75a	17.25bc	8.42bc	487.17bc	23.04ab	4.86ab	10.40bc
T_{12}	60.92a	111.01a	9.53	15.00a	6.17a	347.67a	21.76a	4.36a	8.87a
Treatment									
SE(±)	1.02	0.87	0.61	0.62	0.61	35.36	0.55	0.32	0.27
LSD (P=0.05)	2.91	2.47	1.74	1.76	1.74	100.65	1.57	0.91	0.76
Practice									
SE(±)	0.42	0.35	0.25	0.25	0.25	14.43	0.23	0.13	0.11

LSD (*P*=0.05)	1.23	NS	NS	0.72	NS	NS	0.68	0.40	0.31
Treatment X Practice									
SE(±)	1.45	1.23	0.87	0.87	0.87	50.00	0.78	0.45	0.38
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with common letters are not significantly different at *P*≤0.05, according to Fisher's Protected Least Significant Difference (LSD) test using the algorithm of Studentized range test

Table 2: Effect of treatments on growth and yield attributes of rice under SRI method

Treatments	SRI (pooled data)								
	Plant height (cm)	Number of leaves hill^{-1}	Number of tillers hill^{-1}	Panicle length (cm)	No. of Panicle/plant	Grains/plant	1000 grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})
T_1	77.21e	125.26f	24.72c	22.92gh	11.92ef	758.92def	28.10fg	7.89de	13.40e
T_2	81.09fg	127.51gh	25.24c	24.58hi	14.08gh	774.33ef	28.34g	9.85fg	15.69
T_3	75.36cde	120.02d	20.67b	21.00ef	10.34cde	632.67cd	26.07de	6.90cd	12.55d
T_4	79.54f	125.65fg	24.97c	22.92gh	12.58fg	778.84ef	28.20g	8.69ef	14.01
T_5	82.76g	128.90h	25.60c	26.00i	15.50h	861.50f	29.06g	10.07g	16.97
T_6	74.84cd	119.10cd	20.10b	20.34de	9.59bcd	553.17bc	25.47de	6.84cd	11.87c
T_7	75.67de	122.91e	20.92b	22.08fg	10.92def	694.67de	26.76ef	6.99cd	12.67d
T_8	76.13de	124.72ef	21.71b	22.34fg	11.50ef	701.50de	27.87fg	7.14cd	12.97de
T_9	73.08c	117.73c	17.76a	18.84cd	9.00bc	563.50bc	24.70cd	6.04bc	11.45c
T_{10}	66.17b	113.78ab	14.46	17.00ab	7.84ab	495.17ab	23.15ab	4.99ab	10.43b
T_{11}	67.37b	115.21b	16.95a	18.34bc	8.83bc	502.17ab	24.04bc	5.39ab	10.79b
T_{12}	62.17a	111.78a	10.75	15.83a	6.67a	391.34a	22.62a	4.74a	9.25a
Treatment									
SE(±)	0.80	0.75	0.58	0.61	0.67	45.57	0.49	0.42	0.20
LSD (*P*=0.05)	2.28	2.13	1.65	1.74	1.89	129.72	1.39	1.18	0.57
Practice									
SE(±)	0.33	0.31	0.24	0.25	0.27	18.60	0.20	0.17	0.08
LSD (*P*=0.05)	0.98	NS	NS	0.71	NS	NS	0.60	0.49	0.25
Treatment X Practice									
SE(±)	1.13	1.06	0.82	0.86	0.94	64.45	0.69	0.59	0.28
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with common letters are not significantly different at *P*≤0.05, according to Fisher's Protected Least Significant Difference (LSD) test using the algorithm of Studentized range test

Summary

The study thus showed that the application of 75 percent RDF along with biofertilizer and 25 kg $ZnSO_4$ ha^{-1} rendered the highest growth and yield attributes of rice in SRI method of cultivation. The increasing levels of zinc in soils also increased the grain yield of rice at both the methods of cultivation.

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