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Effect of nutrient management on growth, productivity and economics in rice based cropping system in lateritic soil of West Bengal

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Abstract

The experiment was conducted during 2014-2015 and 2015-2016 at farmers' field situated at Binuria village (23 °40'N and 87 °37'E) of Birbhum district of West Bengal under the red and lateritic belt of West Bengal. The experiment was laid out in Randomized Block Design with three replication and twelve treatments in both during *kharif* and *boro* season. The plot size was 5m x 4m and the treatment combinations are T₁-N₈₀P₄₀K₄₀Zn₂₅S₂₀, T₂-N₄₀P₄₀K₄₀Zn₂₅S₂₀, T₃-N₀P₄₀K₄₀Zn₂₅S₂₀, T₄-N₈₀P₂₀K₄₀Zn₂₅S₂₀, T₅-N₈₀P₀K₄₀Zn₂₅S₂₀, T₆-N₈₀P₄₀K₂₀Zn₂₅S₂₀, T₇-N₈₀P₄₀K₀Zn₂₅S₂₀, T₈-N₈₀P₄₀K₄₀Zn_{12.5}S₂₀, T₉-N₈₀P₄₀K₄₀Zn₀S₂₀, T₁₀-N₈₀P₄₀K₄₀Zn₂₅S₁₀, T₁₁-N₈₀P₄₀K₄₀Zn₂₅S₀ and T₁₂-Control where as in *boro* season the treatment combinations are T₁-N₁₂₀P₆₀K₆₀Zn₂₅S₂₀, T₂-N₆₀K₆₀Zn₂₅S₂₀, T₃-N₀K₆₀Zn₂₅S₂₀, T₄-N₁₂₀P₃₀K₆₀Zn₂₅S₂₀, T₅-N₁₂₀P₀K₆₀Zn₂₅S₂₀, T₆-N₁₂₀P₆₀K₃₀Zn₂₅S₂₀, T₇-N₁₂₀P₆₀K₀Zn₂₅S₂₀, T₈-N₁₂₀P₆₀K₆₀Zn_{12.5}S₂₀, T₉-N₁₂₀P₆₀K₆₀Zn₀S₂₀, T₁₀-N₁₂₀P₆₀K₆₀Zn₂₅S₁₀, T₁₁-N₁₂₀P₆₀K₆₀Zn₂₅S₀, and T₁₂-Control. The high yielding varieties (HYV) rice during *Kharif* season was MTU 7029 (Swarna) and hybrid variety used in *Boro* season was Arize 6444 GOLD. The study concludes that application of N₈₀P₄₀K₄₀Zn₂₅S₂₀ (T₁) during *kharif* and N₁₂₀P₆₀K₆₀Zn₂₅S₂₀ (T₁) in *boro* season during the two season of experimentation was essential for improving growth attributes, yield components and productivity of high yielding variety (HYV) and hybrid rice. The treatments positively influenced the crop efficiency factors, improved physico-chemical properties and fertility status of the soil and paid highest gross and net returns from the rice cultivation. The study suggests the application of ample dose of fertilizer for better growth, higher productivity, profit and sustainability of rice in the lateritic soil of west Bengal.

Keywords: Ample dose, grain yield, rice, nutrient management

Introduction

Rice is a main staple in more than 100 countries worldwide. Rice is most closely associated with South, Southeast, and East Asia, where 90% of the world's rice is produced. Asia's hot and humid climate during the long and heavy monsoon season, and the fertile land along the river basins of the major deltas that are regularly flooded, provide the most favourable agro-ecological environment for rice cultivation. Amongst the rice growing countries, rice cultivation is the most important agricultural operation in India, not only in term of food security but also in term of livelihood. It plays a major part in the diet, economy, employment, culture and history of India. Ninety percent of rice produced is consumed within the country. India ranks number one globally in paddy area with 42.75 million hectares and with production of 105.24 million tonnes (Anonymous, 2014) ^[1] stands next only to China. While there has been no net increase in the area of rice cultivation in the last 30 years, rice contributes nearly 15 percent of India's annual gross domestic product (GDP) and provides 31 percent of the total calorie supply. India needs to produce 120 million tonnes by 2030 to feed its one and a half billion plus population by then. A real-time analysis of this scenario provides sufficient justification for strengthening, intensifying and introducing cutting edge science and technology for increasing rice productivity in India. In West Bengal, the area and production under food grains during 2012-13 were 5.44 million hectares and 15.02 million tonnes respectively (Gupta et al., 2012 and Das *et al.*, 2014) ^[7, 5]. Rice grows in the state in 3 different seasons viz., *Aus* (autumn rice), *Aman* (winter rice) and *Boro* (summer rice). There are three seasons for growing rice in West Bengal viz. - autumn, winter and summer. These three seasons are named according to the season of harvest of the crop.

Autumn or *pre-kharif* rice is known as *Aus* in West Bengal. The pre-monsoon *Aus*, covers April to July in the northern region and May to September in the southern region of the state and accounts for only 5% of total rice area and with the expansion of irrigation facilities, the area under this crop has gradually been declining. At present, more than 99% of the total area is covered with high yielding varieties during *Aus* season. The winter or monsoon rice, known as *Aman*, is grown from June to December. It accounted for 69% of the total rice area and is grown under rainfed conditions in the semi-deep, deep and flooded land (mostly indigenous improved and traditional varieties) and under irrigated conditions in the flood-free medium and shallow lowlands (mostly modern high yielding varieties). Mainly during *Aman*, farmers still grow some traditional or local ice varieties having special features and it covers nearly about 12% of the total rice area cultivated during *Aman*. The remaining 26% of the rice area is covered by the summer or dry season rice popularly known as *Boro*. The nutrient mining issues concern the nutrients that are less mobile in soils and have higher potential of staying in the soil. For example, nitrogen (N) is highly mobile in the soil and has the highest probability, among the major nutrients, to be lost from the soil system through volatilization and leaching, among others. The Indian soils, being in the sub-tropical region coupled with the preponderance of tillage practices, are rarely sufficient in N. Nitrogen is generally applied in adequate quantities to the crops, and “nitrogen mining” is not frequently discussed as crop production relies more on adequate external application through fertilizer/manure sources rather than on the native soil reserve of N. The input-output balance calculations for N, at the regional or the national scale, generally show positive balance in soils (Sanyal, 2014) [13]. The total fertilizer N needed by rice to achieve a profitable yield target is determined from the anticipated crop response to applied fertilizer N and a targeted efficiency of fertilizer N use. Fertilizer N is supplied at critical growth stages, especially active tillering and panicle initiation, to match the crop needs for supplemental N. Fertilizer P and K are applied in sufficient amounts to overcome deficiencies and sustain soil fertility. (Buresh, 2009) [3] Nitrogen management requires special attention in its use so that the large losses can be minimized and the efficiency maximized. Site-specific nutrient management (SSNM) (Banayo *et al.*, 2018) [2] has been found especially useful to achieve the goals of improved productivity and higher N use efficiency (NUE) (Kumar *et al.*, 2018) [8].

Materials and Methods

The experiment was conducted during 2014-2015 and 2015-2016 at farmers' field situated at Binuria village (23 °40'N and 87 °37'E) of Birbhum district of West Bengal under the red and lateritic belt of West Bengal. The experiment was laid out in Randomized Block Design with three replication and twelve treatments in both during *kharif* and *boro* season. The plot size was 5 m x 4 m and the treatment combinations are T₁-N₈₀P₄₀K₄₀Zn₂₅S₂₀, T₂-N₄₀P₄₀K₄₀Zn₂₅S₂₀, T₃-N₀P₄₀K₄₀Zn₂₅S₂₀, T₄-N₈₀P₂₀K₄₀Zn₂₅S₂₀, T₅-N₈₀P₀K₄₀Zn₂₅S₂₀, T₆-N₈₀P₄₀K₂₀Zn₂₅S₂₀, T₇-N₈₀P₄₀K₀Zn₂₅S₂₀, T₈-N₈₀P₄₀K₄₀Zn_{12.5}S₂₀, T₉-N₈₀P₄₀K₄₀Zn₀S₂₀, T₁₀-N₈₀P₄₀K₄₀Zn₂₅S₁₀, T₁₁-N₈₀P₄₀K₄₀Zn₂₅S₀ and T₁₂ -Control where as in *boro* season the treatment combinations are T₁-N₁₂₀P₆₀K₆₀Zn₂₅S₂₀, T₂-N₆₀P₆₀K₆₀Zn₂₅S₂₀, T₃-N₀P₆₀K₆₀Zn₂₅S₂₀, T₄-N₁₂₀P₃₀K₆₀Zn₂₅S₂₀, T₅-N₁₂₀P₀K₆₀Zn₂₅S₂₀, T₆-N₁₂₀P₆₀K₃₀Zn₂₅S₂₀, T₇-N₁₂₀P₆₀K₀Zn₂₅S₂₀, T₈-N₁₂₀P₆₀K₆₀Zn_{12.5}S₂₀, T₉-

N₁₂₀P₆₀K₆₀Zn₀S₂₀, T₁₀-N₁₂₀P₆₀K₆₀Zn₂₅S₁₀, T₁₁-N₁₂₀P₆₀K₆₀Zn₂₅S₀, and T₁₂- Control. The ample dose of nutrients was 80:40:40:25:20 and 120:60:60:25:20 kg/ha of N: P₂O₅: K₂O:Zn:S in *kharif* and *Boro* season rice respectively. The high yielding varieties (HYV) rice during *Kharif* season was MTU 7029 (Swarna). The Hybrid variety used in *Boro* season was Arize 6444 GOLD. The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 (Cochran and Cox, 1977) [4].

Results and Discussion

Growth Attributes

The plant height of *kharif* season rice record highest with application ample dose of nutrients (i.e. T₁:N₈₀P₄₀K₄₀Zn₂₅S₂₀) caused significant increase in height of the rice plants over control (i.e. T₁₂: No fertilizer) in the pooled data analysis. The treatment T₁ (N₈₀P₄₀K₄₀Zn₂₅S₂₀) was significantly superior to control and all the treatments produced and statistically at par with T₂(N₄₀P₄₀K₄₀Zn₂₅S₂₀), T₄ (N₈₀P₂₀K₄₀Zn₂₅S₂₀), T₅ (N₈₀P₀K₄₀Zn₂₅S₂₀), T₆ (N₈₀P₄₀K₂₀Zn₂₅S₂₀), T₈(N₈₀P₄₀K₄₀Zn_{12.5}S₂₀) and T₁₀ (N₈₀P₄₀K₄₀Zn₂₅S₁₀). The plant height of *boro* season rice also produce similar type of observations as recorded in *kharif* season rice. T₁ remained statistically at par with all other treatment except the treatments T₃ and control (T₁₂) remained statistically at par in enhancement of the plant height at the same stage. The dry matter accumulation of *kharif* and *boro* rice which was reflected on pooled data of two years of experiment and observed similar trend was noted in dry matter where T₁ produced significantly higher dry matter than T₃ and control. Moreover, T₁ remained statistically at par with other treatments except T₃, and T₁₂. The control treatment shows lowest dry matter during the growth stage among all other the treatment (Shankar *et al.*, 2014) [16].

The number of tillers per m² recorded at harvesting were statistically analyzed and presented in Table 1 and 2. The data reflect that most of the treatments recorded higher number of tillers per m² during the two years of experimentation. The resulting showed that the rapid increase in number of tillers was observed during both the years of the experiment where application of 100% of recommended dose of fertilizers (T₁:N₈₀P₄₀K₄₀Zn₂₅S₂₀) gave maximum number of tiller per m² was recorded which was statistically at par with the treatments having T₂-N₄₀P₄₀K₄₀Zn₂₅S₂₀, T₄-N₈₀P₂₀K₄₀Zn₂₅S₂₀, T₆-N₈₀P₄₀K₂₀Zn₂₅S₂₀ and T₈-N₈₀P₄₀K₄₀Zn_{12.5}S₂₀ in *kharif* season but during *boro* rice the pooled data analysis, also produce similar trend and the effect of nutrient management observed that T₁; N₁₂₀P₆₀K₆₀Zn₂₅S₂₀ gave higher tillers per plant over T₁₂ (control). T₁(N₁₂₀P₆₀K₆₀Zn₂₅S₂₀) was significantly superior over T₃(N₀P₆₀K₆₀Zn₂₅S₂₀), T₅(N₁₂₀P₀K₆₀Zn₂₅S₂₀), T₇(N₁₂₀P₆₀K₀Zn₂₅S₂₀), T₉(N₁₂₀P₆₀K₆₀Zn₀S₂₀), T₁₁(N₁₂₀P₆₀K₆₀Zn₂₅S₀) and control (T₁₂) which was statistically at par with T₂-N₆₀P₆₀K₆₀Zn₂₅S₂₀, T₄-N₁₂₀P₃₀K₆₀Zn₂₅S₂₀, T₆-N₁₂₀P₆₀K₃₀Zn₂₅S₂₀, T₈-N₁₂₀P₆₀K₆₀Zn_{12.5}S₂₀ and T₁₀-N₁₂₀P₆₀K₆₀Zn₂₅S₁₀. The lowest number of tillers per m² was recorded in T₃, T₅, T₇, T₉, T₁₁ and control which was due to omission of different nutrients gave less growth attribute compared to ample dose of nutrients which follow similar trend in pooled data analysis during both years of experimentation (Nanjappa *et al.*, 2013) [10].

Yield Attributes

During *kharif* and *boro* season of 2014-15 and 2015-16. The yield attributes like number of panicles m^{-2} , panicle length, number of spikelets panicle^{-1} and number of filled grains panicle^{-1} recorded at maturity were presented in the Table 1 & 2. The effect of higher doses of nitrogen, phosphorus, potassium, zinc and sulphur revealed that number of panicles m^{-2} , increased with the 100% application to rice pooled data analysis of *kharif* season. The control show least among all other the treatments. The number of panicles per m^{-2} was maximum in the treatment T_1 ($\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$) was applied with ample dose of nutrient compared to omission and control treatment and it was statistically at par with (T_2) $\text{N}_{40}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, (T_4) $\text{N}_{80}\text{P}_{20}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, (T_6) $\text{N}_{80}\text{P}_{40}\text{K}_{20}\text{Zn}_{25}\text{S}_{20}$, (T_8) $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{12.5}\text{S}_{20}$ and (T_{10}) $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{10}$ and Similar trend was recorded in pooled data of *boro* rice which was statistically at par with T_2 : $\text{N}_{60}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$, T_4 : $\text{N}_{120}\text{P}_{30}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$, T_6 : $\text{N}_{120}\text{P}_{60}\text{K}_{30}\text{Zn}_{25}\text{S}_{20}$, T_8 : $\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{12.5}\text{S}_{20}$ and T_{10} : $\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{10}$. Among all other the treatment T_1 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$) show superior and the lowest value shows in control (Shankar *et al.*, 2018) [14, 15]. The number of filled grain per panicle has been significantly affected due to application of recommended dose of fertilization. The maximum number of grains per panicle has been recorded where T_1 ($\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$) of recommended dose of fertilizer was applied which was at par with (T_2) $\text{N}_{40}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, (T_4) $\text{N}_{80}\text{P}_{20}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, (T_6) $\text{N}_{80}\text{P}_{40}\text{K}_{20}\text{Zn}_{25}\text{S}_{20}$ and (T_8) $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{12.5}\text{S}_{20}$ which was observed in the pooled data of *kharif* season and similar trend was followed in the *boro* season rice. The data has shown in significant increase in number of filled grains per panicle due the recommended dose of NPKZn and S which was applied in (T_1 $\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$) and recorded as the highest number of grains per panicle (142.7) which was significantly superior to all the treatments. This was closely followed by T_2 - $\text{N}_{60}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$, T_4 - $\text{N}_{120}\text{P}_{30}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$, T_6 - $\text{N}_{120}\text{P}_{60}\text{K}_{30}\text{Zn}_{25}\text{S}_{20}$ and T_8 - $\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{12.5}\text{S}_{20}$. the Control (T_{12}) treatment was recorded the lowest number of filled grains per panicle among all the treatments.. The number of spikelets per panicle is one of the important yield contributing parameters of rice which ultimately determines the total yield of the crop. In pooled data analysis, the observations on number of spikelets per

panicle were recorded and a significant variation among the treatments was noticed. Among the different treatment combinations, the application of $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$ (T_1) produced significantly higher number of spikelets per panicle (149.6) than control in the pooled data of *kharif* rice. The data T_1 gave significantly better result which was statistically at par with T_2 : $\text{N}_{40}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, T_4 : $\text{N}_{80}\text{P}_{20}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$, T_6 : $\text{N}_{80}\text{P}_{40}\text{K}_{20}\text{Zn}_{25}\text{S}_{20}$, T_8 : $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{12.5}\text{S}_{20}$ and T_{10} : $\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{10}$. The pooled of *boro* season rice which was closely follow similar trend. The treatment with 100% of RDF gave maximum value among all the treatment and the lowest number of spikelets per panicle observed in control (no fertilizer) (Ray *et al.*, 2015 and Shankar *et al.*, 2018) [12, 14, 15].

Yield (t ha^{-1})

The Grain and straw yield (t ha^{-1}) observed that the highest grain yield (5.6 t ha^{-1}) and straw yield (7.5 t ha^{-1}) of *kharif* rice (Table 1 & 2). in the pooled data which shows that the grain yield has increased significantly due to application of ample dose of nutrient T_1 ($\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$) with compared to the control and Application of fertilizer to rice-rice based cropping system has resulted significantly and appreciably higher grain yield of rice in both the season. Which was statistically at par with all other treatment except T_3 and T_{12} . The maximum grain and straw yield of rice was recorded in T_1 ($\text{N}_{80}\text{P}_{40}\text{K}_{40}\text{Zn}_{25}\text{S}_{20}$). The pooled of *boro* season (2015 & 2016), the highest grain and straw yield (6.60 & 8.52 t ha^{-1}) was achieved T_1 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$) applied with ample dose of nutrients which was statistically at par with T_4 ($\text{N}_{120}\text{P}_{30}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$), T_5 ($\text{N}_{120}\text{P}_{0}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$), T_6 ($\text{N}_{120}\text{P}_{60}\text{K}_{30}\text{Zn}_{25}\text{S}_{20}$), T_7 ($\text{N}_{120}\text{P}_{60}\text{K}_{0}\text{Zn}_{25}\text{S}_{20}$), T_8 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{12.5}\text{S}_{20}$), T_9 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{0}\text{S}_{20}$), T_{10} ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{10}$) and T_{11} ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{0}$) with compared to control treatment. The treatment combination with 100% recommended dose of fertilizers has brought about significant improvement in yield of *kharif* and *boro* rice over control treatments. The ample dose of nutrients (T_1) has proved appreciably and significantly superior to all other the treatments (Kumar *et al.* 2018) [8]. Which resulted the maximum yield of rice-rice cropping system and the lowest straw yield has been recorded in the control plot in both years of the experiment (Shankar *et al.*, 2014) [16].

Table 1: Effect of nutrient management on growth and yield attributes of *Kharif* rice (pooled data over two years)

Treatment	Plant height (cm)	Dry matter Accumulation (g)	Tiller m^{-2}	Number of panicles/ m^2	Number of filled grains/panicle	Number of Spikelets/panicle	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$)	119.6	1308.3	312.1	248	132.1	149.6	5.56	7.59
T_2 ($\text{N}_{60}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$)	111.1	1252.7	296.9	243	127.6	146.4	4.82	7.1
T_3 ($\text{N}_0\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$)	95.4	661.7	258.4	209.9	110.3	132.5	3.32	5.18
T_4 ($\text{N}_{120}\text{P}_{30}\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$)	117	1242.6	295.9	245.4	122.3	145.5	5.26	7.45
T_5 ($\text{N}_{120}\text{P}_0\text{K}_{60}\text{Zn}_{25}\text{S}_{20}$)	108.5	1213.2	277.2	239.3	113.1	135.8	5.03	7.35
T_6 ($\text{N}_{120}\text{P}_{60}\text{K}_{30}\text{Zn}_{25}\text{S}_{20}$)	115.1	1233.2	303.3	234.6	126.9	149.2	5.18	7.46
T_7 ($\text{N}_{120}\text{P}_{60}\text{K}_0\text{Zn}_{25}\text{S}_{20}$)	103.6	1209.4	274.5	226.3	112.4	136.3	5.07	7.29
T_8 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{12.5}\text{S}_{20}$)	114.2	1237.7	302.7	246	124.9	148	5.21	7.52
T_9 ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_0\text{S}_{20}$)	100.8	1206.4	274.4	217.2	113.6	135.6	5.02	7.47
T_{10} ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_{10}$)	114.2	1222.8	299.2	245	118.2	145.5	5.32	7.53
T_{11} ($\text{N}_{120}\text{P}_{60}\text{K}_{60}\text{Zn}_{25}\text{S}_0$)	96	1244	273.2	220.4	113	133.8	5.28	7.50
T_{12} (Control)	88.1	516.3	198.8	188.1	63.6	108.4	2.31	4.08
SEm ($\pm$)	6.5	64.6	9.6	7.2	5.9	4	0.25	0.33
CD ($p=0.05$)	19	189.3	28.2	21.2	17.2	11.7	0.74	0.98
CV (%)	10.4	11.1	6	5.3	8.8	4.8	9.15	8.3

Table 2: Effect of nutrient management on growth and yield attributes of *Boro* rice (pooled data over two years)

Treatment	Plant height (cm)	Dry matter Accumulation (g)	Tiller m ⁻²	Number of panicles/m ²	Number of filled grains/panicle	Number of Spikelets/panicle	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
T ₁ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	123.2	1417.2	360.8	281.6	142.7	157.3	6.60	8.52
T ₂ (N ₆₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	118.0	1397.7	360.9	275.1	134.5	151.6	5.88	8.06
T ₃ (N ₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	96.4	668.4	310.6	237.2	90.8	125.6	3.44	5.96
T ₄ (N ₁₂₀ P ₃₀ K ₆₀ Zn ₂₅ S ₂₀)	117.4	1402.9	355.1	267.3	132.5	155.5	6.18	8.39
T ₅ (N ₁₂₀ P ₀ K ₆₀ Zn ₂₅ S ₂₀)	114.9	1389.5	328.3	255.2	129.6	143.7	6.06	7.91
T ₆ (N ₁₂₀ P ₆₀ K ₃₀ Zn ₂₅ S ₂₀)	119.2	1403.3	354.9	278.5	131.1	156.5	6.22	8.45
T ₇ (N ₁₂₀ P ₆₀ K ₀ Zn ₂₅ S ₂₀)	112.7	1380.6	332.4	258.1	130.6	141.0	6.12	8.30
T ₈ (N ₁₂₀ P ₆₀ K ₆₀ Zn _{12.5} S ₂₀)	121.5	1401.0	351.5	279.7	135.6	151.8	6.31	8.46
T ₉ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₀ S ₂₀)	120.2	1383.5	342.6	263.6	131.0	146.1	6.23	8.48
T ₁₀ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₁₀)	117.2	1405.0	351.1	267.5	138.1	153.2	6.25	8.51
T ₁₁ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₀)	118.1	1399.7	337.8	263.4	131.6	140.9	6.11	8.30
T ₁₂ (Control)	84.4	587.0	226.5	212.6	78.0	140.5	2.06	4.78
SEm(±)	7.7	62.2	10.2	7.6	6.8	5.9	0.25	0.39
CD (p=0.05)	22.7	182.3	29.8	22.3	20.1	17.4	0.72	1.14
CV(%)	12.4	9.3	5.4	5.1	9.5	6.9	7.60	8.58

Economics

The gross return (Rs ha⁻¹) of high yielding rice and hybrid rice grown during *kharif* (2014 & 2015) and *boro* (2015 & 2016) season with different nutrient management practices was estimated on the basis of prevailing market price of different inputs and outputs. The data on gross return, net return in rice cultivation were analyzed statistically and presented in the Table 3. The pooled data of *kharif* and *boro* season rice for the gross return was found that the highest obtained in the ample dose (T₁:N₈₀P₄₀K₄₀Zn₂₅S₂₀). The gross return (Rs ha⁻¹) was significantly affected by nutrient application of ample dose of NPKZnS applied plot was significantly superior than the control plot. The application of 100% N+P+K+Zn+S dose increased yield components, which ultimately reflected on grain yield and straw yield. Due increased in yield which cause the higher gross return in T₁ and highest among all the treatment which was statistically at par with T₁₀ (Singh *et al.*, 2015 and Yadav 2018). The pooled of net return followed similar trend to that of gross return during both the season. The highest net return was recorded from the crop having T₁ in *kharif* and *boro* rice respectively (Rs. 57408.3 and 67,491.4ha⁻¹) and was significantly higher than that of all other fertility treatments. The crop has no fertilizers applied paid the lowest net return which was significantly lower than all other fertility treatments. Due to high requirement of fertilizers and its high cost which directly enhanced in higher grain and straw yield and which reflected in net return of rice-rice cropping system. The highest benefit cost ratio was realized under the application of N₈₀P₄₀K₄₀Zn₂₅S₂₀ (T₁) the average B:C ratio invested was maximum (1.61) and was followed by T₄-N₈₀P₂₀K₄₀Zn₂₅S₂₀, T₅-N₈₀P₀K₄₀Zn₂₅S₂₀, T₁₀-N₈₀P₄₀K₄₀Zn₂₅S₁₀ and T₁₁-N₈₀P₄₀K₄₀Zn₂₅S₀. Among all the

nutrient management practices the lowest value was recorded in control (0.29). The lowest gross return, net return and B:C ratio were received from these treatments due to poor growth of the crop, no application of fertilizers which led to produce lower grain and straw yield. Among the chemical treatments T₁ recorded higher grain and straw yield economically it was superior to all the treatments. The crop received N₁₂₀P₀K₆₀Zn₂₅S₂₀ (T₁) paid the highest benefit cost ratio (1.62) and statistically at par with T₄: N₁₂₀P₃₀K₆₀Zn₂₅S₂₀ and T₅:N₁₂₀P₀K₆₀Zn₂₅S₂₀. The study indicates the need of ample dose of nutrition of hybrid rice for greater productivity along with higher profit. Whereas control (0.06) respond lesser compared to other treatments (Das *et al.*, 2010 ^[6] and Mauriya *et al.*, 2013) ^[9].

Agronomic efficiency (AE)

The NPKZnS level registered significant effect on agronomic efficiency (AE) during *kharif* and *boro* season. There was a strong negative relationship between agronomic efficiency (AE) and nutrient level. The decreased markedly as the NPKZnS level increased. Agronomic efficiency, which reflects the production per kg of nutrient applied, has varied appreciably due to different treatments and similar effect was observed in the pooled data analysis (Table 3). The fertilizer with 50% recommended dose of fertilizer was applied to *kharif* and *boro* rice has recorded higher agronomy efficiency than that of 100% recommended dose of fertilizer (T₁). Waiving the fertilizers application as of T₂, T₄, T₆, T₈ and T₁₀ produced better effects on agronomic efficiency which has remarkably increased amongst all the treatments which was followed by 100% recommended fertilizer level (Ravisankar *et al.*, 2014) ^[11].

Table 3: Effect of nutrient management on economics and Agronomic efficiency (AE) of *kharif* and *Boro* rice (pooled data over two years)

Treatment	Gross Return (Rs ha ⁻¹)	Net Return (Rs ha ⁻¹)	B:C Ratio	Agronomic efficiency (AE)	Treatment	Gross Return (Rs ha ⁻¹)	Net Return (Rs ha ⁻¹)	B:C Ratio	Agronomic efficiency (AE)
T ₁ (N ₈₀ P ₄₀ K ₄₀ Zn ₂₅ S ₂₀)	93139.2	57408.3	1.61	40.6	T ₁ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	109754.5	67,491.4	1.60	37.8
T ₂ (N ₄₀ P ₄₀ K ₄₀ Zn ₂₅ S ₂₀)	81455.0	46332.7	1.32	62.7	T ₂ (N ₆₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	98575.0	57,225.0	1.39	63.7
T ₃ (N ₀ P ₄₀ K ₄₀ Zn ₂₅ S ₂₀)	56517.5	22003.9	0.64	0.0	T ₃ (N ₀ P ₆₀ K ₆₀ Zn ₂₅ S ₂₀)	59455.8	19,018.7	0.47	0.0
T ₄ (N ₈₀ P ₂₀ K ₄₀ Zn ₂₅ S ₂₀)	88473.4	53631.3	1.54	36.9	T ₄ (N ₁₂₀ P ₃₀ K ₆₀ Zn ₂₅ S ₂₀)	103479.3	62,549.6	1.53	34.4
T ₅ (N ₈₀ P ₀ K ₄₀ Zn ₂₅ S ₂₀)	85017.2	51063.9	1.50	34.0	T ₅ (N ₁₂₀ P ₀ K ₆₀ Zn ₂₅ S ₂₀)	100956.6	61,360.1	1.55	33.4
T ₆ (N ₈₀ P ₄₀ K ₂₀ Zn ₂₅ S ₂₀)	87383.2	52185.1	1.48	35.9	T ₆ (N ₁₂₀ P ₆₀ K ₃₀ Zn ₂₅ S ₂₀)	104149.9	62,686.8	1.51	34.7
T ₇ (N ₈₀ P ₄₀ K ₀ Zn ₂₅ S ₂₀)	85507.0	50841.7	1.47	34.5	T ₇ (N ₁₂₀ P ₆₀ K ₀ Zn ₂₅ S ₂₀)	102407.2	61,744.1	1.52	33.8
T ₈ (N ₈₀ P ₄₀ K ₄₀ Zn _{12.5} S ₂₀)	87841.3	52193.6	1.46	36.2	T ₈ (N ₁₂₀ P ₆₀ K ₆₀ Zn _{12.5} S ₂₀)	105478.7	63,298.8	1.50	35.4
T ₉ (N ₈₀ P ₄₀ K ₄₀ Zn ₀ S ₂₀)	85017.5	49453.0	1.39	33.9	T ₉ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₀ S ₂₀)	104286.5	62,189.8	1.48	34.7
T ₁₀ (N ₈₀ P ₄₀ K ₄₀ Zn ₂₅ S ₁₀)	89530.9	54022.0	1.52	37.6	T ₁₀ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₁₀)	104711.2	62,670.1	1.49	35.0

T ₁₁ (N ₈₀ P ₄₀ K ₄₀ Zn ₂₅ S ₀₀)	88870.7	53583.8	1.52	37.1	T ₁₁ (N ₁₂₀ P ₆₀ K ₆₀ Zn ₂₅ S ₀)	102291.6	60,472.5	1.45	33.8
T ₁₂ (Control)	40070.4	9010.4	0.29	0.0	T ₁₂ (Control)	37430.7	1,870.7	0.05	0.0
S.Em(±)	1972.6	1783.1	0.04	-	SEm(±)	4923.7	2461.8	0.05	-
C.D ($p=0.05$)	5785.0	5229.1	0.11	-	CD ($p=0.05$)	14439.3	7219.7	0.16	-
C.V(%)	4.3	6.7	4.93	-	CV(%)	9.0	7.9	7.18	-

Conclusion

Thus It may concluded that the nutrient management approach enhance the growth, productivity and nutrient use efficiency showed positive and significant relationships which in turn positively influenced by the application of ample dose of nutrients. The application of macro and micro nutrient from chemical fertilizers gave better result compared to omission and control treatments. which produced significantly better growth and productivity under rice-rice cropping system.

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