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Effect of establishment methods and levels of zinc on growth, yield and economics of rice (*Oryza sativa* L.)

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Abstract
An experiment entitled "Effect of establishment method and levels of zinc on growth and yield of Rice (*Oryza sativa* L.)" was designed and conducted during *Kharif* season in the year 2020 at Crop Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in Randomized Block design with ten treatments and each replicated thrice. The treatments consisted of three planting techniques *viz*. Direct sowing, conventional transplanting and SRI (System of Rice Intensification) and three levels of Zinc *viz*. Zinc 15 kg/ha, 25 kg/ha and 35 kg/ha and a control plot respectively. The treatments were randomly arranged in three replications and divided into 30 plots. The variety of rice used in this experiment was Pusa Basmati-1. The data of the experiment revealed that all plant growth and yield attributes were significantly influenced by planting techniques and levels of zinc. At 100 DAT, significantly maximum plant height (120.79 cm), maximum number of tillers (10.72), maximum plant dry weight per hill (73.77g), maximum leaf area index (3.96), maximum number of effective tillers/hill (9.38), was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) Significantly maximum number of effective tillers/hill (9.38) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha). Test weight of rice was found to be non-significant. However, maximum test weight (21.25 g) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha). Significantly maximum grain yield (7.67), stover yield (11.62) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha). Significantly maximum harvest index (42.35%) was observed in treatment T_6 - (Conventional method+ Zinc 35 kg/ha) Maximum gross return (1,91,750.00 ₹/ha) Net return (1,40,558.70 ₹/ha) was observed to be highest in treatment T_8 - (SRI+ Zinc 25 kg/ha). Benefit Cost ratio (2.74) was found to be highest in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha) which recorded B:C ratio as 2.43 respectively.

Keywords: Direct sowing, conventional method, system of rice intensification, zinc levels growth, yield

Introduction

Rice (*Oryza sativa* L.) is the principal and the most important staple food for more than half of world's population which provides 21 % and 15 % per capita of dietary energy and protein respectively. Among the rice varieties, scented rice is mostly preferred by population which depend on rice as their staple food due to its quality (size and shape of grain), appearance, hulling and milling and cooking quality accompanied by scent and linear expansion of kernel on cooking. Basmati rice is widely grown in an area of 10.20lakh hectares in the states of Haryana, Punjab, Uttar Pradesh and Uttarakhand that produces 6 - 6.5 lakh tons of milled rice annually and approximately 60% of it is exported earning handsome foreign exchange on production point, some new basmati rice are evolved under high yielding group *viz*. Pusa Basmati-1, Haryana Basmati. Kasturi etc. which are early maturing, high yielder with long slender grains. Rice is mainly cultivated by three major methods *viz*. Direct seeded, conventional method and by System of rice intensification. The world faced many challenges as we entered 21st century especially in agriculture context. The prominent concern is for feeding an ever growing population with safe and healthy food and management of natural resources. Rice occupies 163.20 million hectares area, producing 719.73 million tonnes of rough rice with an average productivity of 4.41t/ha. Rice cultivation is extremely important to food security of Asia where people have rice in their food habit.

Among the micronutrients zinc (Zn) deficiency is taken as major threat to global and regional food security (Rana and Kashif, 2014) [13] as it is the most deficient micronutrient in soils worldwide (Shivay *et al*, 2008) [19] and nearly 30 % of soils have low zinc availability (Alloway, 2008) [3]. In regions where rice is consumed on large scale, zinc deficiency causes reduction in yield and Zn malnutrition in mankind. Zinc is a major component of many enzymes and controls several processes in plants required for growth and development. Sudha and Stalin, 2015 reported reduction in rice yields where there is low zinc availability.

Flood-irrigated rice is more prone to Zn deficiency (Rehman *et al*., 2012) [14] as submerged condition of rice production influences electrochemical and biochemical reactions and alters pH, PCO_2 as well as concentration of certain ions. The grain and straw yield in different rice varieties significantly increased to 14 % and 16 % respectively when Zn is applied (Sudha and Stalin, 2015) [22]. Increasing levels of zinc in rice, enhanced the total zinc content/plant at different growth stages and have significant effect on tiller production (Sarwar *et al*., 2013) [16] and reported that treatments applied with increasing levels of zinc resulted in higher grain and stover yields than treatments where only NPK was applied.

Keeping in the view of importance of Rice methods of sowing and role of micronutrients such as Zinc along with recommended dose the present investigation is entitled "Effect of establishment method and levels of zinc on growth and yield of Rice (*Oryza sativa* L.)", was undertaken.

Materials and Methods

The experiment was conducted during the *Kharif* season of 2020 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agricultural Technology and Science, Prayagraj, Uttar Pradesh, India. The Crop Research Farm is situated at 25^0 57' N latitude, $87^0$50' E longitude and at an altitude of 98 meter above mean sea level. The experimental site was uniform in topography and sandy loam in texture, medium in organic carbon (0.60%), high in available Nitrogen (230 kg/ha, medium in available Phosphorus (29 kg/ha) and very high (346 kg/ha) in available Potassium. The pH of the soil was 7.3 and EC was 0.29 d/Sm. Pusa Basmati-1 variety used for sowing of rice The experiment consists of 3 levels of three Planting techniques *viz*. Direct sowing, conventional transplanting and SRI (System of Rice Intensification) and three levels of Zinc *viz*. Zinc 15 kg/ha, 25 kg/ha and 35 kg/ha and a control plot respectively. It was carried out through a statistical design of in Randomized Block Design (RBD) with three replications consisted of "ten treatments' *viz*. T_1: (Direct sowing method+ Zinc 15 kg/ha), T_2: (Direct sowing method+ Zinc 25 kg/ha), T_3: (Direct sowing method+ Zinc 35 kg/ha), T_4: (Conventional method+ Zinc 15 kg/ha), T_5: (Conventional method+ Zinc 25 kg/ha), T_6: (Conventional methods+ Zinc 35 kg/ha), T_7: (SRI+ Zinc 15 kg/ha), T_8: (SRI+ Zinc 25 kg/ha), T_9: (SRI+ Zinc 35 kg/ha) and T_{10}: (Control plot). The RDF of rice is 120:60:60. Full dose nitrogen is applied through basal application in the form of urea, full dose of phosphorus and full dose of potassium are also applied through basal application. Observations on growth parameters, yield attributes, yield of rice to be recorded and their significance to be tested by the variance ratio. (F-value) at 5% level (Gomez and Gomez, 1984). Relative economics was calculated as per prevailing market prices of inputs and produced during *Kharif* season.

Results and Discussion

Growth attributes

Growth parameters of rice *viz:* Plant height (cm), Number of tillers/hill (no.), Plant dry weight (g/hill), Leaf area index varied due to different treatments and are presented in Table 1**.**

1. Plant height (c.m)

At 100 DAT, plant height differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum plant height (120.79) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha), treatment, T_6 - (Conventional method+ Zinc 35 kg/ha) and T_9 - (SRI+ Zinc 35 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg /ha).

This might be due to greater spacing provided in system of rice intensification leading to lower competition between the plants thus favouring better growth and development of plants. Higher plant height under system of rice intensification as compared to conventional and direct sowing method was also reported by Patwardhan and Patel (2008) [12]. Increase in rice plant height is due to higher nutrient uptake by the crop through zinc increased auxin production, an important growth promoter regulating the stem elongation and cell enlargement. System of rice intensification recorded significantly higher plant height than conventional and direct sowing method of cultivation at all the growth stages. The present results are in agreement with the findings of Azad and Lehria (2001) [2], Sreenivasa Rao (2003) [20], Veerangappa *et al.* (2011) [24] and Gill and Walia (2013) [5].

2. Number of tillers/hill

At 100 DAT, number of tillers/hill differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum number of tillers (10.72) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha) and treatment T_5 - (Conventional method+ Zinc 25 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

No. of tillers/hill were maximum at 60 DAT, which coincided with tillering stage and then declined till harvest (Table 1.). The reduction in tillers after 60 DAT was due to intra species competition for higher space and nutrients which are responsible for degeneration of late formed tillers. As per genetic constitution, the plants have definite tillering period after which they enter into reproductive phase and hence new tillers do not get sufficient opportunities to develop. No. of tillers/hill were increased significantly with system of rice intensification. Tillering ability is genetically controlled, but is also much dependent on environmental factors and system of rice intensification has higher tillers number as under wide spacing each individual crop could have effectively utilized the more available resources such as space, foraging area for root system, better root spread, more light interception etc. resulting in enhanced tiller production. In addition to it, the peak tiller production time was also enhanced in system of rice intensification than conventional method of cultivation resulting in higher number of tillers/hill (Thavaprakash *et. al.* 2008) [23].

3. Plant dry weight (g/hill)

At 100 DAT, plant dry weight differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum plant dry weight per hill (73.77) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_5 - (Conventional method+ Zinc 25 kg/ha) and treatment T_7 - (SRI+ Zinc 15 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

The dry matter production/hill increased as the growth progressed and the maximum value was observed at harvest. System of rice intensification had significant influence on dry matter accumulation at all the stages. The dry matter production is the sum total effect of overall growth. System of rice intensification increased plant height, tillers/hill and leaf area index indicating higher chlorophilic area improving photosynthetic efficiency of plant which in turn resulted in higher dry matter accumulation. These results are also corroborated by Kumar *et al.* (2017) and Singh *et al.* (2005) [17]

4. Leaf area index (LAI)

At 100 DAT, Leaf area index differed significantly with respect to sowing methods and level of zinc application. However, non-significantly maximum leaf area index (3.96) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) was followed T_9 - (SRI+ Zinc 35 kg/ha) T_7 - (SRI+ Zinc 15 kg/ha), T_6 - (Conventional method+ Zinc 35 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

The leaf area index increased successively as the growth progressed up to100 days after transplanting. The leaf area index was significantly higher in system of rice intensification as compared to conventional method of cultivation (Table 1.). When the resources are suboptimal, the leaf growth rate, and thus the LAI, can be limited by low rate of net photosynthesis or insufficient cell expansion. As such system of rice intensification increased supplying capacity of the soil which in turn resulted in higher leaf growth rate and higher leaf area index. Rao *et al.* (2006) [15] also reported that system of rice intensification was superior in leaf area index as compared to traditional method of cultivation and also, application of zinc increased the number of leaves and leaf area and subsequently increased the LAI. This also the conformity of the findings of Amanullah *et al.* (2016) [1].

Yield attributes

1. Number of effective tillers/ hill `

The maximum number of effective tillers/hill differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum number of effective tillers/hill (9.38) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha) T_5 - (Conventional method+ Zinc 25 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

2. Number of grains/panicles

The maximum number of grains/panicles differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum number of grain/panicle (257.04) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha) and T_5 - (Conventional method+ Zinc 25 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

3. Test weight (g)

Test weight of rice was found to be non-significant. However, maximum test weight (21.25 g) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha). while the lowest test weigh (20.72) was noticed in treatment T_{10} - (Control plot) respectively.

4. Grain yield (t/ha)

The maximum grain yield differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum number of grain yield (7.67) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_9 - (SRI+ Zinc 35 kg/ha), T_7 - (SRI+ Zinc 15 kg/ha) and T_6 - (Conventional method+ Zinc 35 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

5. Stover yield (t/h)

The maximum stove yield differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum number of stove yield (11.62) was observed in treatment T_8 - (SRI+ Zinc 25 kg/ha) followed by treatment T_7 - (SRI+ Zinc 15 kg/ha) T_9 - (SRI+ Zinc 35 kg/ha), T_5 - (Conventional method+ Zinc 25 kg/ha) and T_2 - (Direct sowing method+ Zinc 25 kg/ha) respectively and were found to be statistically at par to treatment T_8 - (SRI+ Zinc 25 kg/ha).

6. Harvest index (%)

The maximum harvest index differed significantly with respect to sowing methods and levels of zinc application. Significantly maximum harvest index (42.35) was observed in treatment T_6 - (Conventional method+ Zinc 35 kg/ha) followed by treatment T_4 - (Conventional method+ Zinc 15 kg/ha), T_9 - (SRI+ Zinc 35 kg/ha) respectively and were found to be statistically at par to treatment T_6 - (Conventional method+ Zinc 35 kg/ha).

The significant increase in effective tillers/hill, grains/panicle and test weight was recorded under system of rice intensification. The marked improvement in yield traits i.e., panicle/hill, grains/panicle and test weight (Table 2.) may be ascribed to adequate availability and supply of resources under system of rice intensification and their translocation along with other nutrients to the sink. The favourable conditions formation of higher number of effective tillers also resulted in production of higher number of panicles. The panicle formation is also directly related to the number of productive tillers and conducive condition for the formation of a greater number of productive tillers such as increase in Co_2 assimilation rate delay in the senescence of flag leaf (Orlovius and Hofner, 1976) [11] and effective translocation of photosynthate (Cocucci and Dalla Rosa, 1980) [4] from source to sink resulted in production of higher number of panicles with longer panicle length. The increase in number of grains/panicles with system of rice intensification might be the result of better assimilation of carbohydrate in the panicle. Lu *et al.* (2005) also reported that changes in management under SRI could form more photosynthetic organ, strengthen photosynthetic ability, produce higher dry matter, provide sufficient nutrient to sink continually, make the seed plump, increase 1000-grain weight, seed setting percentage and filled grains per panicle, and finally obtain high yield. As zinc play a key role in chlorophyll synthesis, the higher chlorophyll content might have leads to faster grain filling through increased photosynthetic rate. The contribution of carbohydrates from photosynthetic activity for longer period might have resulted in efficient translocation of food material into the sink (grain) thereby increased the number of filled grains/panicle. Similar of results have also been reported by Masum *et al.* (2013) and Esfahani *et al.* (2014). And also, zinc reduced the disease infection supported with sufficient nutrients increased the growth resulting in increased the grain yield. Similar findings have been also reported by Mumba and Ambara (2013).

Economics

Economics evaluation of the treatments was done on the basis of gross return, net return and B:C ratio. In table: 3, maximum gross returns (1,91,750 ₹/ha), net returns (1,40,558.70 ₹/ha) and benefits cost ratio (2.74) which were recorded with the application of T_8 - (SRI+ Zinc 25 kg/ha). This might be due to higher yield in this treatment compared to other treatments.

SRI and 25 kg Zn/ha recorded higher B:C ratio (2.74) over other treatments. The increase in B:C ratio is due to higher net returns and less cost of cultivation in SRI as compared to conventional and direct sowing methods. The highest gross and net returns per hectare were accrued with 25 kg/ha zinc in comparison with other level of zinc which was mainly due to highest grain and straw yield but little difference from 25 kg Zn/ha. The B: C ratio was also higher with 25 kg Zn/ha than other levels, mainly due to higher gross return and more or less same cost of cultivation. The results are in conformity with the findings of Sinha and Talati (2007) [18] and Shekhar *et al.* (2009) [21].

Conclusion

On the basis of one season experiment on rice (*Oryza sativa)* treatment T_8 - (SRI+ Zinc 25 kg/ha) was found more productive (7.67 t/ha) and registered maximum net return (140558.70 ₹/ha) and B:C ratio was found to be (2.74) respectively.

Table 1: Effect of establishment methods and levels of zinc on growth and growth attributes of rice

Treat. No.	Treatments Details	Plant Height (c.m)	Numbers of tillers/hill (No.)	Plant Dry Weight (g)	Leaf Area Index (%)
T_1	Direct sowing methods + Zinc 15 kg/ha	117.32	9.45	72.65	2.73
T_2	Direct sowing methods + Zinc 25 kg/ha	117.49	9.48	73.21	2.83
T_3	Direct sowing methods + Zinc 35 kg/ha	117.90	9.77	73.25	2.93
T_4	Conventional methods + Zinc 15 kg/ha	115.32	10.00	72.47	3.03
T_5	Conventional methods + Zinc 25 kg/ha	116.57	10.12	73.51	3.13
T_6	Conventional methods + Zinc 35 kg/ha	119.14	9.68	73.00	3.23
T_7	SRI + Zinc 15 kg/ha	120.09	10.34	73.46	3.50
T_8	SRI + Zinc 25 kg/ha	120.79	10.72	73.77	3.96
T_9	SRI + Zinc 35 kg/ha	118.72	9.38	72.92	3.63
T_{10}	Control plot	116.89	9.32	72.41	2.76
	Sem (_+)	0.85	0.20	0.16	0.26
	CD (5%)	2.55	0.49	0.49	0.75

Table 2: Effect of establishment methods and levels of zinc on yield and yield attributes of rice

Treat No.	Treatments Details	No. of Effective tillers/hill	No. of Grains/panicle	Test Weight (g)	Grain Yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
T_1	Direct sowing method + Zinc 15 kg/ha	8.32	175.8	20.96	4.94	8.89	35.71
T_2	Direct sowing method + Zinc 25 kg/ha	8.47	194.9	21.07	5.07	9.24	35.42
T_3	Direct sowing method + Zinc 35 kg/ha	8.57	221.72	20.98	5.46	8.27	39.76
T_4	Conventional method + Zinc 15 kg/ha	8.69	233.04	20.86	5.73	8.15	41.28
T_5	Conventional method + Zinc 25 kg/ha	9.08	246.71	20.67	5.85	9.5	38.11
T_6	Conventional method + Zinc 35 kg/ha	8.73	227.69	21.08	6.15	8.37	42.35
T_7	SRI + Zinc 15 kg/ha	9.09	252.86	20.87	6.73	10.53	38.99
T_8	SRI + Zinc 25 kg/ha	9.38	257.04	21.25	7.67	11.62	39.76
T_9	SRI + Zinc 35 kg/ha	8.48	190.67	21.06	7.23	10.36	41.1
T_{10}	Control plot	8.2	172.7	20.72	4.33	8.04	35
	Sem (±)	0.16	3.87	0.12	0.59	0.82	0.64
	CD (5%)	0.5	11.5	-	1.72	2.44	1.92

Table 3: Economics of rice cultivation

Treat. No.	Treatments Details	Total Cost of Cultivation (≠/ha)	Gross Returns (≠/ha)	Net Returns (≠/ha)	B:C Ratio
T_1	Direct sowing method + Zinc 15 kg/ha	49,565.80	1,23,500	73,934.20	1.49
T_2	Direct sowing method + Zinc 25 kg/ha	52,141.30	1,26,750	74,608.70	1.43
T_3	Direct sowing method + Zinc 35 kg/ha	54,716.80	1,36,500	81,783.20	1.49
T_4	Conventional method + Zinc 15 kg/ha	49,815.80	1,43,250	93,434.20	1.87
T_5	Conventional method + Zinc 25 kg/ha	52,391.30	1,46,250	93,858.70	1.80
T_6	Conventional method + Zinc 35 kg/ha	54,966.80	1,53,750	98,783.20	1.79
T_7	SRI + Zinc 15 kg/ha	48,915.80	1,68,250	1,19,334.20	2.43
T_8	SRI + Zinc 25 kg/ha	51,191.30	1,91,750	1,40,558.70	2.74
T_9	SRI + Zinc 35 kg/ha	54,066.80	1,80,750	1,26,683.20	2.34
T_{10}	Control plot	43,952.50	1,00,000	56,047.50	1.27

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