Effect of Methods of Establishment and Zinc Management on Growth and Yield of Rice *(Oryza sativa* L.*)*

ABSTRACT

The fieldexperiment entitled **"Effect oOf Methods of Establishment aAnd Zinc Management oOn Growth aAnd Yield oOf Rice"** was conducted atShradhay Bhagwati Singh Agriculture Research Farm (Hajipur), Chandra Bhanu Gupta Krishi Snatkottar Mahavidyalaya, B.K.T., Lucknow (Uttar Pradesh) during *Kharif* (rainy) season in 2023-24. The treatment consisted of three methods oOf establishment (M1 – Direct seeding in lLines after pre-irrigation, M2 -Broadcast of sprouted seed on puddled soil , M3 – System of Rice intensification (SRI) of (25 x 25cm) 12 days old seedling.) and five Zinc management practices (Zn0- Without zinc (control), Zn1- Zinc Sulphate ZnSo4@20kg/ha^{-1}(Basal), Zn2- Foliar spray of Zn@0.5% at tillering and panicle initiation stage, Zn3- Seedling dipping in 2% ZnSO$_4$+ 2 Foliar of Zn@0.5% at tillering and Panicle stage, Zn4- Seedling dipping in 2 % ZnSO$_4$ solution+ Foliar spray of Zn@0.2% at tillering and panicle initiation stage) were tested in split-plot design with 3 replications. The Experimental site was silty loam having medium organic carbon (0.70%) and available nitrogen (270 kg ha^{-1}), phosphorous (27 kg ha^{-1}) and Potassium (262 kg ha^{-1}). All the growth parameters, yield attributes, yield, Zinc content and uptake of Zn into grains and sStraw, were increased significantly with SRI method (M3) followed by direct seeding in Lines after pre-irrigation (M2). Amongst zinc management, all the growth parameters and yield attributes of rice were maximum under Seedling dipping in 2% ZnSO$_4$+ 2 Foliar of Zn@0.5% at tillering and pPanicle initiation stage, followed by Seedling dipping in 2 % ZnSO$_4$ solution+ Foliar spray of Zn@0.2% at tillering and panicle initiation stagethe maximum gross income of Rs 158938.18/ha^{-1} was accrued with (SRI method + T4) treatment combination. However, a combination of SRI method along with T3 treatment accrued the maximum net profit of Rs 107981.21/ha^{-1} and benefit: cost ratio of 2.08 which was followed by a combination of SRI method along with T4 with net income of Rs 107234.99/ha^{-1} and benefit cost ratio of 2.07.

1. INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family Poaceae (Gramineae) and is a most iImportant staple food crop in India as well as in the world. It is the major source of calories fFor 40 percent of the world population **(Virdia and Mehta, 2009)**. It is a most important cCereal crop grown under aquatic condition and mostly under submergence or variable pPonding conditions. The slogan "RICE IS LIFE" is especially relevant in India as this crop pPlays a vital role in national food security and is the livelihood of millions of rural hHouseholds. ~~Diet.~~ It is a high-caloric diet, consisting of 75% starch, 6-7% Protein, 2-2.5% fat, 0.8% cellulose and 5-9% ash. Therefore, it is used as a staple food crop aAnd is eaten as cooked rice and is used in various preparations and has commercial and iIndustrial value.At the end of fiscal yYear 2021, India had the largest acreage under rice of 45.0 million ha with production of120 million tonnes and average productivity of about 2.7 thousand kg ha^{-1}. In addition to hHaving the greatest rice harvest area, India was the leading rice exporter in the fiscal year2022–2023. 18.75 million metric tonnes of rice were exported from India at that time. InIndia rice is

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grown over an area of about 46.37 million ha which produces 130.83 million tTonnes with an average productivity of 2809 kg ha^{-1} (**Agricultural Statistics at a Glance, 2023).**

Different methods of crop establishment viz. cConventional transplanting, direct Seeding, drum seeded under puddled condition and broadcasting of sprouted seed under pPuddled condition are adopted for the cultivation of rice. Method of crop establishment Largely affects the performance of rice as a result of its growth and development. The Scarcity of water for agriculture production is becoming a major concern in many Countries, particularly in world's leading rice-producing countries like China and India.

Sommer and **Lipman** as early as 1926 first recognized zinc as an essential plant nNutrient. The deficiency of zinc in India was first reported by **Nene (1966).** Zinc is an iImperative micronutrient and has a number of essential functions in the plant system such aAs the maintenance of structural and functional integrity of biological membranes and fFacilitation of protein synthesis and gene expression.Zinc is one of the most important micronutrients essential for plant growth especially for rice grown under submerged condition. Zinc deficiency continues to be oneof the key factors in determining rice production in several parts of the country(**Muthukumararaja&Sriramachandrasekharan, 2012)**. Zn deficiency is the mostwidespread micronutrient disorder in lowland rice and application of Zn along with NPKfertilizer increases the grain yield dramatically in most cases **(Fageria et al., 2011; Singh *etal.*,2011).**

2. MATERIALS AND METHODS

A field experiment was conducted at the ShradhayBhagwatiSingh Agriculture Research Farm (Hajipur), Chandra BhanuGupta KrishiSnatkottarMahavidyalaya, B.K.T., Lucknow (UttarPradesh) during *Kkharif* season 2023. The soil of experimentalfield was silty loam texture, slightly alkaline in reaction (8.00pH), medium in organic carbon (0.70%), nitrogen (270 kg ha^{-1}),phosphorous (27 kg ha^{-1}) and potassium (262 kg ha^{-1}).

The Experiment was laid out in Split Plot Design with 15 treatment combination. The main plot treatments consisted of three methods establishment(M_1 - Direct seeding in Lines after pre-irrigation, M_2 -Broadcast of sprouted seed on puddled soil , M_3 – System of Rice intensification (SRI) of (25 x 25cm) 12 days old seedling.) and fiveZinc managementpractices (Zn_0 Without zinc (control), Zn_1- Zinc Sulphate ZnSo4$ZnSO_4$@20kg/ha^{-1}(Basal), Zn_2- Foliar spray of Zn@0.5% at tillering and panicle initiation stage, Zn_3- Seedling dipping in 2% $ZnSO_4$+ 2 Foliar of Zn@0.5% at tillering and Panicle stage, Zn_4- Seedling dipping in 2 % $ZnSO_4$ solution+ Foliar spray of Zn@0.2% at tillering and panicle initiation stage) in sun plot. In addition to this a uniform dose of 120 kg N, 60 kg P_2O_5, and 40kg K_2O ha^{-1} was applied in all the plots through urea, DAP and MOP, respectively. Half of total Nand full dose of P_2O_5, Zzinc and K_2O were applied as basal.Wwhile,tThe rest amount of the nitrogen was top-dressed in two splits, first at 30 days (tillering stage) and second at 65 days (panicle initiation stage).respectively.'SHIATS DHAN - 1' non aromatic rice seedlings of 12 days in SRI method transplantedkeeping 1 seedling $hill^{-1}$ at 25x25cm spacing in SRI method,Direct seedling in lines at 20 cm apart, and Broadcast of sprouted seeds in puddled soil. The crop was harvested in ten October. The other agronomic practices were followed asper standard recommendations. The direct seeding of sprouted seeds, andbroadcast of sprouted seeds in puddled soil treatment was done on 4 June 2023

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using 60 kg and 80 kg ha^{-1} seed, respectively. The sowing ofseeds in nursery for seedlings raising was done on the sameday i.e. 4 June 2023 using 6 kg ha^{-1} seed. 12 days old seedlingwere transplanted on 16 Jjune 2023 in well prepared puddled fieldusing one~~1~~ seedling hill^{-1}. Pre-emergence spray of pretilachlor @ 1.5 litre ha^{-1} was done 2-3 days after sowing/transplanting, The crop was irrigated as and when required irrigation. All improved cultural practices were used to raise the crop. The data on plant height and tillers were recorded from the area already marked and tagged. Sample for dry mater accumulation was recorded by cutting of plants 10 cm row length in direct seeded treatment and inSRI method, 4 hills were randomly selected from each plot, and the plants were cut close t~~T~~o the ground put in the paper bags. The samples for dry matter a~~A~~ccumulation were first sun dried and then kept in hot air oven 72° C±0.5° C for 48 hours till the constant weight was achieved. Yield attributes were recorded from 5 spikes selected randomly from each plot at harvest of crop. Grain and straw yield of rice were recorded at harvest, and harvest index (%) was calculated a~~A~~s grain yield divided by total biological yield and multiplied b~~B~~y hundred. The soil and plant analysis was done by using Standard laboratory methods. The uptake of zinc was calculated by multiply zinc content in grain and straw yield. Economics of different treatments was worked out on the basis o~~O~~f prevailing market prices.

Statistical analysis

The observations recorded during the course of investigation were tabulatedanalyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984). The significance of treatment was tested by 'F' test(variance ratio). Standard error of mean was computed in all cases. The difference in the treatment mean were tested by using Least Significant Difference (LSD) at 5% level of probability where 'F' test showed significant

3. RESULTS AND DISCUSSION

3.1 Growth attributes

A perusal of data presented in Table 1 revealed that plant height(cm), number of tillers (m^{-2}), leaf area index and dry matter accumulation (q~~/~~ha^{-1}) of rice were affected significantly due to different methods of crop establishments and Zinc management. Crop transplanted with 12 days old seedling recorded significantly tallest plant (129.67cm), higher number~~Of~~ of tillers (524.13 m^{-2}), dry matter accumulation (129.85 q~~/~~ha^{-1}) and leaf area index (5.46) over rest methods of establishment. The maximum growth parameter under SRI methods was mainly because of availability of optimum space, mor~~v~~e light inception and higher availability of plant nutrients and it's uptake by crop improved the metabolic activities andhigher meristematic activity enhanced the cell multiplication and cell enlargement and finally higher growth in terms of plant height, dry matter accumulation, no. of tillers and leaf area index as compared to higher intra row competition leading to poor availability of nutrients and poor metabolic activity in direct seeded crop.Similar finding ~~were~~was obtained by **Ghoneim (2016).**

The highest plant height (cm), no. of tillers~~/m^2~~ m^{-2}, dry matter accumulation~~/m^2~~ m^{-2} and leaf area index was recorded when rice s~~S~~eedling were dippe~~ding~~ in 2% ZnSO~~so~~$_4$ solution + 2 Foliar spray of Zn@0.5% at tillering and panical initiation stage at all stage of crop growth

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which was followed by sSeed dipping in 2% $ZnSO_4$ solution + 2 Foliar spray of Zn@0.2% at tillering and panical initiation stage. The smallest growth parameter was registered with no zinc application (control) treatment at all stages of crop growth.

Table no 1. Growth attributes of rice as affected by different methods of establishment and zinc management at different stages of crop

Treatment	DAS/DAT			
Methods of establishment	**Plant height (At harvest)**	**No. of tillers (At harvest**	**Dry matter accumulation (At harvest)**	**Leaf area index(90 days)**
M_1-Direct seedling in lines after pre-irrigation	115.6	427.53	100.51	5.31
M_2-Broadcast of sprouted seeds in puddle soil	103.46	366.30	82.37	5.05
M_3-System of rice intensification (SRI) at (25×25) with 12 days old seedling	129.67	524.13	129.85	5.46
SE(m)±	**0.22**	**0.95**	**0.059**	**0.003**
C.D(P=0.05)	**0.98**	**3.86**	**0.236**	**0.011**
Zinc management				
T_0- Without zinc (control)	114.80	426.44	103.24	5.18
T_1- Zinc sulphate $ZnSO_4$@20 kg/ha^{-1}	116.61	432.77	104.95	5.23
T_2- Foliar spray of Zn@0.5% at tillering and panicle initiation stage	112.43	438.66	105.56	5.28
T_3- Seedling dipping in 2% $ZnSO_4$ solution + Foliar spray of Zn@0.5% at tillering and panicle initiation stage	119.58	453.66	107.90	5.36
T_4-Seedlingdipping in 2% $ZnSO_4$ solution + Foliar spray of Zn@0.2% at tillering and panicle initiation stage	118.98	445.0	106.23	5.32
SE(m)±	**0.51**	**0.86**	**0.098**	**0.003**
C.D(P=0.05)	**0.83**	**2.52**	**0.287**	**0.011**

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3.2 Yield attributes and yield studies

The maximum values of yield attributes like effective panicle (m^{-2}), panicle length (cm), panicle weight (gm), number of grains/$panicle^{-1}$ and test weight (g) waswere recorded with transplanting of rice seedling by SRI method followed by direct seeding in lines at 20 cm

apart. Significantly the maximum grain yield (q/ha^{-1}), straw yield (q/ha^{-1}), biological yield (q/ha^{-1}) and harvest index (%) was obtained with transplanting of rice seedling by SRI method followed by to direct seeded rice at 20 cm apart. The lowest grain yield (q/ha^{-1}), straw yield (q/ha^{-1}), biological yield (qha^{-1}q/ha) and harvest index (%) was recorded with broadcast of sprouted seeds in puddled soil.

Crop fertilized sSeed dipping in 2% Znso4 $ZnSO_4$ solution + 2 Foliar spray of Zn@0.5% at tillering and panical initiation stage recorded significantly the maximum values of yield attribute like effective panicle/(m^{-2}), panicle length (cm), panicle weight (g), number of grains/panicle^{-1} and test weight (g) and maximum value of grain yield (q/ha^{-1}), straw yield (qha^{-1}q/ha), biological yield (qha^{-1}q/ha) and harvest index (%). followed by sSeed dipping in 2% Znso4 $ZnSO_4$solution + 2 Foliar spray of Zn@0.2% at tillering and panical initiation stage. Significantly the lowest value of all yield attributes was registered with No zinc application (control) treatment.

Maximum value of all yield attributes and yield was found under transplanting of 12 days old seedling but being at par with direct seeding in lines and significantly superior to broadcast of sprouted seed. This was mainly due to the facts that the transplanted crop had the higher tillering ability as compared to direct seeded crop and thus, recorded profuse growth in terms of tillers m^2, more leaf area, higher dry matter production which enhanced the synthesis of higher photosynthates and its translocation to reproductive parts of crop (sink) enhance the all yield attributes. Similar higher yield attributes and yield with transplanted crop was reported by **Ghasal*et al.* (2014), Kumhar *et al.* (2016) and Kumar *et al.*(2018**). Significantly higher grain and straw yield with transplanted crop was mainly attributed to higher growth and yield attributes.

Table no 2. Yield attributes of rice as affected by methods of establishment and Zinc management

TREATMENT Methods of Establishment	Effective panicle /m^{2}m^{-2}	Panicle length (cm)	Weight of panicle (gm)	Grain/ pPanicle^{-1}	Grain weight/ Panicle^{-1}	1000 grain we
M$_1$Direct seedling in line after pre-irrigation	425.60	22.83	4.28	151.93	2.77	18.73
M$_2$Broadcast of sprouted seeds in puddled soil	361.86	20.01	3.49	119.80	2.12	17.77
M$_3$ System of rice intensification (SRI) at (25x25 cm) with 12 days old seedling	521.80	24.60	5.62	171.33	3.35	19.64
SEM±	**0.41**	**0.04**	**0.01**	**0.46**	**0.03**	**0**
C. D. =(P=0.05)	**2.06**	**0.16**	**0.07**	**1.88**	**0.13**	**0**
Zinc Management						
T$_0$ -Without zinc (control)	425.52	21.67	4.02	136.66	2.52	18.39
T$_1$- Zinc sulphate Znso4$ZnSO_4$@20 kg/ha^{-1}	431.88	22.02	4.23	142.77	2.67	18.62

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T_2 –Foliar spray of Zn@0.5% at tillering and panicle initiation stage	432.67	22.42	4.54	147.66	2.78	18.74
T_3- Seedling dipping in 2%~~Znso4~~ $ZnSO_4$solution + 2 foliar spray of Zn@0.5% at tillering and panicle initiation stage	450.66	23.36	4.81	158.44	3.00	18.98
T_4- Seedling dipping in 2% $ZnSO_4$~~Znso4~~ solution + foliar spray of 0.2%Zn at panicle initiaton stage.	441.7	22.93	4.72	152.88	2.77	18.84
SEM±	**0.40**	**0.04**	**0.01**	**0.69**	**0.01**	**0**
C. D. =(P=0.05)	**2.571**	**0.13**	**0.04**	**2.03**	**0.05**	**0**

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Table no 3. Yield studies of rice as affected by different methods of establishment and zinc management

Treatment	**Grain yield (qt/ha)**	**Straw yield (qt/ha)**	**Total biological yield (qt/ha)**	**Harvest Index (%)**
Methods of establishment				
M_1- Direct seedling in lines after pre-irrigation	40.72	60.18	100.88	40.35
M_2- Broadcast of sprouted seeds in puddled soil.	31.55	51.16	82.72	38.12
M_3- System of rice intensification (SRI) at (25×25cm) with 12 days old seedling	57.93	77.60	135.50	42.74
SE(m)±	**0.07**	**0.07**	**0.02**	**0.07**
C.D(P=0.05)	**0.30**	**0.30**	**0.09**	**0.29**
Zinc Management				
T_0- Without zinc (control)	42.01	76.33	103.47	40.14
T_1- Zinc sulphate $ZnSO_4$~~ZnSo4~~@20 kgha^{-1}~~kg/ha~~(Basal)	42.86	76.93	105.30	40.28
T_2- Foliar spray of Zn@0.5% at tillering and panicle initiation stage.	43.47	77.66	106.50	40.44
T_3- Seedling dipping in 2% $ZnSO_4$~~ZnSo4~~ solution + Foliar spray of Zn@0.5% at tillering and panicle initiation stage	44.56	78.76	108.80	40.62
T_4- Seedling dipping in 2% $ZnSO_4$~~ZnSo4~~ solution + foliar spray of Zn@0.2% at tillering and panicle initiation stage	44.08	78.30	107.77	40.54
SE(m)±	**0.07**	**0.06**	**0.10**	**0.06**
C.D(P=0.05)	**0.23**	**0.19**	**0.29**	**0.18**

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3.3 Development studies

Days taken to 50% flowering:-

The data on number of days to 50% flowering of rice as influenced by method of establishment and zinc management are presented in table no. 4.

Number of days to 50% flowering difference significantly due to methods of establishment and zinc management. SRI (M_3) took significantly more number of days to flowering (94.06 days) closely followed by direct seedling in line after pre- irrigation (M_2) 85.86 while broadcast of sprouted seeds in puddled soil took lesser days (77.60days) to flowering. This was because of optimum nutrient supply to crop which increased the crop space

Turing to the effect of zinc management on days taken to 50 % flowering seedling dipping 2 % zinc solution + foliar spray of zinc @0.5% at tillering and panical initiation stage (82.55days) recorded significantly lesser days followed by seedling dipping in 2% zinc sulphate solution + foliar spray of zinc @0.2% at tillering and panicle ~~inititation~~initiation stage (84.22days).the data further revealed that foliar spray of zinc @0.5% at tillering and panicle initiation stage T_3 was found statistically superior over $ZnSO_4$~~ZnSo4~~ applied @20$kgha^{-1}$~~kg/ha~~ as basal. Crop without zinc recorded significantly late flowering (88.88days). The higher no of days taken to 50 % flowering under (T_3) was due to continuous supply of nutrient to plant which delayed the flowering.

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Days taken to maturity:-

The data on number of days taken to maturity of rice as influenced by method of establishment and zinc management are presented in table no. 4. 6

Days taken to maturity difference significantly due to establishment of establishment and zinc management. SRI (M_3) took significantly more number of days to maturity (114.46 days) closely followed by direct seedling in line after pre- irrigation (M_2.111 days) while broadcast of sprouted seeds in puddled soil took lesser days (104.46 days) to maturity. The higher availability of nutrient under SRI delayed the maturity due to late senescence in plant.

Turing to the effect of zinc management on days taken to maturity seedling dipping 2 % zinc solution + foliar spray of zinc @0.5% at tillering and ~~panical~~panicle initiation stage (108 days) recorded significantly lesser days followed by seedling dipping in 2% zinc sulphate solution + foliar spray of zinc @0.2% at tillering and panicle ~~inititation~~initiation stage (109.66 days).the data further revealed that foliar spray of zinc @0.5% at tillering and panicle initiation stage T_3 was found statistically superior over $ZnSO_4$~~ZnSo4~~ applied @2020$kgha^{-1}$~~kg/ha~~ as basal. Crop without zinc recorded significantly late maturity (110.88 days). This

was mainly because of the facts that (T_3) enhanced the supply of plant nutrients continuously which delayed the senescence in plant thus delayed the maturity.

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Table no 4.Development studies of rice as affected by different methods of establishment and zinc management at different stages of crop

Methods of establishment	Days taken to 50% flowering	Days taken to maturity
Direct seedling in lines after pre-irrigation	85.86	111.0
Broadcast of sprouted seeds in puddled soil.	77.60	104.46
System of rice intensification (SRI) at (25×25cm) with 12 days old seedling	94.06	114.46
SE(m)±	**0.07**	**0.14**
C.D(P=0.05)	**0.31**	**0.60**
Zinc management		
Without zinc (control)	88.88	110.88
Zinc sulphate $ZnSO_4$ ~~ZnSo4~~@20 $kgha^{-1}$ ~~kg/ha~~(Basal)	87.55	110.77
Foliar spray of Zn@0.5% at tillering and panicle initiation stage.	86.00	110.33
Seedling dipping in 2% $ZnSO_4$ ~~ZnSo4~~ solution + Foliar spray of Zn@0.5% at tillering and panicle initiation stage	82.55	108.00
Seedling dipping in 2% $ZnSO_4$ ~~ZnSo4~~ solution + foliar spray of Zn@0.2% at tillering and panicle initiation stage	84.22	109.66
SE(m)±	**0.29**	**0.27**
C.D(P=0.05)	**0.85**	**0.80**

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3.4 Qualitative studies

Zinc content

Data indicated that zinc content (mg~~/~~kg^{-1}) in grain and straw was affected statically by crop establishment methods and Zinc management practices

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In general, the highest zinc content (%) in grain and straw (30.95 and 31.99 mg kg^{-1}) was recorded with broadcast of sprouted seeds in puddled soil. The results are confirmed with the close findings of **Rani and Sukumari (2013).**

A Perusal of the data revealed that maximum zinc content in grains and straw (31.70 and 33.21 mg kg-1) respectively with application of zinc sulphate $ZnSO_4$~~Znso4~~@20kgha^{-1}~~kg/ha~~ (Basal). However, Minimum zinc content in grain and straw (29.31 and 31.09 mg kg^{-1}) respectively was recorded under seedling dipping in 2% $ZnSO_4$~~Znso4~~ solution + foliar spray of Zn@0.5% at tillering and panicle initiation stage (T_3). Zinc plays main role in different plant metabolic processes and many enzymatic activities resulting to the efficient absorption and translocation of essential plant nutrients ultimately more biomass production. Similar finding has been reported by **Saha *et al.*~~,~~(2015).**

Zinc uptake

Data pertaining to zinc uptake by grains of rice as influenced by crop establishment methods and Zinc management practices has been presented in table no. 5.

It is evident from the data that crop establishment methods had significant influence in respect of zinc uptake by grains and straw. The maximum zinc uptake by grains and straw (0.158 and 0.225kg ha^{-1}) respectively was recorded with system of rice intensification (SRI) at (25 x 25) with 12 days old seedling method (M_3), which was at par with direct seedling in line after pre irrigation (M_1) while, significantly superior over rest of the treatments. The significantly maximum uptake (0.134 and 0.252 kg ha^{-1}~~kg/ha~~) through grain and straw, respectively of Zinc was noted when crop received $ZnSO_4$~~$ZnSo_4$~~@20kg ha^{-1}~~kg/ha~~ as basal, however, the minimum uptake of Zn is (0.130 and 0.252 kg ha^{-1}~~kg/ha~~) through grain and straw, respectively was observed with application of seedling dipping in 2% $ZnSo_4$ solution + Foliar spray of Zn@0.5% at tillering and PIS. This was because of lower content (%) and poor grain and straw yield with this treatment.

However, the minimum amount of zinc uptake by grains and straw (0.105 and 0.182 kg ha^{-1}~~kg ha1~~) was recorded with broadcasting of sprouted seed in puddle condition (M_2). This might be due to higher grain and straw recorded with system of rice intensification (SRI) at (25 x 25) with 12 days old seedling. These results are in line with the research findings of **Yadav *et al.*~~,~~ (2014) and Meena *et al.*~~,~~ (2016).**

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Table no 5.Zinc content and uptake as affected by methods of establishment and zinc management

Treatment	Zinc content(mg/kg^{-1}) in		Zinc uptake (kg ha^{-1} kg/ha)	
Methods of establishment	**Grain**	**Straw**	**Grain**	**Straw**
M_1-Direct seedling in lines after pre-irrigation	30.95	31.99	0.126	0.192
M_2-Broadcast of sprouted seeds in puddled soil.	33.57	35.58	0.105	0.182
M_3-System of rice intensification (SRI) at (25×25cm) with 12 days old seedling	27.39	29.06	0.158	0.225
SE(m)±	**0.017**	**0.02**	**0.04**	**0.21**
C.D(P=0.05)	**0.06**	**0.08**	**0.09**	**1.08**
Zinc Management				
T_0-Without zinc (control)	31.30	32.87	0.133	0.253
T_1-Zinc sulphate $ZnSO_4$ ZnSo4@20 kg ha^{-1} kg/ha(Basal)	31.70	33.21	0.134	0.252
T_2-Foliar spray of Zn@0.5% at tillering and panicle initiation stage.	30.81	32.19	0.133	0.249
T_3-Seedling dipping in 2% % $ZnSO_4$ ZnSo4 solution + Foliar spray of Zn@0.5% at tillering and panicle initiation stage	29.31	31.09	0.130	0.244
T_4-Seedling dipping in 2% $ZnSO_4$ ZnSo4 solution + foliar spray of Zn@0.2% at tillering and panicle initiation stage	30.06	31.69	0.132	0.248
SE(m)±	**0.02**	**0.04**	**0.04**	**0.17**
C.D(P=0.05)	**0.07**	**0.13**	**0.13**	**0.52**

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3.5 Economics:-

A critical examination of the data in table no. 6 revealed that the maximum gross income of Rs 158938.18/ha^{-1} was accrued with (SRI method + T_4) treatment combination. However, a combination of SRI method along with T_3 treatment accrued the maximum net profit of Rs 107981.21ha^{-1}/ha and benefit: cost ratio of 2.08 which was followed by a combination of SRI method along with T_4 with net income of Rs 107234.99ha^{-1} and benefit cost ratio of 2.07.

Table no 6.Economics of each treatment as affected by methods of establishment and zinc management

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~~combination of SRI method along with T_4 with net income of Rs 107234.99/ha and benefit cost ratio of 2.07.~~

Treatment	Cost of cultivation (Rs ha^{-1}/~~ha~~)	Gross Income (Rs ha^{-1}/~~ha~~)	Net income (Rs ha^{-1}/~~ha~~)	B:C Ratio (Rs/Re inv
M_1T_0	48,208.19	108,726.28	60,518.09	1.25
M_1T_1	50,608.19	111,554.09	60,945.9	1.20
M_1T_2	49,708.19	112,965.59	63,257.4	1.27
M_1T_3	49,198.19	116,302.68	67,104.49	1.36
M_1T_4	49,018.19	115,098.5	66,080.31	1.34
M_2T_0	46,033.19	85,321.19	39,288	0.85
M_2T_1	48,433.19	87,593.89	39,160.7	0.80
M_2T_2	47,533.19	89,836.08	42,302.89	0.88
M_2T_3	47,023.19	92,750.19	45,727	0.97
M_2T_4	46,843.19	91,174.9	44,331.71	0.94
M_3T_0	50,893.19	154,810.19	103,917	2.04
M_3T_1	53,293.19	156,359.99	103,066.8	1.93
M_3T_2	52393.19	157,525.19	105,132	2.00
M_3T_3	51883.19	159,864.4	107,981.21	2.08
M_3T_4	51703.19	158,938.18	107,234.99	2.07

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The lowest gross return (Rs. 85321.19ha^{-1}~~/ha~~), net income (Rs 39160.7ha^{-1}~~/ha~~) and benefit: cost ratio of (0.08) was obtained with broadcast of sprouted seed in puddled soil + No Zinc application (control) treatment (M_2T_1).

~~Table no 6Economics of each treatment as affected by methods of establishment and zinc management~~

4. CONCLUSION

It can be concluded from the above results that-

1. Transplanting of rice seedling by SRI method 12 days old seedling recorded the highest values of growth, yield attributes and yield which was followed by Direct seeded rice at 20 cm.
2. Seed dipping in 2% $ZnSO_4$~~Znso4~~ solution + 2 Foliar spray of Zn@0.5% at tillering and panical initiation stage (T_3) recorded highest values of growth, yield attributes and yield which was followed by Seed dipping in 2% $ZnSO_4$~~Znso4~~ solution + 2 Foliar spray of Zn@0.2% at tillering and ~~panical~~panicle initiation stage (T_4).
3. The maximum Zinc content (mg/kg) in grain and straw was recorded with Broadcast of sprouted seeds in puddle soil, but uptake of Zn was highest with SRI method.
4. Application of $ZnSO_4$~~ZnSo$_4$~~@20kg ha^{-1}~~kg/ha~~ (Basal) recorded the highest Zn content and it uptake by grain and straw.
5. The maximum net income and benefit: cost ratio was recorded with treatment combination SRI +T_3 (System of rice intensification(SRI) at (25 x 25) with 12 days old seedling + Seed dipping in 2% $ZnSO_4$~~Znso4~~ solution + 2 Foliar spray of Zn@0.5% at tillering and ~~panical~~panicle initiation stage.)

On the basis of above conclusion, the recommendation in follows

Rice crop should be establishment by SRI method with 12 days old seedling along with Seedling dipping in 2% $ZnSO_4$~~Znso4~~ solution + 2 Foliar spray of Zn@0.5% at tillering and panical initiation stage to obtained maximum yield and net profit under central plain zone conditions of Uttar Pradesh.

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Comment [BP10]: Lack of reference and proper discussion of result.

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Comment [BP11]: Conclusion should be written precisely in a paragraph.

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Comment [BP12]: Reference pattern should be as per the journal's instruction and follow similar pattern for all the reference.

Comment [BP13]: Few more reference could be added support the result.