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Effect of Zinc Levels and Moisture Regimes on Growth and Yield of Direct Seeded Rice

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2017 in Split Plot Design with three replications at Crop Research Centre of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. The treatments consist of four moisture regimes in main plots and four zinc levels in sub plots. The result showed that plant height (110.40 cm), no. of tillers/plant (360.91), LAI (5.17), SPAD value (39.38), panicle length (24.62 cm), no. of spikelets/panicle (84.40), grain yield (33.14 q/ha), were found to be maximum with I_1 moisture regime which were significantly superior over I_3 and I_4 but was statistically at par with I_2. With regard to zinc levels plant height (109.82 cm), no. of tillers/m^2 (357.06), LAI (5.08), SPAD value (39.21), panicle length (24.29 cm), were found maximum with Z_3 which was significantly superior over Z_1 but was statistically at par with Z_2 and Z_4. No. of spikelets/panicle (84.41), grain yield (32.57 q/ha), were found maximum with Z_3 which was significantly superior over Z_1 and Z_4 but was statistically at par with Z_2.

Introduction

Rice (*Oryza sativa* L.) is one of the most staple food crops for more than half of the world population by providing 25% calories and 20% protein. More than 2 billion people get 60-70% of their energy requirement from rice and its derived products. In Asia, irrigated agriculture uses 80-90% of the freshwater and about 50% of that is used in rice farming (IRRI, 2001), large amount of water input in rice culture has led to over exploitation of ground water as indicated by alarming fall in water table. Thus, there is a need to explore alternate techniques that can sustain rice production and are resource conservative. On the face of global water scarcity, the future of rice production is under threat; direct seeded rice (DSR) offer an attractive alternative. DSR, is a common practice before green revolution in India, is becoming popular once again because of its potential to save water and labour. Currently, DSR in Asia occupies about 29 million hectare which is approximately 21% of the total rice area (Pandey and Velasco, 2002).

Under no/reduced tillage it is an efficient resource conserving technology holding good promise in coming day due to following advantages over transplanted rice - save labour upto 40%, water upto (60%), energy upto (60%), reduce cost of cultivation about 5000- 6000/ha and increases nutrient use efficiency (Pathak *et al.,* 2011).

Rice is the world's most important cereal and potentially important source of Zn. Plant uptake Zn in Zn^{2+} form, it is a micronutrient but plays a vital role in growth and metabolism of plant. It is essentially required for protein synthesis and gene expression in plants (Cakmak, 2000). It has been estimated that about 10% of the proteins in biological system need Zn for their structural and functional integrity (Andreini *et al.,* 2006). In addition to being essential to plants, it is also an essential mineral nutrient for human beings. It deficiency is known to have serious adverse impacts on human health, especially in children, such as impairments in physical growth, immune system, and causing DNA damage and cancer development (Ho *et al.,* 2003; Black *et al.,* 2008).

In most cases, rice cultivated soils are very low in plant available zinc leading to further decreases in concentration in rice grain. At present 40% area at national level (www.Zincorg.in) and 45% area in Bihar are zinc deficient (www. Krishisewa.com). Its deficiency leads to appearance of dusty brown spots on upper leaves, stunted growth of plants, decrease tillering ability and increases spikelets sterility. Deficiency symptoms are prolonged during early growth stage due to immobilization of zinc, it's deficiency in rice crop is commonly known as *Khaira* disease. Calcareous soils are particularly more prone to its deficiency, at high pH and in waterlogged condition it forms an insoluble compound such as $Zn(OH)_2$ and in calcareous soil due to presence of $CaCO_3$ it forms $ZnCO_3$ leading to reduced its availability. Its deficiency may be corrected by application of zinc fertilizers, among the different zinc fertilizers zinc sulphate (36% Zn) is the most efficient and cheapest source of correcting zinc deficiency. Among different methods of zinc application, soil application through broadcast or its placement below seed, invariably proved more effective except as low levels while foliar application proved equally efficient. Foliar feeding is a relatively new and controversial technique of feeding plants by applying liquid fertilizer directly to their leaves (Mahdi *et al.,* 2011). Its efficiency is hardly 2-5% and remaining 98-95% parts are converted to a compound which is not available to plants. Among various yield limiting factors, irrigation water management and zinc deficiency are the most important variables affecting growth, yield and quality of rice (Fageria *et al.,* 2008; Shivay *et al.,* 2010). To increase water productivity of rice production the interactions between irrigation practices and fertilizers should be addressed (Hortz and Brown. 2004). The future of rice production will therefore heavily depend on developing and adopting strategies and practices through efficient use of resources. Such strategies are producing more rice with low inputs of water. Zinc is an essential nutrient and at little extra cost on zinc fertilization combined with macronutrients, a farmer can enhance the yield (Cruz *et al.,* 2012).

Materials and Methods

A field experiment was conducted during rainy (*kharif*) season of 2017 at Crop Research Centre, Department of Agronomy, Dr. Rajendra Prasad central Agricultural University, Pusa Farm, is situated in Samastipur district of North Bihar on the Southern and Western bank of the river *Burhi Gandak* at 25° 59ʹ North latitude and 85°48´ East longitude with an altitude of 52.92

meters above mean sea level. It has sub-tropical and sub humid monsoon climate. The average rainfall of the area is 1276.1 mm out of which nearly 1026.0 mm is received during the monsoon between June to September. The experiment was laid out in split plot design (SPD) with three replications. In main plots, treatments were I_1-Irrigation at 1 day disappearance of ponded water, I_2-Irrigation at 3 days disappearance of ponded water, I_3-Irrigation at 5 days disappearance of ponded water, I_4-Irrigation at 7 days disappearance of ponded water and in sub plots, treatments were Z_1- Control, Z_2 -Application of $ZnSO_4$ @ 25 kg/ha, Z_3-Application of $ZnSO_4$ @ 37.5 kg/ha, Z_4- Foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering. Rajendra Neelam was taken as test cultivar. Soil of the experimental plot was sandy loam in texture, alkaline in reaction (pH 8.7), low in available N -154 kg/ha (Alkaline permanganate method, Subbiah and Asija, 1956), P_2O_5- 20.51 kg/ha (Olsen's method, Olsen *et al.*, 1954), K_2O- 122 kg/ha (Flame photometer method, Jackson, 1967) and zinc-0.69 ppm (DTPA extractable and observed with AAS, Lindsay and Norvel, 1978). The crop was fertilized with 120-60-40 kg/ha (N-P_2O_5-K_2O) and $ZnSO_4$. Half dose of nitrogen and full dose of phosphorus, potash and zinc (25 kg/ha and 35 kg/ha) were applied as basal and remaining dose of nitrogen was applied in two equal splits (25% at tillering and 25 % at panicle initiation stage), foliar application of $ZnSO_4$ @ 0.5% was done at tillering, pre-flowering and flowering.

Irrigation was given when the ponded water is depleted as per treatment. Water was measured through Parshall flume of 7.5 cm throat size set up at the experimental field applying 6 cm of water at each irrigation. The time of irrigation for every plot was computed by from the following formula;

$$t = \frac{A \times D}{Q}$$

Where,

Q = Rate of discharge (lit/s)
A = Area of the plot (m^2)
D = Depth of irrigation (cm)

The required cultural practices and plant protection measures were done as per recommended package. In order to determine the effect of different treatments, a number of observations on growth and yield attributing characters of crop were recorded at different stages of crop growth. Single plot as a sampling unit, five plants were taken from each plot excluding 50 cm from all sides. The height of randomly selected five tagged plants in net plot area was measured from the base of the plant to the tip of the leaf at all the growth stages except at harvesting. The total number of tillers/m^2 was recorded on the hills selected for the plant height at 30, 60, 90 DAS and at harvest. Final tillers which represented the number of effective tillers/m^2 were recorded before harvest. For LAI the green leaves were detached from the sheath and were categorized into small, medium and large size groups and there counts were taken. The total leaf area determined by maximum (length × width) method, multiplied by correction factor given by Yoshida (1981) for rice (0.75). These data are further used for the calculation of LAI. SPAD (Soil plant analysis development) was estimated non-destructively by measuring leaf greenness using portal chlorophyll meter. SPAD reading were collected from the middle region of first fully opened leaf from the top. Total number of spikelets/ panicle of five panicles are calculated by adding the numbers of spikelets/ panicle and then the average number of spikelets/ panicle was calculated. Collected data were analyzed statistically by using as suggested by Gomez and Gomez (1984).

Results and Discussion

Growth parameters

The growth parameters vary significantly under varying moisture regimes and zinc levels (Table 1).

Plant height

Plant height is an important morphological attributes. It is a function of combined effects of genetic makeup of a plant, soil nutrient status, seedling vigor and the environmental conditions under which it is grown. The maximum plant height (110.40 cm) was recorded at harvest with irrigation at 1 day disappearance of ponded water which was significantly superior over irrigation at 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This might be due to availability of sufficient moisture optimizes the various metabolic processes in plant that increases the effectiveness of the mineral nutrients which resulted in maximum plant height. This is in harmony with the findings of Harishankar *et al.,* (2016) and Kumari *et al.,* (2018). In sub plot treatments the plants fertilized with soil application of $ZnSO_4$ @ 37.5 kg/h showed maximum height (109.82 cm) at harvest as compared to other Zn fertilization treatments which was significantly superior over control plot but was statistically at par with soil application of $ZnSO_4$ @ 25 kg/ha and foliar application of $ZnSO_4$ @ 0.5 % at tillering, pre-flowering and flowering. This might be due to adequate supply of zinc contributed to accelerate the enzymatic activity and auxin metabolism in plants, as auxin promote cell enlargement resulting in elongation of coleoptile, stem etc. thus resulted in higher plant height. These results are in agreement with the findings of Yadi *et al.,* (2012); Mumba and Ambara (2013); Sudha and Stalin (2015).

Number of tillers/m^2

Crown nodes are superimposed by dormant eye. In presence of sufficient light, oxygen and moisture, the dormant eyes are converted into tillers. Tillering, being mainly a varietal character may be influenced by physiological, environmental and nutritional status of field. Significantly highest no. of tillers/m^2 (360.91) was observed with irrigation at 1 day disappearance of ponded water showed significantly more number of tillers as compared to remaining treatments at 60 DAS which was significantly superior over irrigation at 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This might be due to sufficient moisture and more frequent wetting at later stages of crop growth which facilitated to produce and survive more number of tillers. Similar opinion has been expressed by Kumar *et al.,* (2013) and Kumari *et al.,* (2018). With regard to zinc levels plants grown with soil application of $ZnSO_4$ @ 37.5 kg/ha produced more number of tillers/m^2 (357.06) as compared to other treatments at 60 DAS which was significantly superior over control but was statistically at par with soil application of $ZnSO_4$ @ 25 kg/ha and foliar application of $ZnSO_4$ @ 0.5 % at tillering, pre-flowering and flowering. This might be due to adequate supply of Zn contributed to accelerate the enzymatic activity and auxin metabolism in plants, as auxins are involved in cell division and root formation resulted in more no. of tillers. These results are in agreement with the findings of Wilczewski and Warachien (2016) and Kumar *et al.,* (2017).

Leaf area index

LAI is an important indicator of total photosynthetic surface area, available to the plant for the production of photosynthates, which accumulate in the developing sink. Maximum LAI (5.17) was recorded at 60 DAS with irrigation at 1 day disappearance of ponded water which was significantly superior over irrigation at 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This was due to adequate supply of moisture which favoured more number of large size leaves. Similar result was also noticed by Kumar *et al.,* (2015) and Harishankar *et al.,* (2016). In sub plot treatments the plant fertilized with soil application of $ZnSO_4$ @ 37.5 kg/ha resulted in higher LAI (5.08) at 60 DAS as compared to other Zn fertilization treatments which was superior over control but was statistically at par with soil application of $ZnSO_4$ @ 25 kg/ha and foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering. This might be due to the role of Zn as a cofactor in the enzymatic reaction of the anabolic pathway in plant growth. It plays an important role in synthesis of tryptophan and IAA which are responsible for increase in LAI. Similar views are expressed by Amanullah *et al.,* (2016) and Singh *et al.,* (2017).

SPAD value

SPAD value was significantly influenced due to moisture regimes and zinc levels. The maximum SPAD value (39.38) was recorded at 60 DAS with irrigation at 1 day disappearance of ponded water which was superior over irrigation at 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This might be due to adequate supply of water increases the chlorophyll content of leaves, while moisture stress condition for longer period reduced the photosynthetic activity resulted in low chlorophyll content in the leaves. These results are in line with the findings of Deka and Baruah (2000); Das *et al.,* (2016) and Pascual *et al.,* (2017). In context of sub plot treatments, higher SPAD value (39.21) was recorded with the soil application of $ZnSO_4$ @ 37.5 kg/ha at 60 DAS which was superior over control and foliar application of $ZnSO_4$ @ 0.5 % at tillering, pre-flowering and flowering but was statistically at par with soil application of $ZnSO_4$ @ 25 kg/ha. This might be due to the fact that zinc is involved in chlorophyll formation and carbohydrate synthesis, which are further used for higher interception of solar radiation which improve photosynthesis activity of the plant resulted in higher chlorophyll content in leaves. These results are in conformity with the findings of Mumba and Ambara (2013).

Yield attributes

Panicle length

Length of panicle is very important factor which decides how many grains would be carried because of grains is precurer of grain yield. The effect of different treatments on panicle length was significant. Maximum panicle length (24.64 cm) was recorded with irrigation at 1 day disappearance of ponded water which was superior over irrigation at 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. These results are in agreement with the finding of Kumar *et al.,* (2013). Among the zinc level treatments maximum panicle length (24.29 cm) was recorded with soil application of $ZnSO_4$ @37.5 kg/ha which was significantly superior over control but was at par with soil application of $ZnSO_4$ @ 25 kg/ha and foliar application of $ZnSO_4$ @ 0.5 % at tillering, pre-flowering and flowering. This result is in close conformity with the findings of Qaisrani (2011), Dixit *et al.,* (2012) and Saha *et al.,* (2013).

Number of spikelets/panicle

Number of spikelets/panicle depends on the efficient translocation of photosynthates from source to sink. Higher the translocation of photosynthates more will be the number of spikelets. Significant difference in number of spikelets/panicle had been observed. Maximum number of spikelets/panicle (84.40) was found with irrigation at 1 day disappearance of ponded water which was significantly superior over 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This might be due to regular supply of moisture in comparison to other treatments. At optimum moisture level all the physiological activities of plant worked properly which resulted in better translocation of photosynthates from source to sink. This is in close conformity with the result of Kumar *et al.*, (2015); Nayak *et al.*, (2016) and Kumari *et al.*, (2018). In sub plot treatments, maximum number of spikelets/panicle (84.41) was recorded with soil application of $ZnSO_4$ @ 37.5 kg/ha which was significantly superior over control and foliar application of $ZnSO_4$ @ 0.5 % at tillering, pre-flowering and flowering but was at par with soil application of $ZnSO_4$ @ 25 kg/ha. Increase in spikelets/panicle might be ascribed to adequate supply of Zn that had increased the uptake and availability of other essential nutrients. These results are in line with Mahmudi *et al.*, (2015); Wilczewski and Warachien (2016) and Singh and Jangid (2017) (Table 2).

Table.1 Effect of moisture regimes and zinc levels on growth parameters of direct seeded rice

Treatments	Plant height (cm)	No. of tillres/m^2	Leaf area index at 60 DAS	SPAD value at 60 DAS
Moisture regimes				
I_1	110.40	360.91	5.17	39.38
I_2	105.89	342.46	4.19	38.52
I_3	99.47	324.48	4.65	37.26
I_4	92.48	302.75	4.28	36.20
SEm±	2.40	7.95	0.10	0.25
CD (P=0.05)	8.31	27.52	0.35	0.88
Zinc levels				
Z_1	85.53	281.60	4.04	35.22
Z_2	107.28	348.99	4.99	38.68
Z_3	109.82	357.06	5.08	39.21
Z_4	105.91	342.94	4.89	38.33
SEm±	1.61	5.03	0.07	0.25
CD (P=0.05)	4.83	15.09	0.21	0.75

I_1- Irrigation at 1 day disappearance of ponded water, I_2- Irrigation at 3 days disappearance of ponded water, I_3- Irrigation at 5 days disappearance of ponded water, I_4- Irrigation at 7 days disappearance of ponded water, Z_1- Control, Z_2- Application of $ZnSO_4$ @ 25 kg/ha, Z_3- Application of $ZnSO_4$ @ 37.5 kg/ha, Z_4- Foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering

Table.2 Effect of moisture regimes and zinc levels on yield attributes and grain yield

Treatments	Panicle length (cm)	No. of spikelets/panicle	Grain yield (q/ha)
I_1	24.64	84.40	33.14
I_2	23.38	80.44	32.28
I_3	22.16	73.34	28.85
I_4	20.42	66.13	27.70
SEm±	0.48	1.77	0.96
CD (P=0.05)	1.64	6.11	3.32
Zinc levels			
Z_1	19.25	63.85	22.86
Z_2	23.77	80.80	31.54
Z_3	24.29	84.41	32.57
Z_4	23.29	75.25	30.00
SEm±	0.34	1.53	0.66
CD (P=0.05)	1.03	4.60	1.96

I_1- Irrigation at 1 day disappearance of ponded water, I_2- Irrigation at 3 days disappearance of ponded water, I_3- Irrigation at 5 days disappearance of ponded water, I_4- Irrigation at 7 days disappearance of ponded water, Z_1- Control, Z_2- Application of $ZnSO_4$ @ 25 kg/ha, Z_3- Application of $ZnSO_4$ @ 37.5 kg/ha, Z_4- Foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering

Grain yield

In the present investigation, almost all the growth and development characters seemed to be affected by increasing moisture regimes while under moisture stress condition, the photosynthesis activities were reduced owing to closure of stomata which resulted in reduced supply of CO_2 and the capacity of protoplasm to carry out photosynthesis efficiency. Grain yield was influenced significantly due to moisture regimes and zinc levels. Maximum grain yield (33.14 q/ha) was recorded with irrigation at 1 day disappearance of ponded water which was significantly superior over 5 and 7 days disappearance of ponded water but was statistically at par with irrigation at 3 days disappearance of ponded water. This might be due to higher number of tillers/m^2 and dry matter production under better moisture regimes. These findings are collaborated with the results of Kumar *et al.,* (2015), Das *et al.,* (2016), and Nayak *et al.,* (2016). Among the different zinc level treatments plant grown with soil application of $ZnSO_4$ @ 37.5 kg/ha produced significantly more grain yield (32.57 q/ha) which was significantly superior over foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering and control but was at par with soil application of $ZnSO_4$ @ 25 kg/ha this might be due to the combined effect of many yield components, like-number of panicles/m^2, panicle length and test weight as Zn application enhanced synthesis of carbohydrate and transport to the site of grain production. Minimum grain yield was recorded in control plot and this might be due to the non-availability of zinc. These findings are in line with Mustafa *et al.,* (2011); Qaisrani (2011) and Saha *et al.,* (2016).

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