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Effect of zinc levels and moisture regimes on nutrient content 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, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar to investigate the "Effect of zinc levels and moisture regimes on direct seeded rice". The treatments consisted of four moisture regimes *i.e.* 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 and 4 zinc level treatments *i.e.* Z_1-Control, Z_2-$ZnSO_4$ @25 kg/ha, Z_3-$ZnSO_4$@37.5kg/ha, Z_4- Foliar application of $ZnSO_4$@ 0.5% at tillering, pre-flowering and flowering. Test cultivar was Rajendra Neelam. The result showed that N, P, K and Zn content by grain and straw, were found to be maximum with I_1 moisture regime which were significantly superior to I_3 and I_4 but was statistically at par with I_2 in case of Zn content in grain and straw. N, P and K content in grain and straw were not influenced by moisture regimes.

Zn content in grain and straw, were recorded maximum with Z_3 treatment of zinc levels which were significantly superior over Z_1 but were statistically at par with Z_2 and Z_4 N, P and K content in grain and straw did not vary significantly due to different zinc levels.

Keywords: Moisture regimes, nutrient content, foliar application, zinc level

Introduction
Rice (*Oryza sativa* L.) is one of the most staple food crop 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 world rice is grown in 161.1 million hectare of area with production of 487.5 million tonnes and productivity of 3.03 t/ha (The Statistics portal 2017-18). Among the rice growing countries, India ranks first in area of 44.1 million hectare, second in production of 110.2 million tonnes with an average productivity of 2.5 t/ha (INDIA STAT-Advance Estimate 2017-18). In Bihar, area under rice cultivation is 3.2million hactare with production of 6.8 million tonnes and productivity of 2.1 t/ha (Directorate of Economics and Statistics, Govt. of Bihar, 2017-18). 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) offers 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). Rice is the world's most important cereal and potentially important source of Zn for people who eat mainly rice. Plant uptake Zn in the form of Zn^{2+}, however 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) [2]. 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). During germination, production of reactive oxygen species (ROS) is well known (Cakmak *et al*. 1993; Qin and Liu 2010) [3, 16] it plays a central role in detoxification of ROS in plant cells (Cakmak 2000) [2]. In addition to being essential to plants, it is also an essential mineral nutrient for human beings. It is estimated that 1/3 of the world population is affected by Zn deficiency that is associated with low dietary intake. It's 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) [7].

In most cases, rice cultivated soils are very low in plant available zinc leading to further decreases in it's concentration in rice grain. It's deficiency symptom in rice was observed for the first time in calcareous soil of north-India 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 stages due to immobilization of Zinc, it's deficiency sometimes resemble with Fe/ Mn deficiency. It's availability in Indian soils ranges between 0.08–20.5 ppm and it's deficiency in rice crop is commonly known as Khaira disease. It is usually more available to plant in acid soil than alkaline soil. Calcareous soils are particularly more prone to it's 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 it's availability. It's 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) [12]. Timing of foliar application is an important factor determining the effectiveness of the foliar applied fertilizer in increasing grain micronutrient concentration (Ozturk *et al*., 2006) [14]. It's efficiency is hardly 2-5% and remaining 98-95% parts are converted to a compound which are 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) [5, 17]. To increase water productivity of rice production the interactions between irrigation practices and fertilizers should be addressed (Hortz and Brown. 2004) [8]. The future of rice production will therefore heavily depends on developing and adopting strategies and practices through efficient use of resources. Such strategies are producing more rice with low inputs of water.

Methods and Materials

Digestion of plant sample

Weigh 0.5 g powdered plant samples were digested with di-acid (HNO_3: $HClO_4$) mixture at 9: 4 ratio in hot plate till clear solution was observed or till white fumes cease to come out. Cool it and transfer to 50 ml volumetric flask and make up volume to the mark by adding distilled water. Filter it through Whatman No.1 filter paper and a known quantity of aliquot was used for further analysis of phosphorus, potassium and zinc.

Nitrogen content analysis in plant sample

After harvest, the grain and straw samples were separated and oven dried at 65 °C ± 2 ºC for 24 hrs. or till constant weight. Grind the sample in an electric stainless steel grinder. The powdered plant sample of 0.5 g was digested with concentrated H_2SO_4 in presence of digestion mixture ($CuSO_4$ + K_2SO_4 + selenium powder) in digestion unit for 3 hrs. and temperature maintained at 420 °C. The digested sample was further diluted carefully with distilled water to a known volume. Then aliquot was transfer to distillation unit and was steam distilled with 20 ml of 40 percent sodium hydroxide in a semi-microkjeldhal apparatus. The liberated ammonia was trapped in boric acid mixed indication solution. Then, it was titrated against standard acid (0.01N H_2SO_4) and amount of nitrogen liberated was estimated and expressed the concentration in percentage. Nitrogen percent in plant sample was calculated from the following formula;

$$\% N = \frac{N(S-B)\times 0.014}{W} \times 100$$

Where,
S - ml. of standard acid required for the titration of the plant sample
B - ml. of standard acid required for blank titration
N - Normality of acid
W - Weight of the plant sample in gram

Phosphorus content analysis in plant sample

Phosphorus content in plant was determined by Vanado-molybdate yellow colour method (Koenig and Johnson, 1942) by using spectrophotometer at 660 nm wavelength and expressed the concentration in percentage.

Potassium content analysis in plant sample

Potassium content in plant was estimated using flame photometer (Jackson, 1967) [10] and expressed the concentration in percentage.

Zinc content analysis in plant sample

Zinc content in plant was estimated by di-acid mixture (HNO_3: $HClO_4$) method by using atomic absorption spectrophotometer (Lindsay and Norvell, 1978) [11] and expressed the concentration in ppm.

The experimental data were subjected to statistical analysis in order to find the differences among the treatments. The experiment was laid out in a split plot design (SPD). The data obtained from various characters under study were analysed by the method of analysis of variance as described by Gomez and Gomez (1984) [6].

Result and Discussion

N, P, K (%) and Zn (ppm) content in grain

Mean data of N, P, K and Zn content in grain was statistically analyzed and have been presented in Table 1.

Effect of moisture regimes

The effect of moisture regimes on N, P and K content in grain was found to be non-significant. The highest value of N, P and K content in grain was recorded with irrigation at 1 day disappearance of ponded water followed by irrigation at 3 days disappearance of ponded water, irrigation at 5 days disappearance of ponded water and minimum for irrigation at 7 days disappearance of ponded water.

Table 1: Total N, P, K (%) and Zn (ppm) content in grain as affected by different treatments

Treatments	N content (%)	P content (%)	K content (%)	Zn content (ppm)
Moisture regimes				
I_1-Irrigation at 1 day disappearance of ponded water	1.162	0.301	0.242	25.13
I_2-Irrigation at 3 days disappearance of ponded water	1.154	0.290	0.241	24.47
I_3-Irrigation at 5 days disappearance of ponded water	1.150	0.289	0.240	21.73
I_4-Irrigation at 7 days disappearance of ponded water	1.144	0.281	0.237	16.85
SEm±	0.05	0.01	0.01	0.53
CD (P=0.05)	NS	NS	NS	1.85
Zinc levels				
Z_1- Control	1.142	0.303	0.236	16.60
Z_2- Application of $ZnSO_4$ @ 25 kg/ha	1.154	0.289	0.242	23.88
Z_3- Application of $ZnSO_4$ @ 37.5 kg/ha	1.165	0.275	0.244	24.70
Z_4- Foliar application of $ZnSO_4$ @ 0.5% at tillering, pre- flowering and flowering.	1.149	0.292	0.238	23.00
SEm±	0.03	0.01	0.01	0.27
CD (P=0.05)	NS	NS	NS	0.81

Moisture regimes showed significant effect on Zn content in grain of direct seeded rice. The maximum Zn content was observed with irrigation at 1 day disappearance of ponded water which was significantly superior to irrigation at 5 days disappearance of ponded water and irrigation at 7 days disappearance of ponded water but was statistically at par with 3 days disappearance of ponded water.

Effect of zinc levels

N, P and K content in grain did not varied significantly due to levels of zinc. However, the maximum N and K content was noticed with soil application of $ZnSO_4$ @ 37.5 kg/ha followed by soil application of $ZnSO_4$ @ 25 kg/ha, foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering and minimum for control, but an opposite trend was recorded in P content in grain were observed, maximum P content was observed in control plot followed by soil application of $ZnSO_4$ @ 25 kg/ha , foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering and minimum for soil application of $ZnSO_4$ @ 37.5 kg/ha. Zinc levels showed significant effect on zinc content in grain of rice. Plants fertilized with soil application of $ZnSO_4$ @ 37.5 kg/ha showed highest zinc content which was significantly superior over rest of the treatments and minimum Zn content was observed with control. Maximum zinc content was recorded for soil application of $ZnSO_4$ @ 37.5 kg/ha which was significantly superior over rest of the treatments. This result is in line with the finding of Mumba and Ambara (2013) [13].

N, P, K (%) and Zn (ppm) content in straw

Mean data of N, P, K and Zn content in grain was statistically analyzed and have been presented in Table 2.

Effect of moisture regimes

The effect of moisture regimes on N, P and K content in straw was found to be non-significant. The highest value of N, P and K content in straw was recorded with irrigation at 1 day disappearance of ponded water followed by irrigation at 3 days disappearance of ponded water, irrigation at 5 days disappearance of ponded water and minimum for irrigation at 7 days disappearance of ponded water. Moisture regimes showed significant effect on Zn content in grain and straw of direct seeded rice. The maximum Zn content was observed with irrigation at 1 day disappearance of ponded water which was significantly superior to irrigation at 5 days disappearance of ponded water and irrigation at 7 days disappearance of ponded water but was statistically at par with 3 days disappearance of ponded water.

Table 2: Total N, P, K (%) and Zn (ppm) content in straw as affected by different treatments

Treatments	N Content (%)	P content (%)	K Content (%)	Zn content (ppm)
Moisture regimes				
I_1-Irrigation at 1 day disappearance of ponded water	0.584	0.163	1.454	27.23
I_2-Irrigation at 3 days disappearance of ponded water	0.579	0.159	1.408	26.37
I_3-Irrigation at 5 days disappearance of ponded water	0.577	0.151	1.386	23.61
I_4-Irrigation at 7 days disappearance of ponded water	0.564	0.148	1.340	18.73
SEm±	0.03	0.01	0.06	0.55
CD (P=0.05)	NS	NS	NS	1.89
Zinc levels				
Z_1- Control	0.563	0.160	1.338	18.29
Z_2- Application of $ZnSO_4$ @ 25 kg/ha	0.583	0.156	1.411	25.70
Z_3-Application of $ZnSO_4$ @ 37.5 kg/ha	0.586	0.148	1.450	27.87
Z_4- Foliar application of $ZnSO_4$ @ 0.5% at tillering, pre- flowering and flowering.	0.572	0.158	1.389	24.08
SEm±	0.02	0.00	0.04	0.29
CD (P=0.05)	NS	NS	NS	0.87

Effect of zinc levels

N, P and K content in straw did not varied significantly due to levels of zinc. However, the maximum N and K content was noticed with soil application of $ZnSO_4$ @ 37.5 kg/ha followed by soil application of $ZnSO_4$ @ 25 kg/ha, foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering and minimum for control, This might be due to the positive response of Zn on N and K. but an opposite trend was recorded in P content in straw were observed, maximum P content was observed in control plot followed by soil application of $ZnSO_4$ @ 25 kg/ha , foliar application of $ZnSO_4$ @ 0.5% at tillering, pre-flowering and flowering and minimum for soil application of $ZnSO_4$ @ 37.5 kg/ha. This might be due to the antagonistic effect of Zn on P. These results are in accordance with the findings of Ghoneim (2016). Zinc levels showed significant effect on zinc content straw of rice. Plants fertilized with soil application of $ZnSO_4$ @ 37.5 kg/ha showed highest zinc content which was significantly superior over rest of the treatments and minimum Zn content was observed with control. Maximum zinc content was recorded for soil application of $ZnSO_4$ @ 37.5 kg/ha which was significantly superior over rest of the treatments. This result is in line with the finding of Mumba and Ambara (2013) [13].

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