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Effect of Biofortification of Maize (Zea mays) with Zinc on Growth Behaviour

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ABSTRACT: Maize (Zea mays) is most important cereal crop of Begusarai (Bihar) in Indo Gangatic Plains. Bihar is a traditional maize growing state and the crop was grown primarily as a subsistence crop to meet food needs for a long time till recently.During 2018-2019, the state produced about2.42 MT, which is about 12 per cent of the total crop production. However keeping in view the rising demand of the crop for food, feed, fodder and fuel, the productivity enhancement, quality enrichment and ensuring sustainability is the agricultural challenges. A scientific and systematic research on Biofortification of Maize with different levels of Zinc as soil application on a popular variety Dekalb 9081 was carried out and the effect of Biofortification on its various plant growth parameters such as Plant height , Leaf Area Index and Dry Matter accumulation was assessed. The result indicated significant growth in biofortified maize over the control besides the better quality attributes.

I. INTRODUCTION

Zinc (Zn) is an essential micronutrient and has particular physiological functions in all living systems, such as the maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression. Among all metals, Zn is needed by the largest number of proteins. Zinc-binding proteins make up nearly 10 % of the proteomes in eukaryotic cells, and 36% of the eukaryotic Zn-proteins are involved in gene expression (Andreini et al., 2006). Tolerance to environmental stress conditions has a high requirement for Zn to regulate and maintain the expression of genes needed to protect cells from the detrimental effects of stress (Cakmaket.al., 2000).Zinc deficiency appears to be the most widespread and frequent micronutrient deficiency problem in crop and pasture plants worldwide, resulting in severe losses in yield and nutritional quality. This is particularly the case in areas of cereal production. It is estimated that nearly half the soils on which cereals are grown have levels of available Zn low enough to cause Zn deficiency. Since cereal grains have inherently low Zn concentrations, growing them on these potentially Zn-deficient soils further decreases grain Zn concentration. It is, therefore, not surprising that the well-documented Zn deficiency problem in humans occurs in all underdeveloped and developing countries, where soils are low in available Zn, and cereals are the major source of calorie intake (Dileep 2013). Zinc deficiency in humans is a critical nutritional and health problem in the world. It affects, on average, one-third of the world's population, ranging from 4 to 73 % in different countries (Hotz and Brown, et.al. 2004). The recent analyses made under the Copenhagen Consensus in 2008 (www.copenhagenconsensus.com) identified Zn deficiency, together with vitamin A deficiency, as the top priority global issue, and concluded that elimination of the Zn deficiency problem will result in immediate high impacts and high returns for humanity in the developing world. Hence, it is highly important to develop cost-effective and quick solutions to the Zn deficiency problem. Low Zn in plant tissues is a reflection of both genetic and soil related factors. A basic knowledge of the dynamics of Zn in soils, understanding of the uptake and transport of Zn in plant systems and characterizing the response of plants to Zn deficiency are essential steps in achieving sustainable solutions to the problem of Zn deficiency in plants and humans. The present research result emphasise on the effect of Zinc biofortification on Maize crop in Indo Gangatic Plains on its plant growth, yield and quality characteristics as observed in consecutive two years laboratory and field experiments.

II. MATERIALS AND METHODS

Suitable experimentation with Maize variety Dekalb 9081 was conducted in RBD with three replications in a fixed lay out. The main plot treatments consisted of three levels of zinc with Control. Zinc ($ZnSO_4$) dose of 3mg/kg of soil, 9mg/kg of soil and 27mg/kg of soil was applied in three treatments of T1, T2, and T3 besides keeping a control. Similarly three levels of Fe were tried with control. Observations at scheduled fortnighltly intervals i.e 15, 30, 60 and 90 DAS was taken representing growth, development, young and full grown plant stage.Leaf area of the crop was estimated using leaf area meter (1/2- MDL-1000, LICOR Ltd, USA).Statistical analysis was done for the data obtained for different parameters with the help of Analysis of Variance (ANOVA) technique for RBD (Random Plot Design) using MSTAT-C software.

III. RESULT AND DISCUSSION

Observationson important parameter of growth viz. Leaf area index, plant height and for dry matter accumulation sample were taken from one square m area from each plot and finally converted into t/ha by using standard procedure and recommended method.

Plant Height: Result obtained revealed that the effect of Zinc levels on maize Growth parameters Plant height did not vary significantly due to application of Zn at all the growth stages during both the years. Leaf area index and dry matter accumulation differ significantly with the application of different levels of zinc. Leaf area index was significantly increased with Zn application up to 27 kg ZnSO4 /ha. during second year while higher dry matter accumulation at harvest was obtained during first year . Relatively higher plant height was recorded with the application of 27 kg ZnSO4/ ha at all the growth stages during both the years. This treatment was closely followed by application of 9 kg ZnSO4/ ha.

Table 1: Effect of zinc application (ZnSo4) on plant height of maize at different growth stages (Pooled data of two year experiments) 2017- 2018 and 2018- 2019

Treatment	Plant height (cm)			
Application of ZnSO4	15 DAS	30 DAS	60 DAS	90 DAS
T1	44.8	70.5	167.5	172.6
T2	45.8	72.7	168.9	173.4
T3	46.5	74.5	171.1	172.6
T7 (Control)	43.7	69.95	166.5	176.7
SEm+	0.89	1.57	2.5	3.6
CD (P=0.05)	Non Significant	Non Significant	Non Significant	Non Significant

Leaf Area Index: Observeddata indicated that LAI of maize was relatively higher with the application of 27 kg ZnSO4/ ha than the other treatment during both the year. During first year at 60 days after sowing it was significantly higher than control, 9 kg ZnSO4 ha. Application of 3 kg ZnSO4/ ha remained significantly higher than control treatment, whereas, 9 kg ZnSO4/ ha were at par with respect to LAI .

Table 2: Effect of zinc application on leaf area index of maize at different growth stages (Pooled data of two year experiments) 2017- 2018 and 2018- 2019

Treatment	Leaf Area Index (cm)			
Application of ZnSO4	15 DAS	30 DAS	60 DAS	90 DAS
T1	0.56	1.05	2.74	NA
T2	0.59	1.13	2.75	NA
T3	0.62	1.23	3.26	NA
T7 (Control)	0.55	1.05	2.3	NA
SEm+	0.33	0.35	0.12	0.3
CD (P=0.05)	Non Significant	Non Significant	Non Significant	Non Significant

Dry matter accumulation: Relatively higher Dry Matter accumulation was obtained with the application of 27 kg ZnSO4 / ha during both the year at different growth stages. During first year it was higher than control and T2 9 kg ZnSO4 /ha.Application of 9kg ZnSO4/ hawas found similar as control. During second year application of 27 kg ZnSO4/ha was significantly higher than control and9 kg ZnSO4/ha at 30 DAS and at harvesting stage. Control and9kg ZnSO4/hawere found at par among them.

Table 3: Effect of zinc application on dry matter accumulation of maize at different growth stages

Treatment	Dry Matter Accumulation (t /ha)		
Application of ZnSO4	30 DAS	60 DAS	100 DAS
T1	3.05	8.98	10.60
T2	3.26	9.16	11.34
T3	4.18	9.56	11.60
T7 (Control)	2.98	8.89	10.54
SEm+	0.9	0.47	0.21
CD (P=0.05)	Non Significant	Non Significant	0.26

The different growth attributes viz. plant height, dry matter accumulation and leaf area index studied for maize crops did not vary significantly due to zinc application in various doses in soil .However, it varied significantly during second year in relation to first year and higher values of growth attributes, yield attributes and yield were recorded in maize during second year. Zinc has lesser role in the vegetative growth of plant while its requirement is more during reproductive phase in comparison to vegetative growth stage the same was reflected in present investigations (Singh et.al 2007). The uniformity in the growth attributes in maize might be due to equal plant population exerting similar magnitude of competition amongst plants for resources like nutrients, moisture, light and space. The plant height, dry matter accumulation and leaf area index were considerably influenced due to zinc application, besides favourable weather condition during 2018- 19. However, within year the differences in these parameters were not significant. The differences in plant height, leaf area index and dry matter accumulation might be due to the fact that during second year, the cumulative effect of better rainfall distribution and timely availability of nutrient to the plant, better moisture and zinc application produced more yield. Zinc application improves the growth because zinc involved directly and indirectly as co-enzyme in photosynthetic process which provide substrate for growth and development (white et.al 2005). These factors might have contributed for the overall growth and development and yields of both the crop increased with the application of zinc (Hussain et.al 2010).

IV. CONCLUSION

Biofortification is an effective biotechnological tool which successfully enhances the micronutrient availability in crops. The present research output emphasized that 27kg Zn So4 /ha as soil application significantly effect the various growth parameter of the Zea mays Variety Dekalb 9081 and also the quality yield attributes.

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