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Effect of Zinc, Iron and their Methods of Application on Growth and Yield of Pearlmillet (*Pennisetum glaucum* L.)

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The field experiment was conducted during *Kharif* 2019 at Central Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) with the objective to study the effect of Zinc, Iron and their methods of application on growth and yield of Pearlmillet (*Pennisetum glaucum* L.) under Randomised block design comprising of 10 treatments of which soil application of zinc (25 kg/ha) and iron (10 kg/ha) at basal and foliar application of 0.5% of Zinc and iron at 35 and 55 days after sowing which are replicated thrice. The experimental results revealed maximum plant height (156.31 cm), dry weight (49.23g), grain yield (2327.37 kg/ha), stover yield (4584.86 kg/ha) and test weight (7.63 g) was obtained by the application of T_9 (0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 and 55 DAS).

Introduction

Pearlmillet occupies fourth position among cereals crops next to rice, wheat and sorghum. Pearlmillet may be an alternative crop that exhibits great advantages in physiological characteristics when compared to other cereals as it is drought resistant, high salinity and high temperature tolerance (Rai *et al.*, 2008). Pearlmillet is the only cereal crop that is capable of producing a reliable yield under marginal environments and simultaneously responds to high management practices. It is high nutritionally better than many cereals as it is a good source of protein (12.6%), Iron (2.8%), zinc and fat (5%) and it is also rich in various vitamins.

The importance of micronutrients has been realized during the past four decades when wide spread of micronutrient deficiencies particularly that of Zinc and iron were observed in most of the soils of the country. Micronutrients have not only cured nutritional disorder in plants but are also known to improve the yield and quality (Jakhar *et al.*, 2006). Zinc being one of the essential micronutrient plays significant role in various enzymatic and physiological activities. It is required as a structural component of large number of proteins, such as transcription factors and metallo enzymes (Singh and Kumar, 2009).

Iron is a constituent of several enzymes and some pigments and assists in nitrate and sulphate reduction and energy production within the plant.Iron is also a structural component of porphyrin, cytochromes, ferrchrome. Iron in chloroplasts reflects the presence of cytochromes which is performing various photosynthetic reduction process.

Application of micronutrient fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. The amount of nutrients required is much higher compared to foliar application. Foliar application is widely used to apply nutrients for many crops. The deficiency symptoms are usually corrected with in few days (Mortvedt, 2000).

Materials and Methods

The experiment was conducted during *Kharif* season 2019, at the Crop Research farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (7.10), available N (171 kg/ha), available P (15.20 kg/ha), available K (232.50 kg/ha). The treatment consists of soil application of zinc (25 kg/ha) and iron (10 kg/ha) as basal and foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ at 35 and 55 days after sowing. There were 10 treatments each replicated thrice. The experiment was laid out in Randomised Block Design. The crop was sown on 23 July 2019 at a spacing of 45cm*15 cm. The recommended dose of 80 kg N, 40 kg P, 40 kg K per ha was applied according to treatment details through urea, DAP, MOP and zinc and iron applied as zinc sulphate and iron sulphate. The half dose of nitrogen and full dose of phosphorous, potassium, zinc and iron were applied as basal. The split dose of nitrogen applied at 50 days after sowing and foliar application of zinc and iron were done at 35 and 55 days after sowing a per treatment details. Five random plants were selected from each plot to record observations on plant growth attributes. Similarly, five random plant samples were collected from each plot at the time of harvest for recording observations on plant yield attributes. Experimental data collected was subjected to statistical analysis by adopting Fishers method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (2010). Critical Difference (CD) value were calculated whenever the 'F' test was found significant at 5% level.

Results and Discussion

The growth parameters like plant height and dry weight was significantly affected by the different methods of application of zinc and iron at different stages were represented in Table 1.

Plant height (cm)

The Pearlmillet crop fertilized with 0.5 % $ZnSO_4$ and $FeSO_4$ foliar spray at 35 and 55 DAS significantly resulted maximum plant height (156.31cm) which was statistically at par with 0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 DAS (154.71cm) at 80 days after sowing. The increase in plant height may be due to zinc plays a key role in metabolic activity and physiology reaction and acts as catalyzing enzymes, transformation of carbohydrates, chlorophyll content and protein synthesis Srinivasan (1992). The iron also had its role in starch formation, protein synthesis and synthesis of chlorophyll in plants. The increase in iron availability to plant might have stimulated the metabolic and enzymatic activities there by increasing the crop growth Trivedi *et al.,* (2011).

Dry weight (g) per plant

The analysed data presented shown significant variation among all other treatments. At 80 DAS significantly maximum plant dry weight (49.23g) were recorded in 0.5% foliar spray of $ZnSO_4$ and $FeSO_4$ at 35 and 55 DAS. Which was statistically with Soil application of 25 kg/ha $ZnSO_4$ +10 kg/ha $FeSO_4$ (44.82g) and 0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 DAS (46.84g).

The increase in plant dry weight might be due to Zinc is the essential component of cellular growth, oxygen synthesis, differentiation and metabolism which results in vigorous growth of plants and extensive root system leading to increased growth of plants reported by Tamil *et al.,* (2019) and Meena *et al* (2010). The foliar application of Zinc and Iron was found to be more effective due to its higher uptake efficiency compared to soil application as they helps in increased photosynthetic efficiency by delaying leaf senescence reported by Kuldeep *et al.,* (2018).

Yield and Yield Attributes

The yield attributes like test weight, grain yield, stover yield was significantly affected by the different methods of application of zinc and iron at different stages were represented in Table 1.

Test weight (g)

The test weight showed significantly maximum test weight (7.63g) were recorded in 0.5 % $ZnSO_4$ +$FeSO_4$ foliar spray at 35 and 55 DAS which was statistically at par with 0.5% $ZnSO_4$+ $FeSO_4$ foliar spray at 35 DAS (7.2g). The reason for recording maximum test weight might due to the presence of Zinc in the foliar application stimulates the metabolic processes in seed Qudratullah *et al.,* (2016) and Iron plays role in increasing supply of photosynthates to sink due to higher chlorophyll content and photosynthesis due to foliar sprays at different intervals during growing period of crop. The involvement of the sprayed zinc in enzyme activation, membrane integrity and starch utilization at early which enhanced accumulation of assimilates in the grains Abid *et al.,* (2019).

Grain yield (Kg/ha)

The highest grain yield (2327.37 kg/ha) was recorded significantly superior in 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar sprayat 35 and 55 DAS over rest all other treatments. The results might be due to zinc and iron helps in vigorous root development, which promotes growth and development of plant leading to higher photosynthetic efficiency which resulted in better development of higher yield attributes Paramasivan *et al.,* (2011).

The Zinc application might be attributed to its direct role on auxin production, which enables the plant to produce more dry matter and consequently enhanced the partitioning of photosynthates towards newly formed sink. Similar results were observed by Abdul *et al.,* (2018) and Jyothi *et al.,* (2015). Iron is involved in the reductive assimilation pathway of sulphur as ferredoxin is a reductant. Similar results were observed in Yadav and Chippa (2007) and Sareen and Sharma (2010).

Stover yield (Kg/ha)

Stover yield data showing that significant variation among all the treatments. The highest Stover yield was recorded significantly in 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at 35 and 55 DAS which was at par with 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ at 35 DAS.

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Table.1 Effect of zinc, iron and their methods of application on growth and yield attributes of pearlmillet

Treatments	Plant height (cm) at 80 DAS	Dry weight at 80 DAS	Test weight (g)	Grain yield (Kg/ha)	Stover yield (Kg/ha)
1. Soil application of 25 kg/ha $ZnSO_4$	134.68	42.55	5.8	1852	3878.11
2. 0.5% $ZnSO_4$ foliar spray at 35 DAS	125.5	39.34	5.6	1743.21	3693.13
3. 0.5% $ZnSO_4$ foliar spray at 35 and 55 DAS	137.76	43.92	6.33	1871.39	3799.44
4.Soil application of 10 kg /ha $FeSO_4$	123.19	39.14	5.97	1850.83	3754.99
5.0.5% $FeSO_4$ foliar spray at 35 DAS	130.45	43.22	5.57	1785.25	3613.16
6. 0.5% $FeSO_4$ foliar spray at 35 and 55 DAS	135.43	42.99	6.4	1869.82	3665.58
7. Soil application of 25 kg/ha $ZnSO_4$ +10 kg/ha $FeSO_4$	146.37	44.82	6.03	2064.2	4227.07
8. 0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 DAS	154.71	46.84	7.2	2119.57	4351.36
9. 0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 and 55 DAS	156.31	49.23	7.63	2327.37	4584.86
10. Control (80-40-40 kg N-P-K/ha)	123.19	36.39	5.27	1325.39	2706.51
SEm ($\pm$)	2.7	1.60	0.26	32.16	83.65
CD (P=0.05)	8.02	4.76	0.76	95.56	248.54

Zinc application improves the source and sinks relationship due to translocation of photosynthates which leads to increase of stover yield in Pearl millet Pradeep *et al.*, (2014). Similar results were obtained by Abid *et al.*, (2019) and Sareen and Sharma (2010).

More over quantity of nutrients absorbed due to soil application of Zinc and Iron may not be sufficient to meet the crop demands at seed formation stage. Supplementing the nutrients through foliage at flowering might have the better nutrient balance and there by regaining the photosynthetic efficiency of the plant at post anthesis period results in increased yield Inayat *et al.*, (2015). Foliar application of Zinc and Iron at reproductive stages increased the grain and stover yield might be due to existence of favourable nutritional environment below and above ground Chowdhary (2014).

In conclusion the light of the above study, application of 0.5% $ZnSO_4$ and $FeSO_4$ foliar spray at 35 and 55 DAS is more productive.

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