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Original Research Article

Zinc Nutrition in Finger Millet [*Eleusine coracana* (L) Gaertn.] for Better Nutritional Security

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A B S T R A C T

A field experiment was conducted during rainy seasons of 2014-15 to 2016-17 at Hill Millet Research Station, Waghai (Gujarat) to find out the effect of various sources of zinc on yield and nutritional value of finger millet under hilly zone of southern Gujarat. Results of three years field study revealed that higher crop yield of finger millet along with improvement in nutritional composition can be obtained by adopting seed treatment with 30 % ZnO @10 ml/kg seed + root dipping @ 0.5% $ZnSO_4$ along with recommended dose of NPK (40:20:0 kg/ha). The grain yield recorded under treatment of 30 % ZnO @10 ml/kg seed + root dipping @ 0.5% $ZnSO_4$ was 3167, 2887 and 3104 kg/ha during 2015, 2016 and 2017, respectively. Foliar application of $ZnSO_4$ @ 0.5 % at 60 and 80 DAS had resulted in significantly higher zinc content in grain and straw over other treatments. While, treatment of 30 % ZnO @10 ml/kg seed + root dipping @ 0.5% $ZnSO_4$ resulted in significantly higher zinc uptake by grain as well as straw of finger millet.

Keywords

Zinc deficiency, Root dipping, *Eleuscine coracana*, Finger millet

Introduction

Finger millet [*Eleusine coracana* (L) Gaertn.] is one of the most important millet crop belongs to family Poaceae and subfamily Chloridoidae. Finger millet also known as ragi in India is one of the important cereals occupies highest area under cultivation among the small millets. Finger millet is comparable to rice with regard to protein (6-8%) and fat (1-2%) and is superior to rice and wheat with respect to mineral and micronutrient contents. It is a major source of dietary carbohydrates for a large section of the society. Additionally ragi has enormous health benefits and also a good source of valuable micro-nutrients along with the major food components. In Gujarat, finger millet is the staple food of the tribals in Agroclimatic Zone – I, II and III. It is grown as kharif rainfed crop in the least fertile hilly soils. Finger millet grains are rich source of protein, dietary fiber, minerals and amino acids (Shobana *et al.*, 2009). Zinc is an essential for the normal structure and functioning of more than 300 enzymes. Dietary daily intake of 15 and 12 mg Zn for men and women is recommended adequate, respectively, Zinc deficiency, therefore, disrupts multiple biological functions. Recent intervention trial showed that Zn supplementation decreases the rate of diarrhea and lower respiratory infections, two major causes of child mortality, It is estimated that >90 % coverage with zinc supplementation programme to prevent Zn deficiency would reduce child mortality by 5% globally Graham *et al.,* (2001). Zinc deficiency syndrome is next to iron anaemia, as an important nutritional problem in the world Alloway (2008). Zinc concentration in human depends on their diet. In India, Zn deficiency in human diet was reported and expressed its syndrome: hypogonadism, dwarfism, hepatosplenomegaly, anaemia and geophagi Prasad *et al.,* (1961). Dietary zinc intake was found inadequate from cereals, pulses, vegetable grown on zinc deficient soil. The percentage zinc deficiency reported in the soils of Gujarat 24 percent (Patel *et al.,* 1999). Zinc hampers the productivity of cereals and oil seed crops. In addition to nutritional value of Zn, it is a component of various enzyme systems. It also plays a vital role in biosynthesis of indole acetic acid (IAA). It helps in formation of nucleic acids and synthesis of proteins. Among the typical common diseases listed due to Zn deficiency is brown leaf spot' in rice. Keeping all the above points in view a programme has been framed out to effect of zinc on growth and yield of finger millet.

Materials and Methods

The field experiment was conducted during rainy season of 2014-15, 2015-16 and 2016-17 at Hill Millet Research Station, N.A.U., Waghai (Dang) situated under South Gujarat heavy rainfall zone – I and AES- I .The site prepared by removing the plant stubbles of previous crop and cultivated twice

After carrying out the layout as per the standard technique of the design, the half of the recommended N (40 kg ha^{-1}) and P_2O_5 (20 kg ha^{-1}) to the soil through ammonium sulphate and DAP basal application will be given to each plot. Based on the initial soil analysis, K_2O will be not applied due to adequate available potassium (K_2O) status of the soil. Zn at treatments will be applied through zinc Sulphate ($ZnSO_4$) and ZnO in all the three replications. The Finger millet variety GN-4 will be selected for sowing. The sowing will be done on June-July 2014, keeping the seed rate of 5.0 kg ha^{-1}. The grain and straw yield data will be recorded from the net plot area after air drying. The plant samples will be taken simultaneously and washed with tap water followed by washing with 0.1 N HCl and subsequently with de-ionized water before keeping for air drying. The samples will be kept in brown paper bags for air drying. Thereafter, the samples will be kept in an oven at 60 to 70°C for drying till constant weight.

The straw as well as grain samples will be processed by grinding them in a steel Willey mill and stored in paper bags for further chemical analysis. In order to study the impact of the treatments on changes in important soil properties and nutrient status at the harvest of finger millet, soil samples from each plot will be collected with the help of steel tube auger. The samples will be air dried and ground with mortar and pastle to pass through 2 mm sieve. The samples will be stored in polythene coated cloth bags for chemical analysis.

The chemical analysis of the plant samples (grain and straw) was carried out by wet digestion with HNO_3: $HClO_4$ (2:1) di-acid mixture as per the procedure outlined by Jackson (1973). The final volume of digested acid extract was made to 100 ml and stored for analysis of different nutrient contents by using standard analytical methods.

The soil samples were collected from each plot to know the nutrient status of the soil after harvest of mustard and maize. The samples were air dried, ground and passed through 2 mm sieve and were analyzed for nutrient contents by using standard analytical methods.

Results and Discussion

In this study, results (Table 1) indicated that the grain yield and straw yield of finger millet were affected significantly due to different treatments zinc nutrition during the year 2014-15 and 2016-17 and pooled analysis except stover yield in 2014-15. Treatment T_9 (Seed treatment 30% ZnO @10 ml/kg seed and root dipping @ 0.5% $ZnSO_4$) recorded significantly higher grain and stover yield of finger millet as compared to rest of the treatments but it remained at par with treatment T_2, T_3, T_5 and T_6 during the year 2014-15 and 2016-17 for grain yield and treatment T_2, T_3, T_4, T_5 and T_8 during the year 2016-17 for stover yield. In Pooled results, treatment T_9 also registered significantly higher grain and stover yield than other treatments except T_3 and T_6 for grain yield and T_3, T_5 and T_8 for stover yield. The grain yield were recorded under treatment T_9 during 2014-15, 2015-16, 2016-17 and pooled results were 3167, 2887, 3104 and 3053 kg/ha, respectively. This might be due to profound influence of Zinc fertilizers on growth attributes as increased metabolic process in plant which has promoted meristamatic activities and photosynthetic process, ultimately better growth resulted in higher yield and yield attributes (Saraswathi *et al.*, 2019).

The results presented in Table 2 indicated that the protein content as well as protein yield were failed to differ significantly during all the years except in for protein yield. Overall treatment T_9 gave the higher numerical values for both protein content and yield. Results of pooled analysis showed the significant difference in protein yield by producing their higher values by the treatment T_9 over other treatments except treatment T_3 and T_6.

Table.1 Effect of different treatments on grain and stover yield of finger millet

Treatment	2014-15		2015-16		2016-17		Pooled	
	Grain Yield (kg/ha)	Stover Yield (kg/ha)	Grain Yield (kg/ha)	Stover Yield (kg/ha)	Grain Yield (kg/ha)	Stover Yield (kg/ha)	Grain Yield (kg/ha)	Stover Yield (kg/ha)
T_1 -Control (water spray)	2298	7559	2338	8299	2303	7269	2313	7709
T_2 -Soil application @ 12.5 kg $ZnSO_4$/ha	2751	9070	2542	8672	2782	8808	2692	8850
T_3 -Soil application @ 25 kg $ZnSO_4$/ha	2968	10330	2686	8919	2983	10008	2879	9752
T_4 - Foliar application 60 DAS @ 0.5 % $ZnSO_4$	2474	8818	2512	8546	2462	8680	2483	8681
T_5 -Foliar application 80 DAS @ 0.5 % $ZnSO_4$	2842	9322	2487	8471	2882	9388	2737	9060
T_6 -Foliar application 60 and 80 DAS @ 0.5 % $ZnSO_4$	2837	8314	2729	9161	2860	7959	2809	8478
T_7 -Seed Treatment 30% ZnO @10 ml/ kg Seed	2373	8818	2525	8592	2383	8551	2427	8654
T_8 -Root dipping @ 0.5% $ZnSO_4$	2656	9826	2605	8798	2583	8891	2615	9172
T_9 -Seed Treatment 30% ZnO @10 ml/ kg Seed and Root dipping @ 0.5% $ZnSO_4$	3167	10582	2887	9332	3104	10189	3053	10034
S.Em.±	167.35	681.63	194.18	586.32	157.45	544.90	100.12	350.44
C.D. at 5 %	501.74	NS	NS	NS	472.03	1633.71	284.98	997.43
C.V. %	10.71	12.86	12.99	11.60	10.08	10.65	11.26	11.77

Table.2 Protein content and protein yield in grain as affected by different treatments.

Treatment	Protein content (%)				Protein yield (kg/ha)			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled
T_1	7.15	7.42	7.40	7.32	164.32	173.30	169.06	168.89
T_2	7.33	7.38	7.33	7.35	201.17	187.90	203.82	197.63
T_3	7.40	7.33	7.38	7.37	219.92	197.65	220.50	212.69
T_4	7.15	7.15	7.21	7.17	176.40	178.99	177.82	177.74
T_5	7.44	7.19	7.21	7.28	212.30	177.98	207.90	199.39
T_6	7.56	7.15	7.25	7.32	214.53	195.08	208.01	205.87
T_7	7.42	7.71	7.21	7.44	176.14	195.38	172.40	181.31
T_8	7.04	7.40	7.31	7.25	186.93	192.37	189.05	189.45
T_9	7.35	7.44	7.42	7.40	233.95	215.81	230.68	226.82
S.Em.±	0.30	0.26	0.24	0.15	15.50	15.42	14.13	8.68
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	24.69
C.V. %	7.0	6.2	5.6	6.3	13.5	14.0	12.4	13.3

Table.3 Zinc content and uptake in grain as well as straw affected by different treatments (Pooled)

Treatment	Zn content (mg/kg)		Zn uptake (g/ha)		Total Zn uptake (g/ha)
	Grain	Straw	Grain	Straw	
T_1 -Control (water spray)	60.16	19.80	139.15	152.62	291.77
T_2 -Soil application @ 12.5 kg $ZnSO_4$/ha	60.65	20.48	163.21	181.23	344.44
T_3 -Soil application @ 25 kg $ZnSO_4$/ha	61.38	20.75	176.69	202.33	379.02
T_4 - Foliar application 60 DAS @ 0.5 % $ZnSO_4$	62.75	21.51	155.77	186.70	342.46
T_5 -Foliar application 80 DAS @ 0.5 % $ZnSO_4$	63.39	21.52	173.47	194.98	368.44
T_6 -Foliar application 60 and 80 DAS @ 0.5 % $ZnSO_4$	64.46	22.13	181.00	187.43	368.43
T_7 -Seed Treatment 30% ZnO @10 ml/ kg Seed	62.15	20.48	150.82	177.25	328.07
T_8 -Root dipping @ 0.5% $ZnSO_4$	62.15	20.61	162.44	189.03	351.47
T_9 -Seed Treatment 30% ZnO @10 ml/ kg Seed and Root dipping @ 0.5% $ZnSO_4$	62.83	20.92	191.80	209.98	401.78
S.Em.±	0.25	0.14	6.10	7.41	7.84
C.D. at 5 %	0.75	0.41	17.37	21.08	22.30
C.V. %	0.71	2.07	11.03	11.89	6.66

The results of the study revealed that (Table 3) zinc content and uptake by grain and straw as well as total uptake of zinc were affected significantly due to different treatments of zinc nutrition. Treatment T_6 (Foliar application of 0.5 % $ZnSO_4$ at 60 and 80 DAS) resulted in the highest in zinc content in grain and straw over other treatments during both the year of study. While, treatment T_9 (Seed treatment 30% ZnO @10 ml/kg seed and root dipping @ 0.5% $ZnSO_4$) resulted in significantly higher zinc uptake by grain and straw as well as total uptake of zinc over other treatments but it remained statistically at par with treatment T_6 and T_3 for zinc uptake by grain, treatment T_3, T_5 and T_8 for zinc uptake by straw. Pradhan *et al.*, (2016) also reported higher Zn concentration in finger millet with zinc fertilization.

From the results of field experimentation, it can be concluded that to obtained higher crop yield and nutritional composition from finger millet, crop should be sown with seed treatment of 30 % ZnO @10 ml/kg seed and root dipping @ 0.5% $ZnSO_4$ along with recommended dose of NPK under hilly zone of southern Gujarat.

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