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Effect of zinc on growth, yield and economics of finger millet [*Eleusine coracana* (L) Gaertn.] on hilly area of South Gujarat

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ABSTRACT

Experiment was conducted during rainy season of 2014-15 to 2016-17 at Hill millet Research Station, NAU, Waghai (Gujarat) to find out effect of various sources of zinc on growth and yield of finger millet grown under hilly area of south Gujarat. Results of three years field study revealed that economically higher crop yield of finger millet along with better nutritional value can be obtained by adopting seed treatment with 30% ZnO 10 ml/kg seed and root dipping in 0.5% $ZnSO_4$ before transplanting (T_9) with recommendation dose of NPK (40:20:0 kg/ha) to finger millet. Moreover, treatment T_9 was also resulted in significantly higher zinc uptake by grain and stover as well as its total uptake and zinc status of soil after harvest of finger millet as compared to rest of the treatments. Whereas foliar application of $ZnSO_4$ 0.5 % at 60 and 80 DAS resulted in significantly higher zinc content in grain and stover over other treatments. The higher productivity of finger millet may be attributed to improved soil properties and increased nutrient use efficiency of applied nutrients.

Key Words: - *Zn Application, 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 24 % zinc deficiency was reported in the soils of Gujarat (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 field experiment was conducted to study the effect of zinc on growth and yield of finger millet**.**

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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. The initial soil analysis data indicated that the soil of the experimental field was medium in organic carbon (0.60 % and 0.58 %), available nitrogen (270.80 and 274.50 kg/ha), available phosphorus (28.75 and 30.39 kg/ha) whereas high in available potassium (365.25 and 360.55 kg/ha) and slightly acidic in reaction (pH 6.85 and 6.95) with normal electrical conductivity (0.15 and 0.20 dSm^{-1}) during the year 2018 and 2019, respectively.

This experiment was conducted to study the effect of zinc on growth and yield and of finger millet under nine treatments laid out in randomized block design with three replications. Nine treatments *viz*., T_1 -Control (water spray), T_2 -Soil application @ 12.5 kg $ZnSO_4$/ha, T_3 -Soil application @ 25 kg $ZnSO_4$/ha, T_4 - Foliar application 60 DAS @ 0.5 % $ZnSO_4$, T_5 -Foliar application 80 DAS @ 0.5 % $ZnSO_4$, T_6 -Foliar application 60 and 80 DAS @ 0.5 % $ZnSO_4$, T_7 -Seed Treatment 30% ZnO @10 ml/ kg Seed, T_8 -Root dipping @ 0.5% $ZnSO_4$, T_9 -Seed Treatment 30% ZnO @10 ml/ kg Seed and Root dipping @ 0.5% $ZnSO_4$. 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 stover 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 stover 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 stover) 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 fingermillet. 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 DISCUSSIONS

In this study, results (Table 1) indicated that the grain yield and stover 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

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

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).

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

Protein content as well as protein yield were failed to differ significantly during all the years except in for protein yield (Table 2). 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.

The results of the study revealed that (Table 3) zinc content and uptake by grain and stover 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 stover over

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

Treatment	Zn content (mg/kg)		Zn uptake (g/ha)		Total Zn uptake (g/ha)
	Grain	Stover	Grain	Stover	
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

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 stover 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 stover. Pradhan *et al.* (2016) also reported higher Zn concentration in finger millet with zinc fertilization.

Table 4: Effect of Zinc treatments on availability of Zinc in soil after harvest of finger millet

Treatments	2014-15	2015-16	2016-17	Pooled
	DTPA extract Zn (ppm)	DTPA extract Zn (ppm)	DTPA extract Zn (ppm)	DTPA extract Zn (ppm)
T_1	0.63	0.58	0.56	0.59
T_2	0.71	0.65	0.64	0.67
T_3	0.77	0.71	0.70	0.72
T_4	0.67	0.62	0.60	0.63
T_5	0.69	0.63	0.62	0.65
T_6	0.70	0.64	0.63	0.66
T_7	0.69	0.64	0.62	0.65
T_8	0.68	0.63	0.62	0.64
T_9	0.71	0.65	0.64	0.66
S.Em.±	0.02	0.02	0.02	0.01
CD at 5 %	0.06	0.05	0.06	0.03
C.V. %	5.08	4.5	5.85	5.17
Initial Soil Status	0.61	0.62	0.57	

The results presented in Table 4 indicated that Zn status of soil after harvest of finger millet was found significantly due to Treatment T_3 (Soil application 25 kg $ZnSO_4$/ha) resulted in to significantly higher DTPA extract Zn in soil after harvest of crop during all the years as well as in pooled analysis, but it remained on same bar with treatment T_2 and T_9 during years 2014-15 and 2016-17.

For practical utility of the recommendation to farmers, economics of treatment is necessary. Therefore considering grain and stover yield of finger millet and market price, treatment T_9 (Seed treatment 30% ZnO @10 ml/kg seed and root dipping @ 0.5% $ZnSO_4$) resulted into higher gross returns (Rs. 106420 /ha), net return (Rs. 78056 /ha) and BCR (2.75) (Table 5) which was followed by treatment T_3 (soil application @ 25 kg $ZnSO_4$/ha) with gross returns of Rs.101232/ha, net return of Rs.73539/ha and BCR of 2.66.

Table 5: Economics of Finger millet as influenced by different treatments

Treatment	Grain yield (Kg/ha)	Stover yield (Kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	BCR
T_1	2313	7709	25843	80952	55109	2.13
T_2	2692	8850	26768	93842	67073	2.51
T_3	2879	9752	27693	101232	73539	2.66
T_4	2483	8681	28343	88111	59767	2.11
T_5	2737	9060	28343	95606	67263	2.37
T_6	2809	8478	30843	95651	64807	2.10
T_7	2427	8654	25863	86636	60773	2.35
T_8	2615	9172	28343	92882	64538	2.28
T_9	3053	10034	28363	106420	78056	2.75

Selling Price : Grain : Rs. 25/kg, Stover: Rs. 3.0/kg

CONCLUSION

From the results of three year experimentation, it can be concluded that the farmers of south Gujrat heavy rainfall zone (AES-I) growing finger millet are advised to apply seed treatment with 30% ZnO @10 ml/ kg seed and root dipping in 0.5% $ZnSO_4$ solution at time of transplanting with recommendation dose of NPK for higher yield and net profit from finger millet. However in case of unavailability of ZnO, they are also advised to for soil application of $ZnSO_4$ @ 25 kg $ZnSO_4$/ha.

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