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Research Communication

Effect of nitrogen and zinc fertilizer on Zn biofortification in pearlmillet (*Pennisetum glaucum*)

RENU SINGH[1], S.K. PRASAD[2] AND M.K. SINGH[3]

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2011–12 at Mirzapur, Uttar Pradesh to study the response of pearlmillet [*Pennisetum glaucum* (L.) R. Br.] to nitrogen and zinc on Zn biofortification in this crop. The field experiment was laid out in a factorial randomized block design, with 3 replications, comprising 4 nitrogen (N) levels (0, 20, 40 and 60 kg N/ha) and 3 levels of zinc (0, 5 and 10 kg Zn/ha) with constant rates of phosphorus and potassium at 40 and 30 kg/ha respectively. Application of 60 kg N/ha and 10 kg Zn/ha resulted in the maximum grain yield, N content and uptake by grain and stover of pearlmillet. Zinc content in grain linearly enhanced with sole application of N and Zn levels up to 20 kg N/ha and 5 kg Zn/ha. Combined application of 5 kg Zn/ha × 20 kg N/ha was found optimum for enhancement of Zn content in grains of pearlmillet. Agronomic nitrogen and zinc efficiency decreased with the increasing nitrogen and zinc levels.

Key words **:** Agronomic biofortification, Ferti-fortification, Nitrogen and zinc interaction, Zinc content, Zinc uptake

Pearlmillet is a staple food in arid and semi-arid regions and widely cultivated coarse cereal after rice and wheat. Globally, India is the largest producer of pearlmillet in terms of area (9.07 m ha) and production (10.05 million tonnes) (NRAA, 2012). It accounts for more than 50% of total cereal grain consumption in some communities in India, especially in Maharashtra, Gujarat, Uttar Pradesh and Rajasthan as a major source of dietary energy and Zn intake (16–55%) from all food sources (Rao *et al.*, 2006).

Zinc deficiency is common throughout the arid and semi-arid regions of the world (Ahmad *et al*., 2012). Agronomic biofortification through Zn fertilization, also referred to as ferti-fortification, results in increased grain production as well as higher Zn concentration in grains (Prasad *et al.,* 2013). Thus, agronomic Zn biofortification is a promising and cost-effective method to increase Zn concentration in cereal grain to address the ongoing human Zn deficiency (Singh and Prasad, 2014). Viewing the above finding, the effects of N and Zn fertilization on the concentration of Zn in pearl millet was conducted to examine whether improved N nutritional status in pearl millet is associated with higher Zn content in pearl millet.

The experiment was carried out during rainy (*kharif*) season of 2011–12 at the Agronomy farm of Rajiv Gandhi South Campus, Barkachha, BHU, Mirzapur, situated in *Vindhyan* region (25º 10'N, 82º 37'E, 427 m asl). The climate is typically semi-arid with temperature ranges from 10 to 45°C and rainfall during crop period was 550 mm. The soil of the experimental site was sandy clay loam (Typic Ustochrept) (57.61, 19.39, 23.50% sand, silt, clay respectively), organic carbon 0.24%, pH 6.04, available NPK 179.45, 10.89, 190.40 kg/ha respectively, and available Zn 4.74 mg/kg. The pearlmillet cultivar 'Kaveri Super Boss' was sown with 45 cm × 15 cm spacing. The field experiment was conducted in factorial randomized block design, with 3 replications, having 4 nitrogen levels (0, 20, 40 and 60 kg N/ha) and 3 levels of zinc (0, 5 and 10 kg Zn/ha), with constant levels of phosphorus and potassium at 40 and 30 kg/ha respectively. Nitrogen and zinc were applied in the form of urea and zinc sulphate respectively. Uptake was calculated with grain and stover yield. The data were statistically analyzed as per standard statistical procedure.

The results showed that there was a positive relationship between N and Zn fertilization on yield and Zn content in pearl millet. Application of 60 kg N/ha and 10 kg

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[3]**Corresponding Author Email**: manozsingh@rediffmail.com, manoj.agro@bhu.ac.in

[1]M.Sc. (Ag.) Scholar; [2,3]Assistant Professor, Department of Agronomy, Banaras Hindu University, Varanasi, Uttar Pradesh

Zn/ha resulted in significantly highest grain yield, N content and uptake in grain and stover of pearl millet (Table 1). Grain yield increased up to 32.27% and 31.0% from 0 to 60 kg N/ha and 0 to 10 kg Zn/ha respectively. The improvement of yield and nutrient content and uptake might be owing to nitrogen involves in many metabolic reactions, viz. proteins, nucleic acids and chlorophyll and zinc, closely involved in N-metabolism of the plant. Cakmak *et al.* (2010) also stated nitrogen nutrition along with zinc improves physiological and molecular mechanism which increases grain yield. Furthermore, Zn content in grain did not vary significantly with application of 40 to 60 kg N/ha and 5 to 10 kg Zn/ha. Though application of 40 and 60 kg N/ha showed at par grain Zn uptake and significantly higher values over lower levels of N treatments, while application of 40 kg N/ha recorded highest Zn uptake by stover. Application of 10 kg Zn/ha observed significantly highest uptake of Zn by grain and stover of pearl millet followed by 5 kg Zn/ha. However, the stover yield and harvest index were only significantly influenced by Zn and N levels respectively. The highest agronomic nitrogen and zinc-use efficiency observed with 20 kg N/ha and 5kg Zn/ha respectively; however, efficiency decreased with the increase in N and Zn levels. Similar findings also reported by Shivay *et al.* (2008).

Interaction data showed the highest grain nitrogen content under 60 kg N × 10 kg Zn/ha though it was statistically at par to 60 kg N × 5 kg Zn/ha and 60 kg N × 0 kg Zn/ha (Table 2). Similar trends were also observed with 40 kg N/ha with respective combination of Zn levels. Data indicated that N content increased with the increasing N levels, but at higher levels of N, i.e. from 40 kg onwards, increase in Zn levels did not significantly influence the grain N content. However, significantly highest grain Zn content was recorded under 20 kg N/ha × 5 kg Zn/ha. It means grain Zn content did not increase linearly with the increase in N or Zn levels. Application of 20 kg N/ha along with 5 kg Zn/ha was found to be optimum for increasing Zn content in grains of pearlmillet. These results

Table 2. Influence of N × Zn levels on N and Zn content in grain and Zn content in stover of pearlmillet

Treatment	Nitrogen levels (kg/ha)			
	0	20	40	60
Zinc levels (kg/ha)				
	Grain nitrogen content (%)			
0	1.27	1.40	2.16	2.36
5	1.36	1.79	2.22	2.38
10	1.45	2.20	2.32	2.51
CD (P=0.05) of N×Zn			0.16	
	Grain zinc content (mg/kg)			
0	8.6	17.3	11.3	17.1
5	11.8	26.1	13.2	14.3
10	15.0	4.0	25.3	22.1
CD (P=0.05) of N×Zn			2.7	
	Stover zinc content (mg/kg)			
0	8.6	9.6	13.3	11.6
5	11.0	11.4	12.6	12.5
10	10.5	14.0	11.8	14.2
CD (P=0.05) of N×Zn			1.9	

Table 1. Effect of nitrogen and zinc levels on yield, harvest index, content-and uptake of nitrogen and zinc in pearlmillet

Treatment	Yield (t/ha)		Harvest index (%)	Nutrient content				Nutrient uptake (kg/ha)				Agronomic use efficiency (kg/kg)
				Nitrogen (%)		Zinc (mg/kg)		Nitrogen		Zinc		
	Grain	Stover		Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	
Nitrogen-N (kg/ha)												Nitrogen
0	1.43	4.41	24.7	1.36	1.08	11.81	10.06	19.61	22.77	1.72	4.40	
20	1.76	4.83	26.7	1.80	1.24	15.78	11.64	32.28	36.85	2.66	5.70	16.60
40	1.97	4.91	28.5	2.24	1.33	16.60	12.54	44.09	48.82	3.38	6.15	13.43
60	2.11	4.63	31.4	2.42	1.42	17.81	12.74	51.31	64.88	3.79	5.89	11.34
SEm±	0.07	0.33	1.25	0.05	0.06	0.87	0.61	2.05	3.33	0.17	0.38	
CD (P=0.05)	0.14	NS	2.58	0.11	0.06	1.81	1.26	4.24	6.90	0.36	0.80	
Zinc-Zn (kg/ha)												
0	1.55	4.19	27.0	1.80	1.23	13.57	10.76	28.95	34.12	2.17	4.50	–
5	1.85	4.81	27.9	1.94	1.27	16.34	11.85	36.95	43.84	3.00	5.70	61.39
10	2.03	5.07	28.6	2.12	1.31	16.59	12.64	44.57	52.03	3.49	6.40	48.82
SEm±	0.06	0.29	1.08	0.04	0.02	0.75	0.52	1.77	2.88	0.15	0.33	
CD (P=0.05)	0.12	0.60	NS	0.09	0.05	1.57	1.09	3.67	5.97	0.31	0.69	
N × Zn	NS	NS	NS	*	NS	*	*	NS	NS	NS	NS	

* Significant at (P=0.05); NS=Not significant

corroborate the findings of previous studies reporting a positive effect of N fertilization on grain Zn concentration (Kutman *et al*., 2010). Increasing N supply positively affected root uptake, shoot translocation and grain deposition of Zn (Cakmak, 2012). Stover Zn content showed at par values at various Zn levels in combination with 40 and 60 kg N/ha. This implies that increased stover Zn content with increasing Zn levels is possible only up to the addition of 20 kg N/ha.

It may be concluded that application of 60 kg N/ha and 10 kg Zn/ha was found to be optimum for enhancement of grain yield and nitrogen content in grain and stover of pearlmillet. Combined application of 5 kg Zn and 20 kg N/ha was proved to be highly effective level for enhancement of grain Zn content in pearlmillet.

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