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Elucidating the Role of Micronutrient Seed Treatment in the Physiological Performance of Wheat Seed

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seed treatment is one of the key techniques for improvement in physiological performance of seed lot in different crop plants. In the present study, the aim was to explore the technique in wheat, seed lot was treated with the different concentration of iron and zinc sulphate solution. Other method of micronutrient application was also adopted i.e., soil application and foliar spray at recommended dose. The micronutrient treatment with $ZnSO_4$ (0.5, 2.0%) exhibit highest improvement in

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physiological parameters like root length, shoot length, seedling dry weight, standard germination, germination energy, germination rate, seed vigour index-I & II, dehydrogenase enzyme activity, membrane permeability i.e., EC and zinc & iron content in seed and plant in treated seed and harvested seed lot, respectively. Commonly seed treatment with $ZnSO_4$ (0.5%) results in improvement of all the physiological parameters of treated seed as well as harvested seed.

Keywords: Seed treatment; micronutrient; physiological.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the oldest and most significant cereal crop and it is the main staple food cultivated worldwide. Wheat is grown on 224.49 mha land with a production of 792.40 mt having productivity 3.529 t/ha in 2020-21 worldwide. The international trade in wheat is greater than that of all other types of crops put together. In India wheat is cultivated on 31.61 mha area (2020-21) with a production of 109.52 mt and having productivity, 3.464 t/h. As far as Bihar is concerned, it was grown on 2.22 mha area with a production of 6.34mt and productivity 2.855 t/ha during 2020-21 (DES, MoA & FW, 2021) [1].

Crop plants depend on several micronutrients for their growth and development. Seed and grain storage of micronutrients is crucial for initial crop development during germination and early seedling establishment. According to Farooq et al. [2], the application of micronutrients by seed treatment offers a viable and cost-effective approach to enhance plant nutrition with micronutrients. The germination rate of wheat seed is further improved and the mobilising of nutrients, biological, and biochemical activities in the seed are also improved. Additionally, it assists in the stabilisation of membranes, detoxification of free radicals, and various other physiological processes in plants. In general, it has been seen that primed seeds demonstrate a higher rate of germination and a greater degree of synchronisation. Additionally, these young seedlings have been found to possess a certain level of resistance to abiotic stress Ajouri et al. [3]. Moreover, it has been also observed that this practise boosts the uptake of minerals and the accumulation of dry matter in the crop and improve water use efficiency in plants experiencing drought stress.

Several seed priming techniques have been developed *viz.* hydropriming, halopriming, osmo-priming, thermopriming, solid matix priming, biopriming and nutri-priming. Seed nutri-priming provides an effective technology for enhancement in quality of seed as well as enrichment of seed with micronutrient at basic level. The information on these aspects in wheat crop is very much scarce. Therefore, to study the effect of seed treatment with micronutrient in wheat for improvement in physiological parameters of seed present study was carried out.

2. MATERIALS AND METHODS

The experiment was carried out during Rabi season of 2021-22 at Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. The site of the experiment lies between 25°15' North latitude and 87°2'42" E longitude and at an altitude of 45.75 m above MSL. The geographical location of Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone III A. The average annual rainfall is 1046 mm during rabi season. The soils of the experimental area fall in the order "Inceptisols" and subgroup "Typic Ustifluvents." After dividing the field into individual plots of size 5x1.2 m^2 as per the layout plan, and the recommended dose of nitrogen, phosphorous, potassium applied in the soil. The experiment was carried out in randomized block design having three replications. All the treatment was done on wheat *var*. DBW 187 seed lot at room temperature. All the recommended packages and practices were adopted while at proper time during cultivation of wheat for seed production purpose.

To assess the effect of micronutrients on physiological quality of seed, two seed lot was given treatments *viz.,* one seed lot was directly used for data collection after treatment and other one was used for sowing then data collected after once harvested seed. The treatment were arranged as; hydro priming (seed treatment with distilled water, no micronutrient application, seed of each lot was soaked in sufficient amount of distilled water for 10 hours and then seed was dried under shade at room temperature to the initial seed weight to maintain original or near to safe moisture content; soil application of $ZnSO_4$ (25 Kg/ha) at recommended dose after one week of transplanting in the soil of selected plot (30 g $ZnSO_4$ is properly mixed with 500 g soil, which is applied with the help of hand on the selected plot); foliar spray of $ZnSO_4$ (0.5%) on flag leaf in the selected plot at the time of flowering; seed treatment with $ZnSO_4$ solution having different concentration of 0.25, 0.50, 1.0, 2.0 per cent (seeds were soaked in $ZnSO_4$ solution for 10 hours at 25 ºC, then seed lot were dried under shade at room temperature to the initial seed weight to maintain original or near to safe moisture content. The data was recorded for standard germination (SG%; ISTA, [4]), root length (RL, cm), shoot length (SL, cm), seedling dry weight (SDW, mg; seedling were oven dried and weigh), seed vigour index-I & II (SVI-I & II; Abdul Baki and Anderson, [5]), germination energy (GE, % of seed count on 4th day out of total number of seed), germination rate (GR; ISTA, 1996), electrical conductivity (EC, µS/cm/50 seeds; Presley, [6]), dehydrogenase activity (DHA, OD; Kittock and Law. [7]), zinc and iron content (Zn, Fe, ppm) in seed and plant.

The mean value of observations recorded on different parameters were subjected to statistical and graphical analysis. The factorial CRD (Completely Randomized Design) for laboratory parameters and RBD (Randomized Block Design) field parameters were used for analysis of variance [8].

3. RESULTS AND DISCUSSION

3.1 Effect of Micronutrient Treatments on Physiological Parameters of Treated Seed

The treatment with micronutrient improved physiological parameters of treated seed (Table 1, Fig. 1). All the treatments significantly enhanced shoot length (0.18-1.59), root length (1.132-3.05), seedling dry weight, seed germination percentage (4.16-6.50%), germination energy percentage (2.467-9.96), germination rate (0.893-17.437). The improvement in shoot length, root length, seedling dry weight, seed germination percent, seed germination energy and germination rate were recorded highest when seed treated with $ZnSO_4$ (0.50%) among all treatment than untreated and that of hydropriming which was in accordance to the finding by Farhani et al. [9] in basil crop. Hasan et al. (2016) also concluded that paddy seed primed with $ZnSO_4$ (3%) for 30 hours results in highest germination percentage and the lowest mean germination time.

The treatments improved the membrane permeability significantly as seed leachates was collected in the solution was lower in quantity *i.e.,* 8.19 to 1.3 over untreated (24.04). The treatment with both $ZnSO_4$ and $FeSO_4$ at all concentration significantly improved the membrane permeability as the EC of the seed lot decreased. However, none of the treatment improved the EC in comparison to hydropriming treatment except $FeSO_4$ (0.50%). The improvement in membrane permeability *i.e.,* lowest EC was recorded when seed treatment was done with FeSO4 (0.50%) among all treatment than untreated and that of hydropriming. Vanniarajan et al*.* [10] *and* Afreen et al. [11] have also found the equivalent result in black gram and paddy, respectively.

The seed vigour index-I of the seed lot was increased by 327.8 to 704.6 over untreated (2265.7) upon treatment. However, none of the treatment improved the vigour Index-I in comparison to hydropriming. The improvement in seedling vigour index-I was recorded highest when seed treated with $ZnSO_4$ (0.50%) among all treatment than untreated which was also in concurrence to the finding reported by Mirshekari et al. [12]. Further, these treatments enhanced SVI-II which was increased by 4.6 to 188.3 over untreated (599.7). The treatment with $ZnSO_4$ (0.50%) and $ZnSO_4$ (2.0%) both, significantly enhanced the vigour of the seed lot along with hydropriming in the range of (10.0-59.0). However, none of the treatment improved the vigour index-II in comparison to hydropriming. The improvement in seedling vigour index-II was recorded highest when seed treated with $ZnSO_4$ (0.50%) among all treatment than untreated. Pal et al*.* [13] also find the equivalent result in chilli crop.

The dehydrogenase enzyme activity (DHA) improved upon treatment with micronutrient including hydropriming and increases from 0.062 to 0.193 over untreated (0.226). However, none of the treatment improved the dehydrogenase activity in comparison to hydropriming. The improvement in DHA was recorded highest when seed treated with $FeSO_4$ (1.0%) among all treatment than untreated. The result is in concurrence to the finding reported by Gokhan et al., [14] in common bean.

As far micronutrient content in seed is concerned, the seed treatment with $ZnSO_4$ (2.0%) and $FeSO_4$ (2.0%) improved the zinc and iron content in treated seed, respectively, among all the treatment and over and above the hydropriming. These findings are in accordance to Harris et al., [15] who reported that $ZnSO_4$ (1.0%) gives higher zinc content in seed.

3.2 Evaluation of Micronutrient Treatments for Enhancing Physiological Parameters of Harvested Seeds

The seed treatment with micronutrient result in improvement of physiological parameters of seed once harvested (Table 2, Fig. 2). The treatment with foliar spray of $ZnSO_4$ (0.5%) and seed treated with $ZnSO_4$ (0.50, 2.0%) and foliar spray of $FeSO_4$ (1.0%), and all concentration of $FeSO_4$ except 0.5% significantly enhanced the shoot length. All the treatments including hydropriming enhanced the root length (1.22-2.11 cm), germination energy percentage (1.84-10.40) and germination rate percentage (0.25-17.52) over untreated in harvested seed lot. The zinc sulphate and iron sulphate significantly enhanced the seedling dry weight *viz*., foliar spray of $ZnSO_4$ (0.5%), seed treated with $ZnSO_4$ (0.25, 0.5, and 2.0%), and $FeSO_4$ (0.25 and 0.5%).

The standard germination improved in the harvested seed upon treatment with both $ZnSO_4$ and $FeSO_4$ significantly *viz.,* soil application of $ZnSO_4$ (25 Kg/ha), seed treated with $ZnSO_4$ (1.0, 2.0%) and soil application of $FeSO_4$ (50 Kg/ha), foliar spray of $FeSO_4$ (1.0%) and seed treated with $FeSO_4$ (0.5%). The $ZnSO_4$ (2.0%) significantly enhanced the SVI-I of the seed lot over hydropriming. Further, the treatment with both $ZnSO_4$ and $FeSO_4$ significantly enhanced the SVI-II *viz*., foliar spray of $ZnSO_4$ (0.5%), seed treated with $ZnSO_4$ (0.25, 0.5, 1.0 and 2.0%), and $FeSO_4$ (0.25 and 0.5%).

These micronutrients significantly enhanced the DHA in harvested seed *viz.*, soil application of $ZnSO_4$ (25 Kg/ha), foliar spray of $ZnSO_4$ (0.5%) and $FeSO_4$ (0.25 and 0.5%).

The electrical conductance was decreases from over untreated (22.70). However, none of the treatment improved the membrane permeability (low EC) in comparison to hydropriming. The improvement in membrane permeability (low EC) was recorded highest when seed was treated with distil for 10 hours *i.e.,* hydropriming.

The micronutrient treatment with both $ZnSO_4$ and $FeSO_4$ significantly enhanced zinc and iron content in seed and plant after harvest. The improvement in seed and plant for zinc content was recorded highest when seed treated with $FeSO_4$ (0.25%) and in plant $ZnSO_4$(2.0%) among all treatment than untreated and that of hydropriming. Further, the improvement in seed and plant for iron content was recorded highest with $FeSO_4$ (2.0%) in seed and in plant hydropriming was result in improvement. These findings were in accordance to Harris et al., 2007 who reported that $ZnSO_4$ (1.0%) gives higher zinc content in seed.

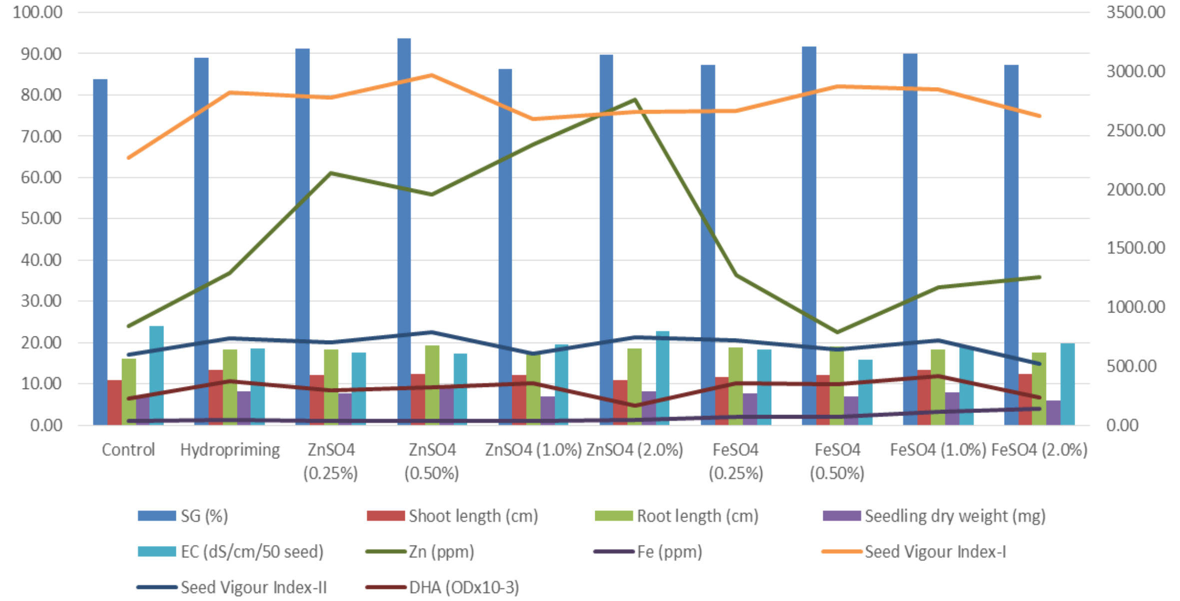

Fig. 1. Mean value of different physiological parameters for directly treated seed

Table 1. Mean values for different physiological parameters for directly treated seed

Treatments		SL	RL	SDW	SG	GE	GR	EC	SVI-I	SVI-II	DHA	Zn seed	Fe seed
Control		10.88	16.19	7.166	83.7	78.61	66.27	24.04	2265.7	599.7	226	24.00	1.060
Hydropriming		13.34	18.41	8.3	89.0	83.67	73.79	18.67	2824.9	739.0	378	37.00	1.410
Micronutrient	Conc. (%)												
$ZnSO_4$	0.25	12.15	18.26	7.7	91.3	86.82	67.17	17.71	2777.2	699.3	295	61.00	1.080
	0.50	12.47	19.24	7.7	93.7	88.58	83.71	17.43	2969.6	718.3	327	56.00	1.045
	1.0	12.10	17.95	7.0	86.3	81.08	65.94	19.60	2593.5	604.3	354	68.00	1.20
	2.0	11.06	18.55	8.3	89.7	84.28	71.57	22.74	2656.5	746.3	164	79.00	1.270
$FeSO_4$	0.25	11.71	18.88	9.0	87.3	82.18	81.06	18.49	2668.8	788.0	354	36.50	2.020
	0.50	12.24	19.10	7.0	91.7	86.12	69.67	15.85	2872.2	641.7	349	22.50	2.035
	1.0	13.37	18.28	8.0	90.0	84.65	68.40	18.78	2848.2	720.3	419	33.50	3.355
	2.0	12.50	17.51	6.0	87.3	82.17	69.87	19.80	2621.1	524.3s	239	36.00	4.025
CD (p=0.01)		1.251	1.275	1.361	4.047	NS	3.305	2.095	185.744	129.29	0.055	0.059	0.314
CV (%)		5.989	4.075	10.420	2.651	5.240	2.686	6.326	3.996	11.116	10.245	3.448	7.509

SL-Shoot length; Rl-Root Length; SDW-Seedling Dry Weight; SG-Standard Germination; GE-Germination Energy; GR- Germination Rate; EC-Electrical Conductivity; SVI-I-Seedling Vigour Index-I; SVI-I-Seedling Vigour Index-II; DHA-Dehydrogenase Activity; Zn-Zinc; Fe-Ferrous (Iron)

Table 2. Mean values for different laboratory parameters of once harvest seed

Treatment		SL	RL	SDW	SG	GE	GR	EC	DHA	SV-I	SV-II	Zn (seed)	Zn (plant)	Fe (seed)	Fe (plant)
Control		7.46	13.63	5.71	66.00	86.29	71.28	22.70	0.212	1390.9	377.0	14.0	31.5	0.620	1.835
Hydropriming		8.72	15.60	5.81	78.00	88.13	74.62	17.89	0.195	1898.9	451.6	31.0	29.5	1.500	1.960
Soil application of $ZnSO_4$ (25 kg/ha)		8.19	14.97	6.57	85.33	93.06	72.07	19.19	0.289	1977.7	559.8	17.0	28.0	0.660	1.550
Foliar spray of $ZnSO_4$ (0.5%)		8.84	14.85	5.98	76.00	85.60	78.05	18.67	0.326	1803.3	456.0	24.0	36.0	1.070	1.730
Soil application of $FeSO_4$ (50 kg/ha)		8.36	15.92	5.56	91.33	96.00	88.20	18.29	0.112	2216.2	506.9	24.5	24.5	0.920	0.720
Foliar spray of $FeSO_4$ (1.0%)		8.83	15.64	5.29	82.00	95.04	78.40	18.17	0.180	2004.7	435.4	29.5	29.5	1.350	0.990
Micronutrient	**Conc (%)**														
Seed treatment with $ZnSO_4$	0.25	8.05	15.78	6.57	77.33	89.40	69.76	18.86	0.213	1844.3	508.9	37.0	20.0	1.500	1.585
	0.50	8.47	15.13	6.71	78.67	92.05	75.03	18.25	0.245	1853.8	527.2	32.0	31.0	1.740	1.440
	1.0	8.34	16.19	6.33	83.33	94.12	86.40	18.00	0.223	2041.5	529.6	35.5	31.0	1.210	0.930
	2.0	9.36	15.35	6.65	85.33	96.69	88.80	18.75	0.274	2109.3	566.5	30.5	39.0	1.000	1.200
Seed treatment with $FeSO_4$	0.25	8.50	16.21	6.76	75.33	88.89	70.11	18.28	0.320	1860.9	509.8	42.0	24.0	1.540	0.850
	0.50	8.30	15.26	6.60	83.33	94.67	71.53	19.26	0.305	1954.4	548.2	24.5	28.0	1.140	0.680
	1.0	8.70	16.10	6.38	80.00	89.40	73.07	18.05	0.200	1987.2	510.1	39.0	28.0	1.560	0.720
	2.0	9.15	16.40	6.31	74.00	85.57	79.47	22.13	0.221	1889.9	467.6	37.5	14.5	3.310	0.730
CD (p=0.01)		0.912	1.028	0.798	9.146	7.148	5.278	1.832	0.051	239.75	83.785	0.050	0.052	0.121	0.067
CV (%)		0.347	3.928	7.586	6.799	4.651	4.066	5.704	13.291	7.412	9.994	5.807	8.525	4.081	2.408

SL-Shoot length; Rl-Root Length; SDW-Seedling Dry Weight; SG-Standard Germination; GE-Germination Energy; GR- Germination Rate; EC-Electrical Conductivity; SVI-I-Seedling Vigour Index-I; SVI-I-Seedling Vigour Index-II; DHA-Dehydrogenase Activity; Zn-Zinc; Fe-Ferrous (Iron)

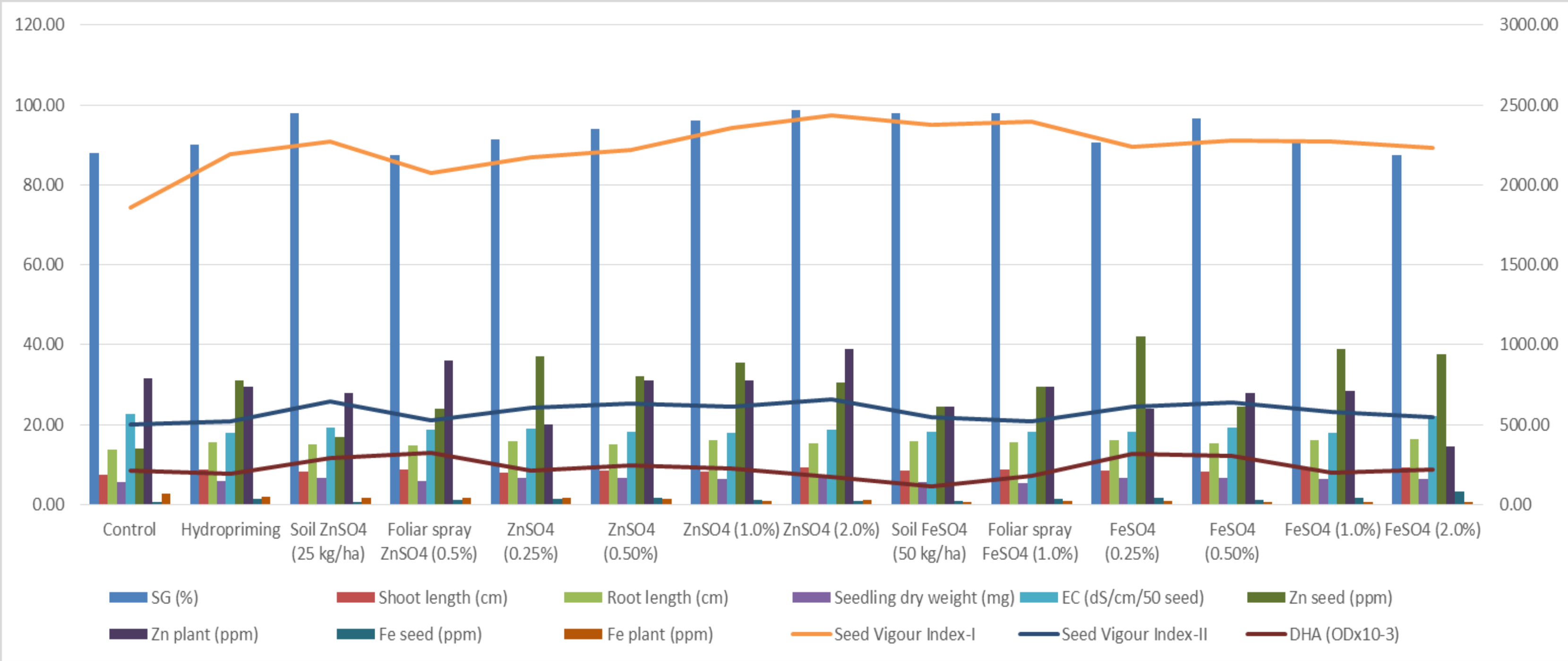

Fig. 2. Mean value of different physiological parameters of harvested seed

The micronutrient treatment with $ZnSO_4$ (0.5%) exhibit highest root length, shoot length, seedling dry weight, SG, SVI-I, SVI-II, whereas, $ZnSO_4$ (2.0%) given highest Zn content in seed and $FeSO_4$ (2.0%) Fe content in seed.

4. CONCLUSION

Though a variable response of treatments was observed in this investigation, yet the seed treatment with $ZnSO_4$ (0.5%) and $ZnSO_4$ (2.0%) for treated seed and harvested seed, respectively improved the physiological parameters in seed at highest level. Therefore, seed treatment with $ZnSO_4$ (0.5%) was commonly found highly promising for physiological improvement of seed lot either at only treatment level or after harvesting.

Though an additional cost might be included if farmers treat the seed with $ZnSO_4$ (0.5%), but they may get a high quality seed for further planting in next season and treated lot exhibits higher field establishment which results in good harvest in wheat crop.

The present investigation could not conclude concisely about whether seed treatment with zinc and iron sulphate may increase the zinc and iron content in seed effectively or not and correlation with improvement in seed quality i.e germination and vigour of seed lot. The investigator may have answer whenever they may go for long term study with certain micronutrient.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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