International Journal of Environment and Climate Change

Volume 13, Issue 9, Page 2425-2433, 2023; Article no.IJECC.102891
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Graded Levels of Nitrogen with Iron and Zinc Nutrition on Growth, Yield and Quality of Pearl Millet (*Pennisetum glaucum* L.)

S. Ravi [a*], K. Narayan Rao [b], R. L. Jadhav [c], S. N. Bhat [d] and Kamble Anand Shankar [b]

[a] ICAR-KVK-Hagari, Karnataka, India.
[b] UAS, Raichur, Karnataka, India.
[c] ARS, Bidar, Karnataka, India.
[d] ICAR-KVK, Raichur, Karnataka, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2023/v13i92475

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102891

Original Research Article

Received: 23/05/2023
Accepted: 25/07/2023
Published: 31/07/2023

ABSTRACT

The experiment was conducted at Agricultural Research Station (ARS), Hagari of Northern dry zone of Karnataka for the two consecutive years 2021-2022 to study the effect of graded levels of nitrogen with iron and zinc nutrition on growth, yield and quality of Pearl Millet. The experiment consists of nine treatments replicated thrice in randomized complete block design (RCBD).The results showed that application of 100 % Recommended dose of nitrogen (RDN) + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each at 30 and 45 days after sowing has recorded higher growth parameters *viz.,* plant height (199.4.cm), number of leaves (18.6), leaf area (3160.7 cm^2), leaf area index (4.73) and total dry matter production (259.96 g $plant^{-1}$) at harvest stage. The yield

**Corresponding author;*

parameters such as weight of ear head (53.13 g plant^{-1}), grain weight (46.11 g plant^{-1}), test weight (21.84 g), grain yield (1739 kg ha^{-1}), stover yield (2900 kg ha^{-1}) and harvest index (37.48 %) recorded significantly higher in treatment T_9 consists of 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each at 30 and 45 days after sowing. The quality parameters like, protein content (19.62 %) and protein yield (341.0 kg ha^{-1}) recorded significantly higher in the same treatment. Thus, application of recommended dose of fertilizer along with foliar spray of zinc and iron enhances the growth, yield and quality of pearlmillet.

Keywords: Nitrogen; zinc; iron; pearlmillet; growth; yield and quality.

1. INTRODUCTION

Pearl millet [*Pennisetumglaucum* (L.)] is the fifth most important cereal crop and widely grown in India during *kharif* season [1]. It is cultivated by economically poor farmers and provides staple food for the poor in short period in the relatively dry tracts of semi-arid India [2]. Now a day, in the context of changing climate, this crop is mostly identified as contingent crop in the country particularly in dry areas [3]. Pearlmillet grain is the staple diet and nutritious source of vitamins, minerals, proteins and carbohydrates, while its straw is a valuable livestock feed. India is the largest producer of pearl millet in the world occupying about 7.48 million hectares with annual production of 9.2 million tonnes and an average productivity of 1231 kg ha^{-1}. In Karnataka, the pearl millet area, production and productivity are 2.31 lakh ha, 2.86 lakh tonnes and 1,241 kg ha^{-1}, respectively [4]. Pearl millet may be an alternative crop that exhibits great advantages in physiological characteristics when compared to other cereals as it is resistant to drought, low soil fertility, high salinity and high temperature tolerance [5]. The major area is confined to dry regions of Northern Karnataka and generally grown as a rainfed crop and fits well in various cropping systems. In India, millets are commonly cultivated under rainfed condition. Different parts of India grow diverse kinds of millets especially coarse millet like sorghum and pearl millet are extensively grown in northern parts of Karnataka [6].

Nitrogen (N) is essential for plant growth and is known to be present in proteins, nucleic acids and chlorophyll. Adequate N nutrition is required for full development of tillers and leaves and also enables the plant to operate at peak photosynthetic capacity [7]. N is the major nutrient required by pearl millet and has shown variable growth and yield response to N application [8]. About half of the world's population suffers from micronutrients malnutrition a term used to refer any condition in which the body does not receive enough nutrients for proper function, including selenium (Se), zinc (Zn), iron (Fe) and iodine (I) which is mainly associated with low dietary intake of micronutrients in diets with less diversity of food [9].

Zinc and iron deficiencies are well-documented public health issue and an important soil constraint to crop production. Generally, there is a close geographical overlap between soil deficiencies and human deficiencies of Zn and Fe, indicating a high requirement for increasing concentrations of these nutrients in food crops [10]. Zinc and iron plays significant role in various enzymatic and physiological activities of the plant. Zinc catalyses the process of oxidation in plant cells and is vital for transformation of carbohydrates, regulates the consumption of sugar, increases source of energy for the production of chlorophyll, aids in the formation of auxins which produce more plant cells and more dry matter, that in turn will be stored in seed as a sink and promotes absorption of water [11].Iron is an important component of enzymes and a constituent of non-heme iron proteins involved in photosynthesis, N_2 fixation, and respiration. Iron is an essential micronutrient for both plants and human beings with numerous physiological functions [12]. In plants, the deficiency of zinc and iron arises mainly due to alkaline soil pH, calcareousness, low organic matter content in soil, exposed sub soil, use of Zn and Fe free fertilizers and flooding induced electrochemical changes of soil.Therefore, the objective of the present research studythe "effect of graded levels of nitrogen along with iron and zinc nutrition on growth, yield and quality of pearl millet (*Pennisetumglaucum*L.*)*".

2. MATERIALS AND METHODS

The study was carried out at Agricultural Research Station (ARS), Hagariof Northern dry zone of Karnataka for the two consecutive years (2021-2022) where test crop pearl millet was grown with spacing of 45 x 15 cm. The net plot size for the experiment was 4.5 m × 3.0 m. There were nine treatments replicated thrice in randomized complete block design (RCBD). The treatment details were listed below. The recommended package of practice100:50:25 kg NPK ha^{-1}+ 20 kg $FeSO_4.7H_2O$ $ha^{-1}$and farm yard manure (FYM)at 6 t ha^{-1} was followed for the pearl millet crop. The FYM and recommended dose of P and K were common to all treatments.N was applied in two split doses *viz.,* 50 % as basal and remaining 50 % at 30 days after sowing as top dressing. Full dose of P and K were applied at the time of sowing. The nutrients were applied in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP) for N, P and K respectively. Soil application of full dose of Fe and Zn was done as basal. Foliar application of Fe and Zn was done according to treatment combinations at 30 and 45 days after sowing. Fe and Zn was applied in the form of $FeSO_4.7H_2O$ (19.5%) and $ZnSO_4.7H_2O$ (21%).

Treatments:

- T_1: Recommended package of practice(100:50:25 kg NPK ha^{-1} + 20 kg $FeSO_4$ ha^{-1})
- T_2: 50 % RDN +10 kg $ZnSO_4$ $7H_2Oha^{-1}$
- T_3: 100 % RDN + 10 kg $ZnSO_47H_2Oha^{-1}$
- T_4: 50 % RDN + 10 kg $FeSO_47H_2Oha^{-1}$
- T_5: 100 % RDN + 10 kg $FeSO_47H_2Oha^{-1}$
- T_6: 50 % RDN +10 kg $ZnSO_47H_2Oha^{-1}$ + 10 kg $FeSO_4$ $7H_2O$ ha^{-1}
- T_7: 100 % RDN +10 kg $ZnSO_47H_2Oha^{-1}$ + 10 kg $FeSO_4$ $7H_2O$ ha^{-1}
- T_8: 50 % RDN + Foliar spray of $ZnSO_47H_2O$at 0.5 % + $FeSO_4$ $7H_2O$at 0.5 % at 30 and 45 DAS
- T_9: 100 % RDN + Foliar spray of $ZnSO_47H_2O$at 0.5 % + $FeSO_47H_2O$at 0.5 % at 30 and 45 DAS

The soil samples were drawn at initial, then processed and analyzed for basic soil properties pH, EC, OC, N,P,K, Fe and Zn. The initial properties of the experimental site were presented in Table 1.Growth parameters such as plant height (cm), number of leaves /plant, leaf area, leaf area index and total dry matter production (g $plant^{-1}$)were recorded from the 5 labelled different plants. Similarly, yield parameters, such as weight of ear head (g $plant^{-1}$), grain weight, (g $plant^{-1}$), test weight (g), grain yield (kg ha^{-1}), stover yield (kg ha^{-1})and harvest index (%)were recorded. The quality parameters such as protein content (%) and protein yield (kg ha^{-1}), were analyzed by using standard analytical procedures. The protein content was calculated by multiplying the per cent nitrogen with a factor 6.25 [13].

2.1 Statistical Analysis

The observations recorded in these studies were analysed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by [14]. The level of significance on 'F' test was tested a five percent. The results have been discussed based on critical difference at P=0.05. Wherever the treatment differences were found non-significant, it is denoted as 'NS'.

Table 1. Initial soil properties of experimental site

Sl. No	Parameters	Values
1	pH (1:2.5)	8.15
2	EC(dS m^{-1})	0.64
3	Organic carbon (%)	0.55
4	Available Nitrogen(kg/ha)	273
5	Available P_2O_5 (kg/ha)	26.9
6	Available K_2O (kg/ha)	286
7	Available S (ppm)	8.90
8	Available Fe (ppm)	2.29
	Available Zn (ppm)	0.55

3. RESULTS AND DISCUSSION

The results of the two years' investigation revealed that levels of nitrogen with iron and zinc and their combination treatments had significant influence on plant height, number of leaves per plant, leaf area, leaf area index and total dry matter production, weight of ear head, grain weight per plant, test weight, grain yield, stover yield and harvest index of pearl millet crop. Results revealed that application of 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each at 30 and 45 days after sowing has recorded higher growth parameters *viz.,* plant height (199.4.cm), number of leaves (18.6), leaf area (3160.7 cm^2), leaf area index (4.73) and total dry matter production (259.96 g $plant^{-1}$) at harvest stage.The increase in nitrogen levels in general, increased the number of leaves significantly probably due to increasing the production of new meristemetic tissues [15]. The significant increase in plant dry matter at different stages of crop growth due to increase in nitrogen levels might be attributed to the effect of nitrogen in increasing the amount and efficiency of chlorophyll which intern influence the photosynthetic efficiency and formation of other nitrogen compounds. Similar results were also reported by [16].

Table 2. Influence of graded levels of nitrogen with iron and zinc nutrition on plant height andnumber of leaves of pearl millet crop

Treatment	Plant height(cm)			No. of leaves		
	2021	2022	Mean	2021	2022	Mean
T_1: RPP (Recommended Package of Practice)	165.6	167.2	166.4	10.0	11.4	10.7
T_2: 50 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	175.9	177.6	176.8	15.2	16.3	15.8
T_3: 100 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	178.6	180.4	179.5	15.8	17.5	16.7
T_4: 50 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	170.5	173.3	171.9	12.3	13.7	13.0
T_5: 100 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	183.5	184.7	184.1	13.5	15.0	14.3
T_6: 50 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	184.3	186.0	185.2	15.5	16.2	15.9
T_7: 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	198.2	199.9	199.1	17.3	18.5	17.9
T_8: 50 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each	185.1	187.2	186.2	16.3	17.8	17.1
T_9: 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	198.5	200.3	199.4	17.5	19.7	18.6
S.Em. ±	**4.45**	**4.07**	**4.26**	**0.36**	**0.46**	**0.41**
C.D. at 5%	**13.00**	**12.20**	**12.60**	**1.06**	**1.38**	**1.22**

Table 3. Influence of graded levels of nitrogen with iron and zinc nutrition on leaf area,Leaf area index and total dry matter Productionof pearl millet crop

Treatment	Leaf area (cm^2)			Leaf area index			Total dry matter production (g $plant^{-1}$)		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
T_1: RPP(Recommended Package of Practice)	1931.7	1947.6	1939.7	2.86	2.89	2.88	197.89	199.43	198.66
T_2: 50 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	2389.8	2395.6	2392.7	3.54	3.68	3.61	217.23	223.41	220.32
T_3: 100 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	2471.4	2489.4	2480.4	3.66	3.73	3.70	223.47	229.40	226.44
T_4: 50 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	2245.8	2257.8	2251.8	3.33	3.53	3.43	211.08	218.10	214.59
T_5: 100 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	2721.5	2745.3	2733.4	4.03	4.15	4.09	224.57	229.63	227.10
T_6: 50 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	2675.2	2693.2	2684.2	3.96	3.99	3.98	235.13	238.19	236.66
T_7: 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	3123.9	3148.9	3136.4	4.63	4.78	4.71	252.24	260.18	256.21
T_8: 50 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	2789.5	2793.4	2791.5	4.13	4.21	4.17	236.89	240.29	238.59
T_9: 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	3152.1	3169.3	3160.7	4.67	4.79	4.73	254.44	265.47	259.96
S.Em. ±	**65.11**	**85.37**	**75.24**	**0.10**	**0.13**	**0.12**	**5.61**	**7.21**	**6.41**
C.D. at 5%	**190.04**	**255.95**	**223.00**	**0.28**	**0.40**	**0.34**	**16.37**	**21.62**	**19.00**

Table 4. Influence of graded levels of nitrogen with iron and zinc nutrition on yield attributes of pearl millet crop

Treatments	Yield attributes								
	Weight of ear head (g plant^{-1})			Grain weight (g plant^{-1})			Test weight (g)		
	2021	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**
T_1: RPP (Recommended Package of Practice)	35.84	36.23	36.04	28.71	29.93	29.32	13.74	13.89	13.82
T_2: 50 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	41.56	42.79	42.18	33.37	34.05	33.71	15.32	15.59	15.46
T_3: 100 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	43.25	44.39	43.82	34.13	35.63	34.88	14.67	14.75	14.71
T_4: 50 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	38.94	39.93	39.44	32.14	33.69	32.92	15.02	15.23	15.13
T_5: 100 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	43.78	45.10	44.44	34.46	35.87	35.17	15.89	15.93	15.91
T_6: 50 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	47.46	46.83	47.15	40.84	41.93	41.39	18.56	19.26	18.91
T_7: 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	52.11	53.41	52.76	44.98	46.10	45.54	21.12	21.81	21.47
T_8: 50 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	48.01	49.21	48.61	41.58	42.43	42.01	19.85	19.93	19.89
T_9: 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	52.57	53.68	53.13	45.22	47.00	46.11	21.74	21.93	21.84
S.Em. ±	**1.12**	**1.42**	**1.27**	**0.95**	**1.33**	**1.14**	**0.44**	**0.63**	**0.54**
C.D. at 5%	**3.28**	**4.27**	**3.78**	**2.78**	**4.00**	**3.39**	**1.28**	**1.90**	**1.59**

Table 5. Influence of graded levels of nitrogen with iron and zinc nutrition on grain yield, stover yield and harvest index of pearl millet crop

Treatments	Grain yield (Kg ha^{-1})			Stover yield (Kg ha^{-1})			Harvest index (%)		
	2021	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**
T_1: RPP (Recommended Package of Practice)	1455	1468	1462	2698	2715	2707	35.03	35.09	35.06
T_2: 50 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	1521	1530	1526	2747	2763	2755	35.64	35.64	35.64
T_3: 100 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	1578	1590	1584	2773	2781	2777	36.27	36.38	36.32
T_4: 50 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	1475	1493	1484	2699	2603	2651	35.34	36.45	35.89
T_5: 100 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	1505	1516	1511	2657	2674	2666	36.16	36.18	36.17
T_6: 50 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	1610	1613	1612	2812	2814	2813	36.41	36.44	36.42
T_7: 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	1698	1705	1702	2869	2913	2891	37.18	36.92	37.05
T_8: 50 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	1619	1628	1624	2866	2889	2878	36.10	36.04	36.07
T_9: 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	1732	1745	1739	2874	2925	2900	37.60	37.37	37.48
S.Em. ±	**37.00**	**38.57**	**37.78**	**20.40**	**36.83**	**28.61**	**0.45**	**0.42**	**0.43**
C.D. at 5%	**112.12**	**115.72**	**113.90**	**61.21**	**110.13**	**85.60**	**1.35**	**1.30**	**1.32**

Table 6. Protein content and protein yield in pearl millet grains as influenced by graded levels of nitrogen with iron and zinc

Treatment	Protein content (%)			Protein yield (kg ha^{-1})		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
T_1 : RPP (Recommended Package of Practice)	10.56	10.66	10.61	153.65	156.49	155.07
T_2: 50 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	14.06	14.29	14.18	213.85	218.64	216.24
T_3: 100 % RDN + $ZnSO_4.7H_2O$ at 10 kg ha^{-1}	17.38	17.43	17.41	274.26	277.14	275.70
T_4: 50 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	13.25	13.55	13.40	195.44	202.30	198.87
T_5: 100 % RDN + $FeSO_4.7H_2O$ at 10 kg ha^{-1}	15.75	15.91	15.83	237.04	241.20	239.12
T_6: 50 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	14.81	14.98	14.90	238.44	241.63	240.03
T_7: 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each	19.31	19.43	19.37	327.88	331.28	329.58
T_8: 50 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	15.38	15.65	15.52	249.00	254.78	251.89
T_9: 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at0.5 % each	19.50	19.73	19.62	337.74	344.29	341.01
S.Em. ±	**0.39**	**0.65**	**0.52**	**6.71**	**8.81**	**7.76**
C.D. at 5%	**1.12**	**1.95**	**1.54**	**19.58**	**26.41**	**23.00**

The linear increase in grain yield of pearl millet with increased nitrogen levels [17]. Actually, nitrogen is an integral part of protein and thus all enzymes [18], whereas, zinc involve in many metallic enzyme system, regulatory functions and auxin production [19]. Thus, it is hypothesized that, application of both the fertilizers (N and Zn) at optimum levels synergistically improve the grain yield.The increase in plant height, number of leaves and dry weight per plant might be due to combined application of nitrogen along with iron and zinc. Iron plays vital role in metabolic process such as respiration, photosynthesis and it also involves in synthesis of chlorophyll which is essential for maintenance of chloroplast structure and translocation of photosynthates from source to sink. Iron also helps in the proliferation of roots and thereby increasing the uptake of the nutrients from the soil supplying to the aerial parts of the plant and ultimately enhancing the vegetative growth of the plant. The study was in close conformity with [20 and 21].The increase in total dry matter yield might be due to the additive response of cultivars to applied iron and zinc. Zinc fertilization, leading to higher total dry matter yield, has a beneficial effect on the physiological process, plant metabolism and plant growth [22and 23].

The treatment which consists of 100 % RDN + Foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each at 30 and 45 days after sowing recorded significantly higher yield parameters, weight of ear head (53.13 g plant^{-1}), grain weight (46.11 g plant^{-1}), test weight (21.84 g), grain yield (1739 kg ha^{-1}), stover yield (2900 kg ha^{-1}) and harvest index (37.48 %). The quality parameters like, protein content (19.62 %) and protein yield (341.0 kg ha^{-1}) and it was on par with treatment which received 100 % RDN + $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$ at 10 kg ha^{-1} each and was superior to other treatments.Nitrogen nutrition of plants appears to be synergistic with zinc, which may lead to increase in many physiological and molecular activities which in turn improve yield attributing characters [24 and 25]. The increase in yield and yield attributes might be due to foliar application of $FeSO_4$ would have resulted in enhanced grain and stover yield. Iron plays a major role in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial reproductive part and portioning of photosynthetic towards them which promotes the yield [26]. The increase in yield attributes might due to role of zinc in biosynthesis ofindole acetic acid [27 and 28]. The increase in the yield attributes could be due to continuous supply of micronutrients (Zn and Fe) to the crop. Zn and Fe are part of the photosynthesis, assimilation, absorption and translocation of photosynthates from source (leaves) to sink (ear head) [29]. Similar trend was noticed by [30 and 31].

4. CONCLUSION

Micronutrients especially zinc and iron are important for increasing yield and productivity of crops.The application of 100 % recommended dose of fertilizer+ foliar spray of $ZnSO_4.7H_2O$ + $FeSO_4.7H_2O$at0.5 % each at 30 and 45 days after sowing has recorded significantly higher growth, yield and quality parameters compared to treatment T_1 which consists of recommended package of practice (100:50:25 kg NPK ha^{-1} + 20 kg $FeSO_4$ ha^{-1}).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rana KS, Kumar D, Bana RS. Agronomic research on pearl millet (*Pennisetum glaucum* L.). Indian J Agron. 2012;57(3s):45-51.
2. Rani P, Singh Charu, Kumar K. Growth trend of pearl millet and its impact on Indian economy: performance analysis. Int J Adv Multidiscip Res Stud. 2023;3(3):162-6.
3. Latha HS, Ravi MV. Studies on agronomic bio-fortification with zinc and iron on nutrient availability, uptake and yield in pearl millet [*Pennisetum glaucum* (L.)] genotypes. J Pharmacogn Phytochem. 2020;9(4):721-5.
4. Anonymous. Agricultural statistics at a glance, Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics. 2014;63.
5. Singh S, Shukla DR, Yadav B. Effect of planting geometry and phosphorous levels on pearl millet. Int J Prog Res. 2019;14(1):18-22.
6. Padulosi S, Mal B, Ravi SB, Gowda J, Gowda KTK, Shanthakumar G et al. Food security and climate change: role of plant

genetic resources of minor millets. Indian J Plant Genet Resour. 2009;22(1):1-16.

7. Reddy VSN, Singh R, Deepika CL. Effect of phosphorus and zinc on growth and yield of pearl millet (Pennisetumglaucum L.); 2022.
8. Prasad SK, Singh MK, SINGH R. Effect of nitrogen and zinc fertilizer on pearl millet (*Pennisetum glaucum*) under agri-horti system of eastern Uttar Pradesh. Significance. 2014;400:0-05.
9. Schebendach JE, Mayer LE, Devlin MJ, Attia E, Contento IR, Wolf RL, Walsh BT. Dietary energy density and diet variety as predictors of outcome in anorexia nervosa. The American Journal of Clinical Nutrition. 2008;87(4):810-816.
10. Akhter S, Rasool R, Nabi A, Yousuf V, Dar NA, Sofi KA et al. Agronomic biofortification in rice with Zn. Int J Curr Microbiol Appl Sci. 2020;9(10):2995-3008.
11. Osman KT, Osman KT. Plant nutrients and soil fertility management. Soils Princ Prop Manag. 2013:129-59.
12. Anandhan J, Shamugasundaram R, SaravanaPandian P, Swaminathan C, Vanniarajan C, Govindaraj M. Influence of soil application of iron and zinc on their content, uptake and total dry matter yield of pearl millet cultivars. Pharm Innov. 2021;10(4):98-104.
13. Tai YP, Young GP. Variation in protein percentage in different properties of peanut cotyledons. Crop Sci. 1974;14:222-9.
14. Cochran WG, Cox GM. Experimental designs. 1965;7(3):203.
15. Arshewar SP, Karanjikar PN, Dambale AS, Kawde MB. Effect of nitrogen and zinc levels on growth, yield and economics of pearl millet (*Pennisetum glaucum* L.). Int J Bio-Resource Stress Manag. 2018;9(6):729-32.
16. Heringer I, Moojen EL. Productive potential, structure changes and quality of pearl millet under different nitrogen levels. Rev Bras Zootec. 2002;31(2):875-82.
17. Kennedy C, Bell P, Caldwell D, Habetz B, Rabb J, Alison MA. Nitrogen application and critical shoot nitrogen concentration for optimum grain and seed protein yield of pearl millet. Crop Sci. 2002;42(6):1966-73.
18. Arif M, Chohan MA, Ali S, Guland R, Khan S. Response of wheat to foliar application of nutrients. J Agric Biol Sci. 2006;1(4): 30-4.
19. Muthukumararaja TM, Srirama chandrasekharan MV. Effect of zinc on yield, zinc nutrition and zinc use efficiency of lowland rice. Agric Technol. 2012; 8(2):551-61.
20. Rao V, Bamboriya JK, Yadav S, Jeeterwal RC. Response of pearl millet (*Pennisetum glaucum* L.) to Integrated nitrogen management. Int J Curr Microbiol Appl Sci. 2019;8(2):429-37.
21. Shrivastava S, Jain AK, Arya V. Response of organic manure, zinc and iron on soil properties, yield and nutrient uptake by pearlmillet crop grown in inceptisol. Int J Pure Appl Sci. 2018;6(1):426-35.
22. Jemila C, Shanmugasundaram RA. Preface screening of zinc use efficient pearl millet varieties in calcareous soil. Journal of Pharmacognosy and Phytochemistry. 2018;7(5):1833-1837.
23. Debbarma V, Vaishnavi N. Influence of organic manures and zinc on growth, yield and economics of pearl millet (*Pennisetum glaucum* L.). Int J Environ Clim Change. 1. 2023;13(7):160-7.
24. Cakmak I, Pfeiffer WH, McClafferty B. REVIEW: Biofortification of durum wheat with zinc and iron. Cereal Chem. 2010;87(1):10-20.
25. Prasad SK, Singh MK, Singh R. Effect of nitrogen and zinc fertilizer on pearl millet (*Pennisetum glaucum*) under agri-horti system of eastern Uttar Pradesh. Significance. 2014;400:0-05.
26. Maharana S, Singh S. Effect of iron and zinc on growth and yield of pearl millet [*Pennisetum glaucum* (L.)]. The Pharm Innov J. 2021;10(10):546-50.
27. Ganapathy BA, Savalgi VP. Effect of micronutrients on the performance of Azospirillum brasilense on the nutrient uptake, growth and yield in maize crop. Karnataka J Agric Sci. 2006;19(1):66.
28. Rakesh K, Umesha C, Balachandra Y. Influence of Nitrogen and Zinc Levels on Pearl Millet (*Pennisetum glaucum* L.);2021.
29. Esfahani AA, Pirdashti H, Niknejhad Y. Effect of iron, zinc and silicon application on quantitative parameters of rice (Oryza Sativa L. CV. TaromMahalli). Int J Farming Allied Sci. 2014;I(5):529-33.
30. Adsul PB, Pawar A, Gaikwad G, Puri A, Shaikh MSS. Uptake of NPK and yield of Kharif sorghum as influenced by soil and foliar application of micronutrients. BIOINFOLET A Q J Life Sci. 2014; 11(2c):578-82.

31. Girish A, Mehera B, Kumar P. Influence of foliar application of zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.) varieties. Int J Environ Clim Change. 15. 2023;13(7):593-601.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/102891