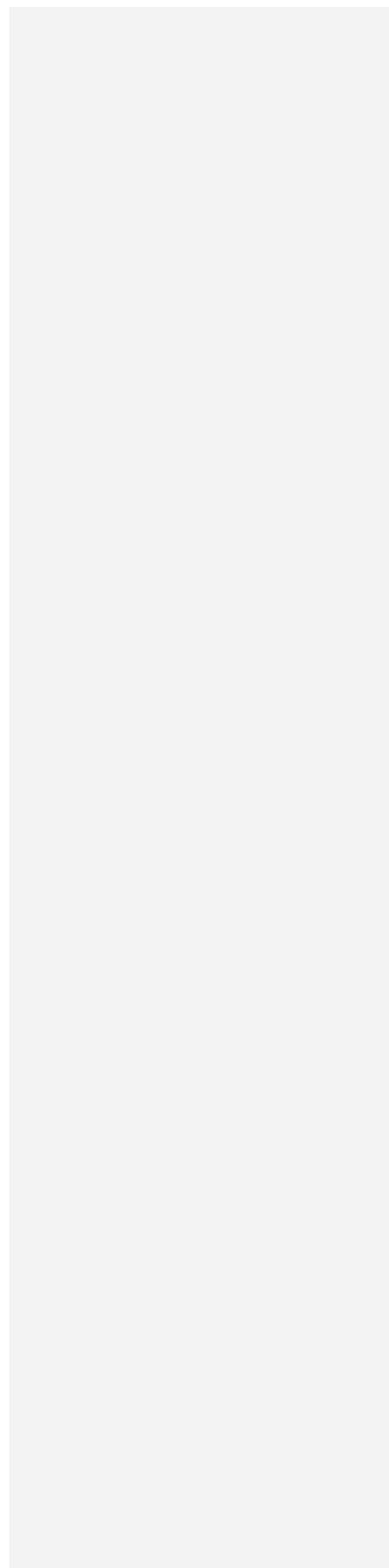


Original Research Article

“Effect of Nano zinc and Foliar application of Boron on growth and yield of Finger millet Finger millet”



ABSTRACT

A field experiment was conducted during Kharif 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to determine the "Effect of nano zinc and foliar application of boron on growth and yield of finger millet (*Eleusine coracana* L.)". The treatments consisted of three levels of [Nano zinc 300 ppm, 600 ppm, 900 ppm] and three levels of foliar application of Boron at [0.1%, 0.3% and 0.5%], whose effect is observed in finger millet. The results revealed that the treatment with application of Nano zinc 900 ppm + Boron at 0.5% recorded higher plant height, number of tillers/plant, plant dry weight, CGR, RGR and yield parameter test weight, seed yield, stover yield and harvest index.

Keywords: Nano zinc; Boron; Growth; Yield.

Introduction

Finger millet (*Eleusine coacana* L. Gaertn.) is known as African millet and Ragi in India. Finger millet belongs to the family Poaceae. The third most important millet crop in India. India's third-largest millet crop. One of the main food staples in some regions of eastern and central Africa and India is finger millet. In Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, and Maharashtra there has been tremendous development. Even in the mountains of Himachal Pradesh and Uttar Pradesh, it develops. It is generated yearly in 1.29 million tonnes on 2.5 million hectares (M/ha) of lands (aut, 2019). An important grain crop, ragi is a C₄ plant with such a high production potential which, under perfect situations, could reach up to 40 to 50 quintals per hectare.

Millet has a higher nutrient value than other grains like rice and wheat. It performs well as a substitute for rice and wheat. Proteins (5-8%), carbs (65-75%), dietary fibre (15-20%), minerals (2.5-3.5%), and other extractives (1-2%) are all present in finger millet. Among the cereals, it has the greatest calcium content (344 mg/100 g).

Nano fertilizers help to improve the production of dry matter, photosynthesis, or chlorophyll, which benefits plant growth in general (Qureshi *et al.*, 2018). In view of this, the goal of this research was to develop a cropping system that includes bio seed priming composed of extracts of plant leaves and foliar nanoparticles of zinc oxide, a nanoparticle which could be simultaneously efficient and environmentally friendly, approach that could increase seed nutrient content for improved seed emergence, more uniform plant population, and high yield. As in the food industry and agriculture, nanotechnology is essential. Usually, nanoparticles (size 1-100 nm) have a variety of applications in industries including medical medicine and pharmaceuticals. Several patented products using nano-materials, including nano-pesticides, nano-fertilizers, and nano-sensors, have been developed regardless of the ongoing controversy about the use of nanoparticles in agriculture (Prasad *et al.*, 2017; Kah, 2015).

Zinc deficiency is now recognized as one of the most widespread mineral deficiencies in global human nutrition. Zinc is required for the structural and functional integrity of about 2800 proteins, contributes to protein biosynthesis and is a key defense-defence factor in the detoxification of highly toxic oxygen-oxygen-free radicals (Andreini *et al.*, 2009).

Concluded that foliar or combined soil and foliar application of zinc fertilizer under field conditions is a highly effective and very practical way to maximize the uptake and accumulation of zinc in whole wheat grain. Finger millet flour fortified with zinc-oxide was specifically examined for the bioaccessibility of the fortified mineral, as measured by in-vitro, stimulated gastrointestinal digestion procedure and storage stability (Bhumika and Kalpana, 2010).

Nutrients including zinc and boron are recommended. Zinc, among the essential microelements for both plants and animals, is essential to a plant's metabolic process since it promotes the manufacturing of proteins, lipids, carbohydrates, DNA, and enzymes. Zinc is also another

important mineral. Serves an essential function in reducing the production and cytotoxicity of free radicals that can damage membrane lipids. A lack of zinc affects both vegetative and productive growth, ~~as~~ according to research. Since the establishment of the essentiality of boron for the growth and development of higher plants (**Warington 1923**), our knowledge about its importance in agriculture has grown rapidly.

In addition to helping with cell division, cell elongation, cell membrane strength, flowering, pollination, seed set, and sugar translocation, boron is essential for the growth and nutrition of crop plants. Although calcium and boron are necessary to improve grain yields, their mixed application can have an effect on the accessibility and use of boron by plants (**Kanwal et al., 2008**).

The biological responses of plants, such as cell elongation, cell maturation, meristematic tissue development, and protein synthesis, all benefit from the presence of the element boron (**Mengeland Kirkby, 1982**). The use of boron in finger millet is essential for improving the crop's growth, development, and yield. The application of boron also promotes the soil's uptake of nitrogen, ~~that-which~~ improves plant height and dry weight (**Jing et al., 1994**). The information on finger millet's boron content in Karnataka is important. Thereby, the aim of this research was to research the effects of graduated boron doses on the growth and yield of finger millet, an important staple food crop in Karnataka's Eastern Dry Zone. Although ~~many-much~~ research ~~have~~ has been performed simultaneously, a thoroughly repeated experiment in various Karnataka regions is needed to determine the considered valid.

MATERIALS AND METHODS:

The experiment was conducted during the kharif season of 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), low level of organic carbon (0.51%), available N (108.69 Kg/ha), P (80.5 kg/ha), K (83.3 kg/ha). The treatment consists of Nano zinc @ 300 ppm + Boron @ 0.1%, Nano zinc @ 300 ppm + Boron @ 0.3%, Nano zinc @ 300 ppm + Boron @ 0.5%, Nano zinc @ 600 ppm + Boron @ 0.1%, Nano zinc @ 600 ppm + Boron @ 0.3%, Nano zinc @ 600 ppm + Boron @ 0.5%, Nano zinc @ 900 ppm + Boron @ 0.1%, Nano zinc @ 900 ppm + Boron @ 0.3%, Nano zinc @ 900 ppm + Boron @ 0.5% and control.

The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The observations were recorded for plant height, plant dry weight, Crop growth rate ($\text{g/m}^2/\text{day}$), Relative growth rate (g/g/day), test weight (g), seed yield (t/ha), stover yield (t/ha) and harvest index (%). The collected data was/were subjected to statistical analysis by analysis of variance method.

3. RESULTS AND

DISCUSSION Growth parameters

Plant height:

The data revealed that a significant and higher plant height (36.3 cm) was observed in treatment T₉ [ZnO (900 ppm) + Boron (0.5%)] However, treatment T₈ [ZnO (900 ppm) + Boron (0.3%)] where ~~statistically~~ statistically at par with the treatment T₉ [ZnO (900 ppm) + Boron (0.5%)].

Improved nutritional uptake and absorption, notably of zinc and boron, which were lacking in the soil at the experimental site, may have contributed to the increase in plant height. The rise in plant height brought on by the administration of micronutrients may be linked to the crop receiving the right nutrition, which promotes growth. In addition to enhancing the nutrient supply, the addition of FYM may have enhanced the physical qualities of the soil, fostering favourable conditions for crop growth. The taller plants seen with micronutrient treatment may bear a result of enhanced ~~meristematic~~ meristematic cell activity and cell elongation, which raises plant height. In conjunction with Zn spraying, **Dadhich and Gupta (2005)** and **Jakhar et al., (2006)** also noted increased plant height. According to **Mubsharet al., (2012)**, boron spraying increased plant height.

Number of Tillers/plant:

The data revealed that treatment T₉ [ZnO (900 ppm) + boron (0.5%)] recorded a significant and maximum number of tillers/plant (6.4) which was superior to all the treatments and the treatment T₈ [ZnO (900 ppm) + Boron (0.3%)] and T₇ [ZnO (600 ppm) + Boron (0.5%)] were statistically at par with the treatment T₉ [ZnO (900 ppm) + Boron (0.5%)].

The increased number of tillers due to the application of these micronutrients might be related to their physiological role in plants. The stimulatory effect of Zn on enzymes and on the increased availability of major nutrients might have caused for an increased number of tillers in the present study. These results corroborate the findings of **Dadhich and Gupta (2005)** and **Mubsharet al., (2012)**. The results very clearly indicated that the application of both the nutrients increased the number of tillers per hill and also the need for the application of boron at a nearly stage of the crop to increase tiller numbers. These results are in accordance with the findings of **Muhammad et al., (2012)**.

Plant dry weight (g):

Results revealed that treatment T₉ [ZnO (900 ppm) + Boron (0.5%)] recorded significantly higher plant dry weight (8.24), which was superior to all the treatment and treatment T₆ [ZnO (600 ppm) + Boron (0.5%)], were statistically at par with treatment T₉ [ZnO (900 ppm) + Boron (0.5%)].

Kobrae et al., (2011) claimed that zinc, iron and boron application at the same time could lead to higher dry matter and seed yield as compared to using them separately. Foliar application with micronutrients (Fe, B and Zn) might be due to their critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activities and thus their importance in achieving high yields (**Salih, 2013**).

Crop Growth Rate (g/m²/day):

The data recorded that during 60-80 DAS that treatment T₉ [ZnO (900 ppm) + Boron (0.5%)] was the highest crop growth rate (28.50 g/m²/day).

Relative Growth Rate (g/g/day):

The data revealed that during 60-80 DAS, treatment T₁₀ control: 100:50:50 (NPK kg/ha) recorded a significantly higher relative growth rate (0.046 g/g/day).

Yield parameter:**Test weight:**

Significant A significant and maximum test weight (3.82) was recorded in treatment T₉ [ZnO (900) + boron (0.5%)]. However, treatment T₈ [ZnO (900 ppm) + boron (0.3%)] was statistically at par with the treatment T₉ [ZnO (900) + boron (0.5%)].

Seed yield (t/ha):

Significant and higher seed yield (2.69 t/ha) was obtained in treatment T₉ [ZnO (900) + boron(0.5%)], and there were no statistically significant differences.

Consequently, providing zinc and boron to a soil low in those elements improved plant development and growth in general, which in turn will increase crop yields of grain and straw. As in several research in various crops, such as those by **Shrivastava et al. (2003)**, **Sammauria (2007)**, **Singh et al., (2009)**, **Tripathi et al., (2011)**, and **Jat et al., (2015)**, also support these conclusions. The combined use of Zn and B in this experiment improved crop yield much more than both the elements' application alone. These results are similar with **Muhammad et al., (2012)** and **Quddus et al., (2011)**

Stover yield (t/ha):

Significant and higher seed yield (4.29 t/ha) was obtained in treatment T₉ [ZnO (900) + boron(0.5%)], and there were no statistically significant differences.

Sandhya Rani et al., (2017) reported higher grain and straw yield (78.1q ha⁻¹ and 33.7q ha⁻¹ respectively) of finger millet with the application of 150% RDF + ZnSO₄ @ 0.5% Foliarspray + FeSO₄ @ 0.2%. Thus, the application of zinc and boron in a soil deficient in zinc and boron improved the overall growth and development of plants and ultimately the grain and straw yields. These findings are also supported by **Shrivastava et al., Sammauria, Singh et al.**

Harvest index (%):

~~Significant~~ A significant and higher harvest index (38.59 %) was obtained in treatment T₉ [ZnO (900) + boron(0.5%)], and there were no statistically significant differences.

Baktear Hossain et al., (2001) also reported a similar improvement in the growth and yield of finger millet crops with the application of NPK and Zn. The greater growth, higher photosynthetic activity, and movement of photosynthates from source to harvest are the results of which the yield qualities have improved. The increased supply of nutrients provided by the application of FYM to get fertilizers there with chemical fertilisers may be the cause of the improvement in growth as a result of better physiological processes in plants. Moreover, the application of FYM might have enhanced the physical, chemical, and biological characteristics of the soil, which collectively might have favoured the processes in the soil that change nutrients, leading to an increase in the availability of nutrients. **Nutrient uptake by the crop was improved has improved by the rise in nutrient availability, the increase in nutrient availability improved the crop's nutrient uptake, which ultimately led to an improvement in growth and production parameters.** According to **Jena et al., (2006)** and **Mohamed et al., (2010)**, the application of zinc and boron may have enhanced the transfer of photosynthates from source to sink, which may account for the higher values of yield attributes (2015). Increased plant vigour, improved photosynthesis, and better transfer of photosynthates from source to sink may all contribute to the better yield parameters brought on by the combined application of N, P, K, Zn, and B. (**Ramachandrapa et al., 2014**)

Table1.EffectofNanozincandfoliarapplicationofboronongrowthof Fingermilletcrop

Sl No.	Treatment	60DAS			60-80DAS	
		Plant height (cm)	Number of tillers/plant	Dryweight (g/plant)	Crop growth rate(g/m ² /day)	Relative growth rate(g/g/day)
1	ZnO(300ppm) +Boronat (0.1%)	34.0	5.0	7.48	26.37	0.044
2	ZnO(300ppm) +Boronat (0.3%)	34.3	5.1	7.61	26.84	0.044
3	ZnO(300ppm) +Boronat (0.5%)	35.1	5.7	8.00	27.68	0.043
4	ZnO(600ppm) +Boronat (0.1%)	34.8	5.5	7.84	27.04	0.043
5	ZnO(600ppm) +Boronat (0.3%)	35.5	5.9	8.06	27.55	0.043
6	ZnO(600ppm) +Boronat (0.5%)	36.2	6.1	8.17	27.77	0.043
7	ZnO(900ppm) +Boronat (0.1%)	35.0	5.6	7.91	27.33	0.043
8	ZnO(900ppm)+Boron at (0.3%)	35.9	6.0	8.09	27.87	0.043
9	ZnO(900ppm)+Boron at (0.5%)	36.3	6.4	8.24	28.50	0.043
10	Control(100:50:50 NPK kg/ha)	32.8	4.9	7.08	26.90	0.046
	F _{test}	S	S	S	S	S
	SEm(±)	0.10	0.16	0.04	0.21	0.0003
	CD(P=0.05)	0.29	0.49	0.11	0.63	0.0001

Table 2. Effect of Nano zinc and foliar application of boron on yield parameter of Finger millet crop

Sl No.	Treatment	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1	ZnO(300ppm) + Boron at (0.1%)	3.50	1.83	3.39	35.09
2	ZnO(300ppm) + Boron at (0.3%)	3.57	1.91	3.56	34.96
3	ZnO(300ppm) + Boron at (0.5%)	3.74	2.08	3.98	34.35
4	ZnO(600ppm) + Boron at (0.1%)	3.61	1.98	3.71	34.80
5	ZnO(600ppm) + Boron at (0.3%)	3.75	2.14	4.05	34.58
6	ZnO(600ppm) + Boron at (0.5%)	3.78	2.34	4.14	36.15
7	ZnO(900ppm) + Boron at (0.1%)	3.63	2.02	3.86	34.37
8	ZnO(900ppm) + Boron at (0.3%)	3.77	2.20	4.09	34.92
9	ZnO(900ppm) + Boron at (0.5%)	3.82	2.69	4.29	38.59
10	Control (100:50:50 NPK kg/ha)	3.45	1.78	3.22	35.62
	F _{test}	S	S	S	S
	SE _m (±)	0.05	0.05	0.05	0.56
	CD(P=0.05)	0.16	0.14	0.11	1.30

CONCLUSION

It can be concluded that the application of nano zinc (900ppm) and Boron (0.5%) as foliar spray as performed bettering growth parameters and yield attributes of finger millet (GPU-67). Since the findings are based on one season, further ~~trails~~ trials are needed to confirm the results.

REFERENCES

1. **Adikant, P., Abhinav, S., Nag, S.K and Chandrakar, T.P. 2016.** Effect of zinc fertilization on growth and yield of finger millet. International Journal of Science Environment and Technology. 5(3): 1477-1487.
2. **Ahmad, A., Tahir, M., Ehsan Ullah, M., Naeem, M., Ayub, M., Rehman, H., Talha, M. 2012.** Effect of silicon and boron foliar application on yield and quality of rice. Pakistan Journal of Life and Social Sciences 10:161-165.
3. **Bhumika, T and Kalpana, P. 2010.** Finger millet flour as a vehicle for fortification with Zinc. Journal of Trace Elements in Medicine and Biology. 24(1): 46-51.
4. **Bozorgi HA, Azarpour E, Moradi, M. (2011).** The effects of bio, mineral nitrogen fertilization and foliar zinc spraying on yield and yield components of faba bean. World Appl. Sci. J., 13(6): 1409-1414.
5. **Begum, R., Jahiruddin, M., Kader, M.A., Haque, M.A. and Hoque, A.,** Effects of zinc and boron application on onion and their residual effects on Mungbean. Progre. Agric., 26: 90-96 (2015).
6. **Cakmak, I. 2008.** Enrichment of cereal grains with Zinc Agronomic or genetic biofortification. Plant and Soil. 302(1-2): 1-17.
7. **Chowdary, K.A. and Patra, B.C. (2019).** Effect of micronutrient application with different sources of application on growth and yield of finger millet crop in red laterite zone (*Eleusine coracana* L. Gaertn) in the Central Rift Valley of Ethiopia. International Journal of Agriculture and Forestry. 3(9):1-7.
8. **Dholariya, H.P., Zinzala, V.J., Patel, J.V. and Patil, V.M. (2020).** Zinc nutrition in finger millet (*Eleusine coracana* L.) for better nutritional security. International Journal of Current Microbiology and Applied Sciences. Issue-11:1082-1086.
9. **Farsheid Aref, 2011,** Combination of zinc and boron in corn leaf as affected by zinc sulphate and boric acid fertilizers in a deficient soil. Life Sci. J., 8 (1): 26-31.
10. **Fulpagare, D.D., Patil, T.D. and Thakare, R.S. 2018.** Effect of application of iron and zinc on nutrient availability and pearl millet yield in vertisols. International Journal of Chemical Studies. 6(6): 2647-2650.
11. **Govinda, K., Srinivasa, N. and Prakash, S.S. (2020).** Effect of graded levels of borax and gypsum on growth and yield attributes of irrigated finger millet (*Eleusine Coracana*

- L.) in southern dry zone of Karnataka. International Journal of Chemical Studies. 8(4):1194-1197.
12. **Hossain, B., Talukder Narayon, K. and Ahmed, S.,** Effect of zinc, boron and molybdenum application on the yield and nutrient uptake. J. Biol. Sci., 1(8): 698-700(2001).
 13. **Jaison, M., Kiran, P., Harish, S.G. and Chikkaramappa, T. (2018).** Response of foxtail millet to application of zinc and boron in Alfisols of Karnataka. International Journal of Chemical Studies, 6(6): 2658-2661.
 14. **Liaqat, A., Mushtaq Ali, and Qamar Mohyuddin, 2011,** Effect of foliar application of zinc and boron on seed cotton yield and economics in cotton-wheat cropping pattern. J. Agric. Res., 49 (2): 173-180.
 15. **Liaqat, A., Mushtaq Ali, and Qamar Mohyuddin, 2011,** Effect of foliar application of zinc and boron on seed cotton yield and economics in cotton-wheat cropping pattern. J. Agric. Res., 49 (2): 173-180.
 16. **Meena, B.L. and Kumar, P.,** Zinc and Iron nutrition to increase the productivity of pearl millet -mustard cropping system in salt affected soils. International journal of current microbiology and applied sciences ISSN:2319-7706 Vol.7.
 17. **Muhammad, A., Shehzad, M. A., Bashir, F., Tasneem, M., Yasin, G. and Iqbal, M.,** Foliar application of zinc and boron in paddy. African J. Biotech., 11(48): 10851-10858(2012).
 18. **Pradhan, A., Sao, A., Nag, S.K and Chandrakar, T.P. 2016.** Effect of zinc fertilisation on growth and yield of finger millet. (Eleusine coracana. L. GAERTN.). International Journal of Science, Environment. 5(3):1477-1487.
 19. **Sandhya Rani, Y. and Patro T. S. S. K., 2014,** Evaluation of effect of zinc biofortification on crop growth and grain yield in finger millet (Eleusine coracana). Inter. J. Food Agric. Vet. Sci., 4 (2): 146-148.
 20. **Sankaranarayana, K., Praharaj, C. S., Nalayani, P., Bandopadhyay, K. K. and Gopalakrishnan, N., 2010,** Effect of magnesium, zinc, iron and boron on yield and quality of cotton (*Gossypium hirsutum* L.), Indian J. Agric. Sci., 80(8):699-703.
 21. **Sai Divya B, Rajesh Singh and Wasim Khan (2021)** Effect of foliar application of iron and zinc on yield and economics of finger millet (*Eleusine Coracana* L.). The Pharma Innovation Journal; 10(4): 897-899.
 22. **Sammauria, R.,** Response of fenugreek to phosphorous and zinc application and their residual effects on succeeding pearl millet (*Pennisetum glaucum*) under irrigated conditions of north west Rajasthan. Ph.D Thesis, Rajasthan Agricultural University, Bikaner (2007).
 23. **Sandhya, R. Y. and Patro, T. S. S. K. (2014).** Evaluation of effect of zinc biofortification on crop growth and yield in finger millet. International Journal of Food and Agriculture and Veterinary Sciences 4(2): 146-148.
 24. **Shankar, M. A., Thimme Gowda, M. N., Bhavitha, N. C. and Manjunatha, B. N., 2017,** Comparative efficiency of soil and foliar application of boron on growth and yield of finger millet (*Eleusine coracana*). Mysore J. Agric. Sci., 51 (2): 430-435.

25. **Shankar, M. A., Mohan Kumar, H. K., Gajanan, G. N., Rajendra Prasad, S. and Ramappa Jakanur, 2005**, Seed quality as influenced by zinc and boron in groundnut and finger millet. Technical Bulletin, All India Coordinated Project for Dryland Agriculture. UAS, Bangalore, pp.7-23.
26. **Thippeswamy, T.G, Junna, L and Shinde, M.2016**. proximate composition, resistant starch and other phytochemical constituents of native finger millet cultivar. International journal of food and nutritional science. 3(5): 2320-7876.
27. **Vijayakumar, M., R. Sivakumar and Tamilselvan, N. (2020)**. Effect of Zinc and Iron Application on Yield Attributes, Available Nutrients Status and Nutrient Uptake of Finger Millet under Rainfed Condition. International Journal of Current Microbiology and Applied Science. 9(5): 323.
28. **Vijayakumar, M., R. Sivakumar and Tamilselvan, N. (2020)**. Effect of Zinc and Iron Application on Yield Attributes, Available Nutrients Status and Nutrient Uptake of Finger Millet under Rainfed Condition. International Journal of Current Microbiology and Applied Science. 9(05): 323.
29. **Zeidan E. Satyanarayan swamy Y and Triveni C. (2010)**. Effect of micronutrient application with different sources of application on growth and yield of finger millet crop in laterite zone. Journal of Agricultural Science and Technology 4: 403-41

