

Original Research Article

Impact of Foliar application of Zinc and Biofertilizers on Growth of Sorghum

(*Sorghum bicolor* L.)

Abstract

The field experiment took place in the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, during the *kharif* season of 2021. (UP). The experiment was set up in a Randomized Block Design with ten treatments, including control, that was replicated thrice using various biofertilizers. viz. *Azospirillum* sps. 25g/kg seeds, PSB 25g/kg seeds and combination of *Azospirillum* sps. 25g/kg seeds + PSB 25g/kg seeds and foliar application of 0.5% zinc at 30, 50 and 30 + 50 DAS /ha. The Research revealed that foliar application of zinc 0.5% at 50 DAS/ha along with seed inoculation by *Azospirillum* sps. 25g/kg Seeds + PSB 25g/kg seeds significantly increased the growth parameters of Sorghum viz., plant height (163.31cm), dry matter accumulation (92.71 g), No. of Leaves (12.87), Absolute growth rate (1.33 g/plant/day), crop growth rate (44.31 g/m²/day) and leaf area (414.67 cm²).

Keywords: Sorghum, Biofertilizers, Zinc, *Azospirillum* sps., Phosphate solubilizing bacteria, Growth

Comment [FG1]: these keywords are already in the title

1. INTRODUCTION

Sorghum is one of the most significant crops produced in India, and it is used on a daily basis by the majority of Indians. ~~After wheat, corn, rice, and barley, it ranks fifth in cereal production.~~ It is also important in the industrial sector, since it is used in malting, the production of high fructose syrup, breads and many value-added products, and animal feed. Sorghum is a millet with many health ~~benefits~~ benefits, and it is recommended to diabetic patients.

Sorghum is also a drought tolerant crop. ~~It~~ It can be easily grown in areas with dry -

climate and less rainfall. Minimum 350-400 mm of rainfall is good for cultivation, it can tolerate both drought as well as water logging conditions. Sorghum can be grown on wide range of soil but sandy loam soil is considered to be best for its cultivation. Sorghum is a good source of vitamins and minerals, along with providing great protein content and making up for a large portion of your dietary fiber intake. For every 100 grams of sorghum cereal, you get about 3.5 grams fat, out of which only 0.6 grams is saturated fat. The 100 g grain content 10.4 g proteins, 1.9 g fats, 72.6 g carbohydrates, 1.6 g Crude Fiber and 25 g Calcium. Major pest problem is very less in this crop and that's why it can be stored easily for long time. Sorghum has high content in vitamins and fiber rich source. Sorghum is known to be rich in phenolic compounds, many of which act as antioxidants, which helps in reduction of tumor.

Comment [FG2]: Rewrite this

The sorghum productivity has been low due to growing of this crop on small and marginal lands and continuous use of harmful fertilizers. Micronutrient deficiency in soil especially zinc, is the most common problem in the soil due to which there is severe yield loses and nutritional quality get affected. The integrated nutrient management is being implemented on many of the crops because of that the use of biofertilizers uses has been increased in all types of crops, especially using biofertilizers in the cereal crops has been proven beneficial in many ways for fixing the nitrogen. Use of biofertilizers and foliar application of zinc combined can result in good growth of the sorghum crop. Biofortification of zinc strategy appears to be essential in keeping sufficient amount of available zinc in plants to maintain adequate zinc transport to grain during the reproductive stage and other growth stages.

2. MATERIALS AND METHODS

The experiment was conducted in the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, during the *kharif* season of 2021. (U.P.) which is situated at 25° 39' 42" north latitude, 81° 67' 56" east longitude, and 98 meters above sea level. The soil in the experimental plot was sandy loam in texture, pH 7.7, low in organic carbon (0.57 percent), available N (230 kg/ha), available P (32.10 kg/ha), and available K (346.00 kg/ha). The crop was planted on July 19, 2021, with the NTJ-5 variety. The experiment used a Randomized Block Design with three replications and a total of ten treatments. *viz.*: T₁: Control- 80: 40:40 Kg NPK ha/ (Farmer's Practice), T₂: *Azospirillum* sps. 25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T₃: *Azospirillum* sps. 25 g/kg seeds + 0.5 %

Comment [FG3]: What this mean?

Comment [FG4]: The first time an abbreviation appears, it must be explained what it is. even if it's obvious

zinc foliar spray 50 DAS, T₄: *Azospirillum* sps. 25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS, T₅: PSB 25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T₆: PSB 25 g/kg seeds + 0.5 % zinc foliar spray 50 DAS, T₇: PSB 25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS, T₈: *Azospirillum* sps. + PSB: 25+25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T₉: *Azospirillum* sps + PSB: 25+25 g/kg seeds + 0.5 % zinc foliar spray 50 DAS. T₁₀: *Azospirillum* sps. + PSB: 25+25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS. All nutrients were applied as urea, single super phosphate (SSP), and muriate of potash through the soil (MOP). For each plot, a full dose of P and K was applied basal, and half of the nitrogen (as urea) was applied basal. The remaining half of the nitrogen should be top dressed 30-35 days following sowing. The growth parameters of the randomly selected five tagged plants in each treatment were measured at intervals of 20,40,60,80 DAS and at harvest stage.

Comment [FG5]: I assume this means days after sowing. But it should be clear

3. RESULTS AND DISCUSSION

3.1. Impact of foliar application of zinc and biofertilizers and on growth parameters

Impact of foliar application of zinc and biofertilizers on growth parameters of sorghum are in Table 1.

3.1.1. Plant height

The findings resulted that the treatment with dual inoculation of *Azospirillum* and PSB along with foliar application of 0.5% zinc at 50 DAS/ha recorded maximum plant height (163.31 cm). Similar findings were reported by Rafi and Charyulu *et al.*, [26], Prasad *et al.*, [25] and Priyanka *et al.*, [14]

3.1.2 Number of leaves per plant

The results revealed that maximum number of leaves per plant (12.87) was recorded with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was maximum over the other treatment combinations. Similar findings were reported by Anil kumar *et al.*, [2]

3.1.3. Dry matter accumulation

The results recorded that significantly highest plant dry matter accumulation (92.71 g) was observed with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was higher over the treatments. It is due to

better availability of nitrogen and phosphorus and the action of biofertilizer which lead in overall better development of the crop. The combined use of biofertilizer and foliar application of zinc just before flowering stage at 50 DAS helped in good foliage and good panicle development in the crop which improved the growth parameters due to increased dry matter production, which in turn contributed to improved yield attributes. Similar findings were reported by *et al.*, [26].

3.1.4. Absolute growth rate

At 80-100 DAS, results revealed that significantly highest absolute growth rate (1.33 g/plant/day) was observed with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was superior over the treatments.

3.1.5. Crop growth rate

At 80-100 DAS, significantly highest crop growth rate (44.31 g/m²/day) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of zinc at 50 DAS over control.

3.1.6. Leaf area

At 80 DAS, significantly highest leaf area (414.67 cm²) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of zinc at 50 DAS.

Comment [FG6]: These should be explained in methods

Table 1. Impact of biofertilizers and foliar application of zinc on growth parameters of sorghum

Treatments	Growth parameters (80DAS)					
	Plant height (cm)	No. of leaves per plant	Dry matter accumulation	Absolute growth rate (g/plant/day) 80-100 DAS	Crop growth rate (g/m ² /day) 80-100 DAS	Leaf area (cm ²)
1. Control 80:40:40 kg NPK/ha (Farmer's Practice)	143.98	11.53	75.71	1.12	37.32	312.90
2. <i>Azospirillum</i> sps. 25 gm/kg seeds + 0.5% zinc foliar spray 30 DAS	153.75	11.67	81.66	1.15	38.32	343.03
3. <i>Azospirillum</i> sps. 25 gm/kg seeds + 0.5 % zinc foliar spray 50 DAS	153.90	12.47	83.30	1.19	39.57	337.50
4. <i>Azospirillum</i> sps. 25 gm/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS	157.07	12.67	85.54	1.25	41.74	383.00
5. PSB 25 gm/kg seeds + 0.5% zinc foliar spray 30 DAS	158.95	11.73	86.03	0.99	32.99	374.90
6. PSB 25 gm/kg seeds + 0.5 % zinc foliar spray 50 DAS	161.30	11.93	85.03	1.15	38.29	362.57
7. PSB 25 gm/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS	161.67	11.60	90.32	1.02	33.83	396.53
8. <i>Azospirillum</i> sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 30 DAS	155.91	11.53	86.19	0.86	28.81	386.13
9. <i>Azospirillum</i> sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 50 DAS	163.31	12.87	92.71	1.33	44.31	414.67
10. <i>Azospirillum</i> sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 30 + 50 DAS	154.73	12.60	86.69	1.00	33.35	378.07
F test	S	S	S	S	S	S
Sem (\pm)	2.34	0.34	0.83	0.06	0.91	1.46
CD (P=0.05)	6.95	1.00	2.47	0.17	5.67	4.34

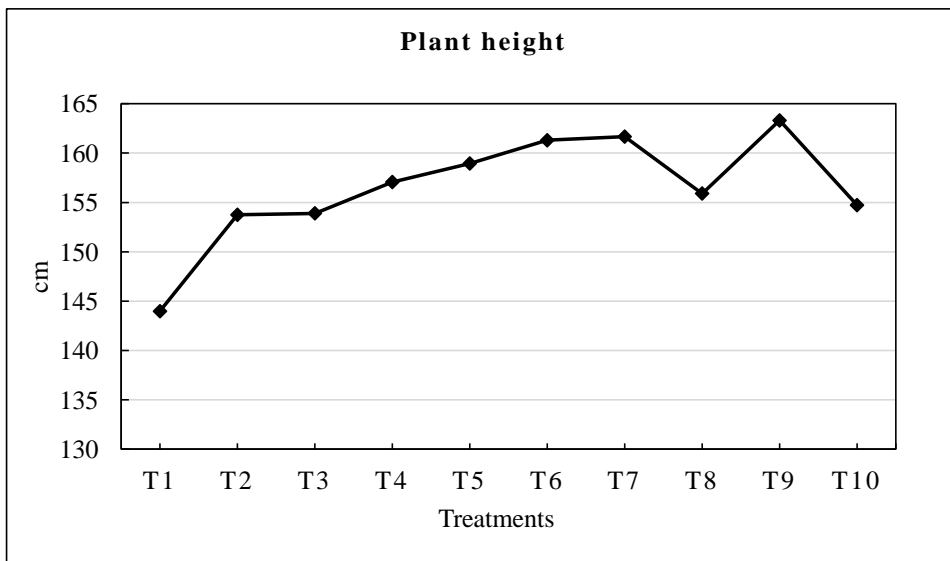


Fig. 1. Impact of biofertilizers and foliar application of seaweed on plant height of sorghum

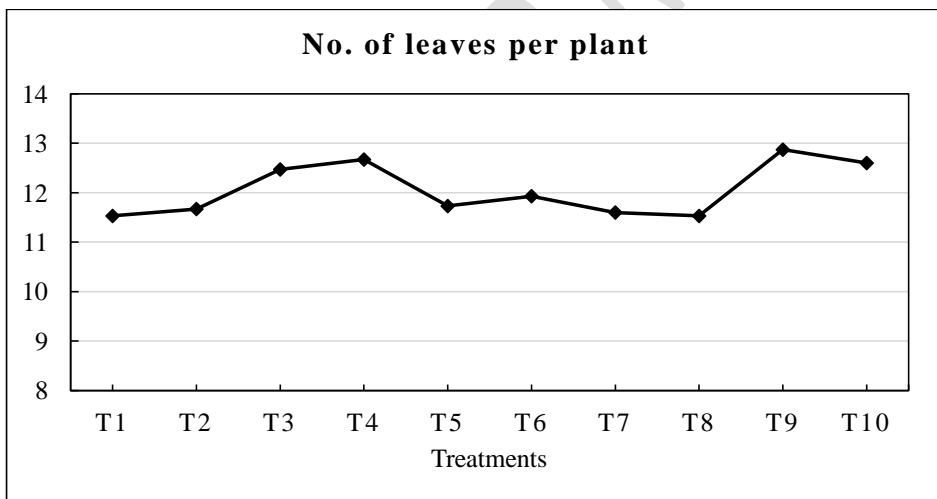


Fig. 2. Impact of biofertilizers and foliar application of seaweed on No. of leaves per plant of sorghum

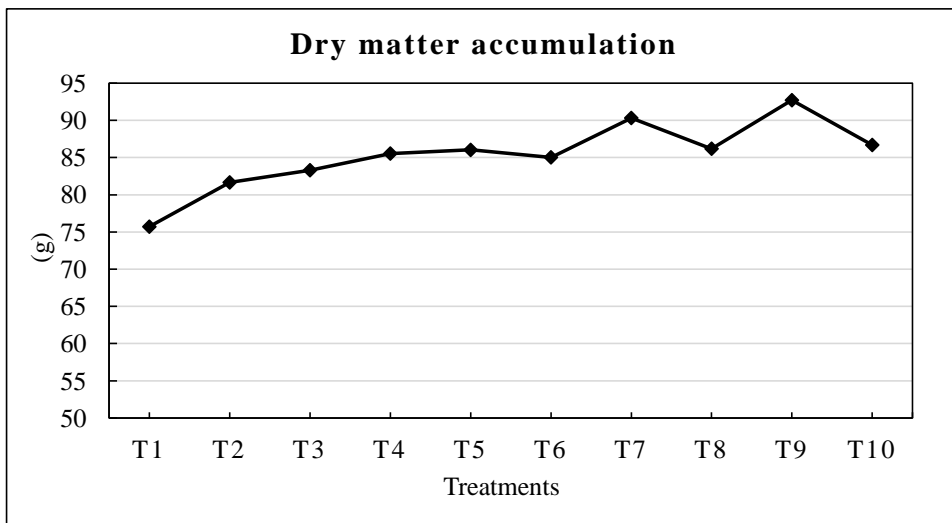


Fig. 3. Impact of biofertilizers and foliar application of seaweed on dry matter accumulation of sorghum

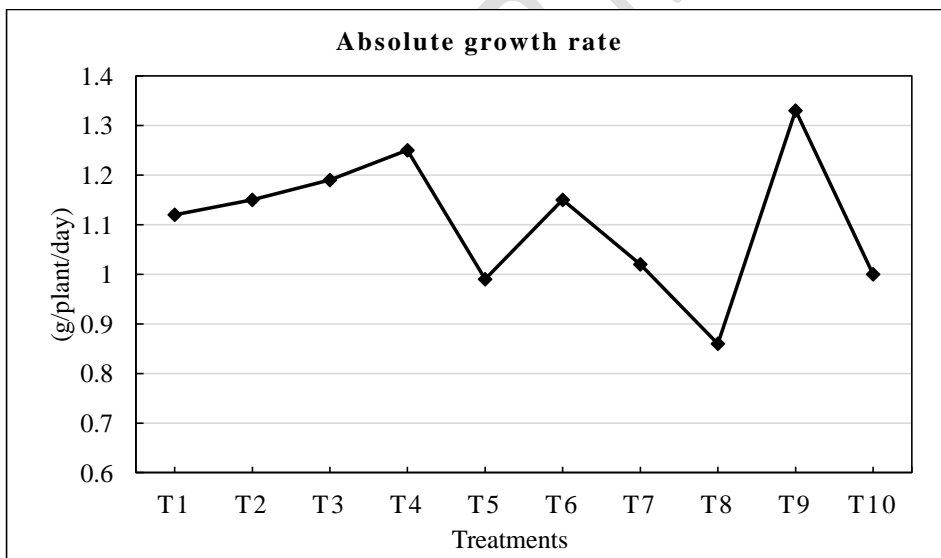


Fig. 4. Impact of biofertilizers and foliar application of seaweed on absolute growth rate of sorghum

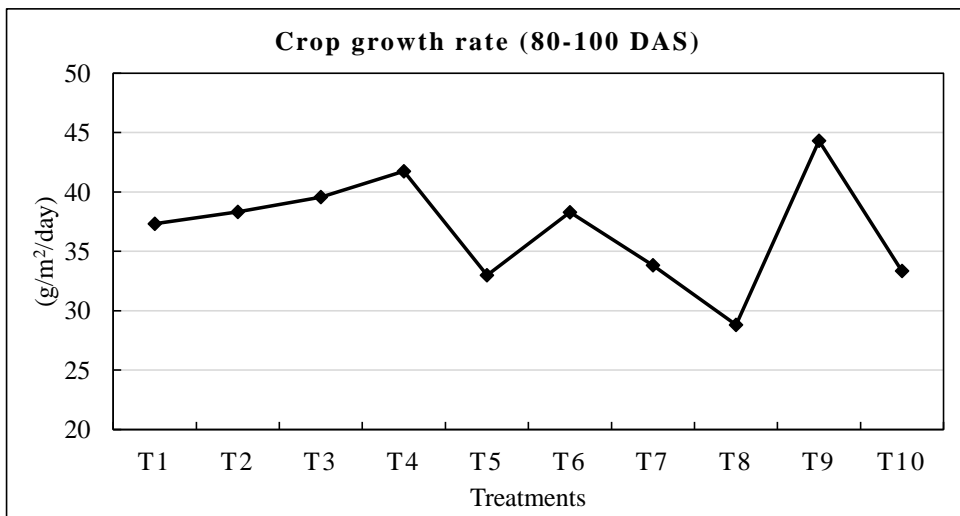


Fig. 5. Impact of biofertilizers and foliar application of seaweed on crop growth rate of sorghum

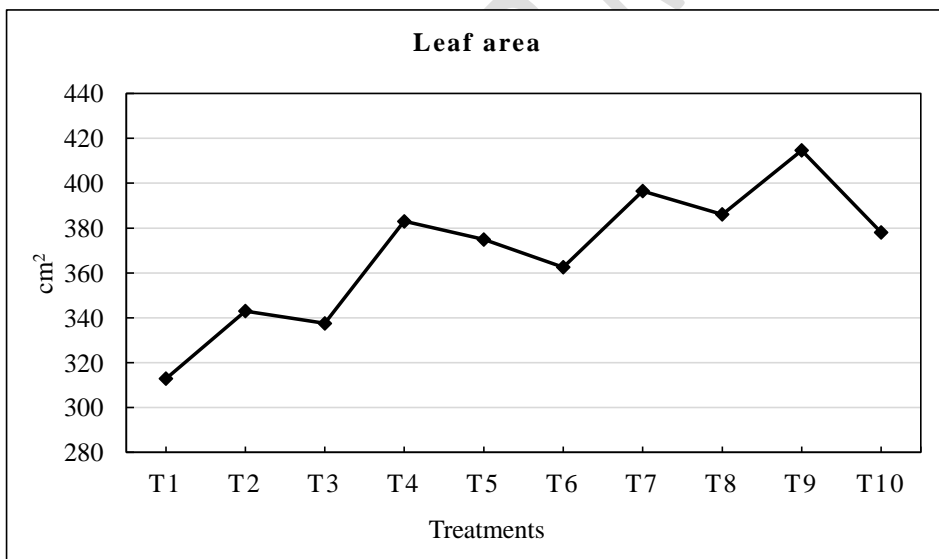


Fig. 6. Impact of biofertilizers and foliar application of seaweed on leaf area of sorghum

Comment [FG7]: this information is already in the table. So the information is being duplicated.

Conclusion

The findings of this study suggest that sorghum should be sown with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha as it has resulted in higher growth and development of sorghum.

References

1. Ali Soleymani and Mohamad Hesam Shahrajabian. The Effects of Fe, Mn and Zn Foliar Application on Yield, Ash and Protein Percentage of Forage Sorghum in Climatic Condition. *International Journal of Biology* 2012;4(3):92-96.
2. Anil Kumar S, Chidanandappa HM and Vijay Sankar Babu M. Effect of different sources of zinc on growth, yield and uptake of nutrients by maize crop (*Zea mays* L.). *Mysore Journal Agriculture Science*. 2010;44(1):92-99.
3. Aref F. Effect of different zinc and boron application methods on leaf nitrogen, phosphorus and potassium concentrations in maize grown on zinc and boron deficient calcareous soils. *Journal of Soil and Nature*. 2012;6(1):1-10.
4. Bhoya M, Chaudhary PP, Raval CH and Bhatt PK. Effect of nitrogen and zinc on growth and yield of fodder sorghum (*Sorghum bicolor* L.) varieties. *International Journal of agricultural Science*. 2014;10(1):294-297.
5. Chalwade PB, Bakan RG, Kulkarni VK and Khandare RN. Effect of organic manure and inorganic fertilizers on grain and stover yield of kharif sorghum. *Annals of Plant Physiology*. 2005;19(2):181-183.
6. Chaudhary PP, Patel KH, Italia AP, Garaniy NH and Patel D D. Effect of sulphur and zinc with organics on yield and quality of fodder sorghum under south Gujarat condition. *Journal of Pharmacognocny and Phytochemistry*. 2018;7(5):1711-1714.
7. Choudhary GL, Rana KS, Bana RS and Prajapat K. Soil microbial properties, growth and productivity of pearl millet (*Pennisetum glaucum* L.) as influenced by moisture management and zinc fortification under rainfed conditions. *Journal of Microbiology Research*. 2014;8(36):3314-3323.

8. Ghodpage RM, Balpande SS, Babhulkar VP and Sarika Pangade. Effect of phosphorous and zinc fertilization on nutrient content in root, yield and nutritional quality. *Journal soils and crops*. 2008;18(2):458-461.
9. Harpreet Kaur oberoi, Gulab Pondove and Anupreet Kaur. Effect of pre-sowing seed inoculation with liquid biofertilizers on fodder yield and quality of sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy*. 2020;65(1):100-106.
10. Jakhar SR, Singh M and Balai CM. Effect of farm yard manure, phosphorus and zinc levels on growth, yield, quality and economics of pearl millet (*Pennisetum glaucum*). *Indian Journal of Agricultural Sciences*. 2006;76(1):58-61.
11. Jan M, Anwar-ul-haq, M, Tanveer-ul-haq, Ali S and Wariach EA. Evaluation of soil and foliar applied zinc sources on rice (*oryza sativa*) genotypes in saline environments. *International Journal of Agriculture and biology*. 2016;18(3):643-648.
12. Jat M.K., Purohit H. S., Bahadur Singh, Garhwal RS and Mukesh Choudhary. Effect of integrated nutrient management on yield and nutrient uptake in sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy*. 2013;58(4):543-547.
13. Kalibhavi CM, Patil RH and Kachapur MD. Studies on integrated nutrient management in rabi sorghum. *Journal of Maharashtra Agricultural Universities*. 2003; 28:104-105.
14. Kaushik MK, Priyanka Pareek, Singh P, Sumeriya HK. Effect of Iron and Zinc on Yield and Quality of Sorghum Fodder. *Forage Research*. 2010; 36:181-184.
15. Kotangale, Vandana S, Bharambe PR, Katore, and Ravankar HN. Influence of organic and inorganic fertilizers on fertility status of soil under sorghum-wheat cropping sequence in vertisol. *Journal of soils and crops*. 2009;19(2):347-350.
16. Krishna S and Bhushan. Effect of different doses of zinc and its methods of application on yield and chemical composition of wheat. *Agriculture Science Digest*. 2004;24(2):124-126.
17. Kubsad VS. Agronomic fortification of iron and zinc with organics in post-rainy season sorghum (*Sorghum bicolor*) *Indian Journal of Agronomy*. 2019;64 (4):501-505.

18. Kumar R, Kumar D, Singh RM, Kumar P and Khippal A. Effect of phosphorus and zinc nutrition on growth and yield of fodder cowpea. *Legume Research*. 2016;39(2):262-267.
19. Manish Kushwaha, Magan Singh, Rakesh Kumar, Nitin Tyagi, Pooja Gupta Soni, Sunita Choudhary and Govind Makarana. Yield and Quality of Multicut Fodder Sorghum as Affected by Nutrient Levels and Biofertilizer Application. *Indian Journal of animal nutrition*. 2018;35(1):82-89.
20. Mishra., Thakur N.S., Singh P., Kubsad V.S., Kalpana R., Alse, U.N. and Nemade S.M., Tillage and integrated nutrient management in rainy season grain sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy*. 2014; 59:619-623.
21. Mitesh Bhoja, Chaudhari, PP, Raval CH, Bhatt PK. Effect of Nitrogen and Zinc on Yield and Quality of Fodder Sorghum Varieties. *Forage Research*. 2013;39(1):24-26.
22. Mohan S, Dar EA and Singh M. Fodder quality of teosinte fodder as influenced by nitrogen, phosphorus and zinc application. *International Journal of Pure and Applied Bioscience*. 2017;5(3):596-604
23. Murthy, Dakshina KM and Rao A, Upendra. Effect of organically bound micronutrients on growth and yield of rice. *Journal of Eco-friendlily Agriculture*. 2008;3(1):86-87.
24. Nataraja TH, Halepyati AS, Pujari BT and Desai BK. Grain yield, dry matter production and its partitioning in wheat as influenced by interactive effects of iron, zinc and phosphorus levels. *Karnataka Journal Agriculture Science*. 2005;18(4):1071-1074.
25. Prasad SK, Singh MK and Singh R. Effect of Nitrogen and Zinc fertilizer on pearl millet under agri-horti system of eastern Uttar Pradesh. *The Bioscan*. 2014;9(1):163-166.
26. Rafi M MD, Varalakshmi and Charyulu PBBN. Influence of *Azospirillum* and PSB inoculation on growth and yield of Foxtail Millet. *Journal Microbiology and Biotechnology Research*. 2012; 2(4):558-565.
27. Rana DS, Bhagat Singh, Gupta K, Dhaka AK, and Satyawan Arya. Response of Fodder Sorghum to Zinc and Iron. *Forage Research*. 2013;39(1):45-47.

28. Shanka MA, Thimmegowda MN and Bhavitha NC. Integrated nutrient management for enhancing the productivity of finger millet under dry land condition. *Mysore Journal of Agricultural Science*. 2015;49(3):502-509.
29. Sutaria GS, Ramdevputra MV, Akbari K N. Effects of Potassium and Zinc Nutrition on Yield and Quality of Forage Sorghum. *Indian Journal Agriculture Research*. 2013;47(6):540-544.

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