Madras Agric.J.,2025; https://doi.org/10.29321/MAJ.10.901248

RESEARCH ARTICLE

Effect of Soil and Foliar Zinc Fertilization on Growth and Fodder Yield of Cumbu Napier [CO (BN) 5] under Zinc-Deficient Soils of Tamil Nadu

Soorya. M[1], Suganya. S[2*], Elayarajan. M[3], Chitra. P[2], Davamani. V[3], Sanjeeb Kumar Behera[4]

[1]Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore,
[2]Department of Agronomy, Veterinary and Animal Sciences Unit TNAU, Coimbatore,
[3]Associate Professor, Department of Environmental Sciences, Directorate of NRM, TNAU, Coimbatore,
[4]Head of the Department, Division of Soil Chemistry & Fertility & I/c Project Coordinator AICRP-MSPE, Indian Institute of Soil Science, Bhopal.

Received: 19 Aug 2025

Revised: 24 Oct 2025

Accepted: 09 Dec 2025

ABSTRACT

A field experiment was conducted at Anaikatti, Coimbatore district, Tamil Nadu, to evaluate the effect of zinc fertilization on the growth and yield attributes of Cumbu Napier [CO (BN) 5]. The treatments included soil and foliar applications of zinc sulphate at different levels in combination with soil-test-based NPK recommendations. Results indicated that the combined application of soil test-based NPK + 25 kg $ZnSO_4$ ha^{-1} + 0.5% $ZnSO_4$ foliar spray applied thrice at 10-day intervals (T_4) significantly improved plant height, number of tillers, SPAD values, and green fodder yield compared to other treatments. The enhanced growth and yield performance under T_4 was attributed to improved zinc availability, increased photosynthetic efficiency, and better enzymatic and hormonal regulation. These findings indicate the potential of combined soil and foliar zinc application to maximize fodder yield and maintain the nutritional quality of Cumbu Napier.

Keywords: Cumbu Napier [CO (BN) 5]; Zinc fertilization; Combined soil and foliar application; SPAD chlorophyll content; Growth and yield attributes

INTRODUCTION

Zinc (Zn) is one of the most essential micronutrients required for the normal growth, development, and metabolic functioning of plants. Although needed in small quantities, its deficiency has become a major constraint on agricultural productivity, particularly in tropical soils where intensive cultivation, low organic matter, and imbalanced fertilizer use have depleted available zinc reserves (Alloway, 2008). In India, nearly 50% of cultivated soils are reported to be zinc-deficient, which adversely affects crop growth, yield, and quality (Singh *et al.*, 2017).

Zinc plays a vital role in several physiological and biochemical processes, including enzyme activation, auxin synthesis, chlorophyll formation, and protein metabolism (Broadley *et al.*, 2007). In fodder crops, zinc deficiency not only limits vegetative growth and biomass production but also reduces the nutritional quality of the forage, indirectly influencing animal health and productivity

*Corresponding author mail: suganssac2010@tnau.ac.in

(Kumar *et al*., 2021). Therefore, the balanced application of micronutrients such as zinc, along with macronutrient-based fertilizer recommendations, is essential for sustaining fodder yield and improving its nutritive value.

Cumbu Napier [CO (BN) 5], a perennial hybrid between *Pennisetum glaucum* and *Pennisetum purpureum*, is widely cultivated for its high biomass potential, rapid growth rate, and palatability to livestock (Madesh *et al*., 2021). However, the productivity of this high-yielding fodder crop is greatly influenced by nutrient availability, particularly zinc, which regulates both growth and photosynthetic efficiency (Ramesh *et al*., 2020). While soil application of zinc improves the long-term nutrient status of the rhizosphere, foliar application offers a rapid correction of deficiency during critical growth stages (Dambiwal *et al*., 2017). Thus, a combined soil-and-foliar application of zinc may offer synergistic benefits by ensuring sustained and immediate nutrient supply.

The present investigation was undertaken to study the effect of zinc fertilization through soil and foliar applications on the growth and yield attributes of Cumbu Napier [CO (BN) 5] grown under the zinc-deficient soils of Anaikatti, Coimbatore district, Tamil Nadu.

MATERIALS AND METHODS

The field experiment was conducted at a farmer's holding in Anaikatti village, Coimbatore district, Tamil Nadu, to evaluate the response of Cumbu Napier [CO (BN) 5] to different zinc fertilization levels. The subsequent laboratory analyses were carried out at the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University (TNAU), Coimbatore.

The experimental soil had a neutral pH (7.39), was non-saline (EC = 0.32 dS m^{-1}), and had a sandy clay loam texture. The soil contained medium organic carbon (0.56%), low available nitrogen (238 kg ha^{-1}), medium phosphorus (12.9 kg ha^{-1}), and potassium (261 kg ha^{-1}). The micronutrient status revealed zinc deficiency (0.72 mg kg^{-1}), while iron, manganese, and copper levels were sufficient.

The experiment was laid out in a Randomized Block Design (RBD) with five treatments and four replications. Details of the treatments are given in Table 1. Slips of Cumbu Napier [CO (BN) 5] were planted at a spacing of 60 × 50 cm. All agronomic practices were followed as per TNAU recommendations. Foliar sprays were applied at 10-day intervals starting 30 days after planting (DAP). The plant height, number of tillers per plant, and SPAD values were measured at 40, 50, and 60 days after planting, respectively.

RESULTS AND DISCUSSION

Growth Attributes

The growth attributes of Cumbu Napier [CO (BN) 5] fodder were significantly influenced by zinc fertilization (Table 2). Significant improvements were observed in plant height, number of tillers per clump, and SPAD values obtained at 40, 50, and 60 DAP, respectively. Among the treatments, the combined application of zinc through soil at 25 kg $ZnSO_4$ ha^{-1} + 0.5 % foliar spray of $ZnSO_4$ recorded the maximum plant height of 320.8 cm, which was significantly superior to the soil treated with STCR-based NPK recommendations alone. Similarly, the number of tillers per plant was highest under the integrated zinc treatment (T_4) with a value of 35.4, indicating enhanced vegetative growth.

The SPAD values, which indicate relative chlorophyll content, also showed significant improvement with zinc application. The highest SPAD readings were recorded in T_4 (40.0, 47.2, and 49.5 at 40, 50, and 60 DAP, respectively), followed

Table 1. Treatment Details

Treatment	Description
T_1	Soil test-based NPK recommendation
T_2	T_1 + SA 25 Kg $ZnSO_4$ ha^{-1}
T_3	T_1 + 0.5% $ZnSO_4$ FS thrice at 10 days intervals
T_4	T_1 + SA 25 Kg $ZnSO_4$ ha^{-1} + 0.5% $ZnSO_4$ FS thrice at 10 days intervals
T_5	T_1 + SA 12.5 Kg $ZnSO_4$ ha^{-1} + 0.5% $ZnSO_4$ FS thrice at 10 days intervals

Table 2. Effect of zinc fertilization on growth parameters

Trt. No.	Height (cm)			No. of tillers per plant			SPAD Values		
	40 DAP	50 DAP	60 DAP	40 DAP	50 DAP	60 DAP	40 DAP	50 DAP	60 DAP
T_1	143.4	211.5	235.9	20.3	22.3	23.3	35.0	38.8	40.1
T_2	162.0	239.4	290.0	27.2	30.0	33.3	39.7	42.4	44.8
T_3	157.0	231.8	269.5	20.4	27.4	27.4	36.2	40.1	43.2
T_4	178.6	265.3	320.8	28.8	34.4	35.4	40.0	47.2	49.5
T_5	162.5	252.3	294.1	21.6	31.8	32.1	37.9	44.5	46.1

by T_5 and T_2, all of which showed a significantly better response than the STCR-based NPK recommendation alone (T_1).

The increase in growth parameters may be attributed to zinc's essential role in auxin synthesis, protein formation, and enzyme activation, which promote meristematic activity, internodal elongation, and chlorophyll development. Adequate zinc nutrition enhances photosynthetic rate and assimilates production, resulting in taller plants and greater tiller formation (Alloway, 2008). The improved growth under foliar + soil application also reflects better zinc mobility and utilization, ensuring nutrient availability during critical growth phases (Singh *et al.*, 2019).

Furthermore, zinc application promoted root proliferation, facilitating efficient uptake of water and other essential nutrients, thereby supporting overall plant growth (Prasad *et al.*, 2016). The pronounced vegetative growth observed under combined zinc treatments aligns with the findings of Mir *et al.* (2025), who reported similar improvements in the growth and yield of fodder maize through zinc application. These results are also supported by Chaudhary *et al.* (2021), who observed that the vegetative growth of fodder crops was significantly enhanced by zinc fertilization under zinc-deficient soil conditions.

Yield Attributes

Zinc fertilization significantly affected the yield attributes of Cumbu Napier fodder (Table 3). The highest green fodder yield was recorded in T_4 (53.4 t ha^{-1} cut^{-1}), followed by T_5 (50.6 t ha^{-1} cut^{-1}), T_2 (48.2 t ha^{-1} cut^{-1}), and T_3 (44.8 t ha^{-1} cut^{-1}), all of which were significantly superior to T_1 (42.6 t ha^{-1} cut^{-1}). The dry fodder yield followed a similar trend, with T_4 producing 10.89 t ha^{-1} cut^{-1}, significantly higher than the T_1 (8.35 t ha^{-1} cut^{-1}) and other zinc treatments. The dry matter percentage was also highest in T_4 (20.4%), though differences among treatments were not statistically significant. The differences in green and dry fodder yield were significant (CD at 5% = 1.39 and 0.28 t ha^{-1} cut^{-1}, respectively).

The substantial increase in yield under T_4 can be attributed to enhanced plant growth, higher chlorophyll content (SPAD values), and improved nutrient uptake and utilization efficiency driven by adequate zinc availability. Zinc enhances nitrogen metabolism, carbohydrate synthesis, and

Table 3. Effect of zinc fertilization on growth parameters

Trt. No.	Green fodder yield (t ha^{-1} cut^{-1})	Dry fodder yield (t ha^{-1} cut^{-1})	Dry matter (%)
T_1	42.6	8.35	19.6
T_2	48.2	9.74	20.2
T_3	44.8	9.00	20.1
T_4	53.4	10.89	20.4
T_5	50.6	10.27	20.3

photosynthate translocation, which in turn increase biomass accumulation and fodder productivity (Rahman *et al*., 2020). The combined soil and foliar application ensures immediate nutrient absorption and sustained availability in the rhizosphere, providing continuous nutrient support throughout the growth period and enhancing green and dry fodder yields. Similar results were reported by Ramakrishna *et al*. (2022) in fodder maize, Nanda *et al*. (2025) in fodder oats, and Dambiwal *et al*. (2017) in sorghum, who all observed that combined zinc application significantly improved green fodder yield over individual application methods.

The enhanced dry matter yield in T_4 can also be associated with improved water-use efficiency and stomatal regulation under adequate zinc nutrition (Cakmak, 2000), as well as better uptake of macronutrients such as nitrogen and phosphorus (Broadley *et al*., 2007). The overall findings indicate that combined soil and foliar zinc fertilization substantially improves growth, photosynthetic efficiency, and yield performance of Cumbu Napier fodder, indicating the importance of balanced micronutrient management for sustainable fodder production.

CONCLUSION

The present study clearly demonstrated that zinc fertilization plays a pivotal role in enhancing the growth and yield performance of Cumbu Napier [CO (BN) 5]. Among the treatments, the combined application of soil test-based NPK + 25 kg $ZnSO_4$ ha^{-1} + 0.5% $ZnSO_4$ foliar spray applied thrice at 10-day intervals (T_4) recorded the highest plant height, number of tillers, SPAD values, and green as well as dry fodder yield. The improvement in growth and yield attributes under this treatment could be attributed to the synergistic effect of soil and foliar zinc application, which ensured both immediate and sustained zinc availability, thereby enhancing chlorophyll synthesis, photosynthetic efficiency, enzymatic activities, and nutrient uptake.

The findings confirm that combined zinc management not only improves biomass production but also enhances nutrient-use efficiency and plant growth. Hence, the combined soil and foliar application of zinc sulphate, along with soil-test-based NPK fertilization, is recommended as an effective and sustainable strategy to maximize fodder yield and maintain the nutritional quality of Cumbu Napier in zinc-deficient soils of Tamil Nadu.

REFERENCES

Alloway, B. J. (2008). *Zinc in soils and crop nutrition* (2nd ed.). International Zinc Association & International Fertilizer Industry Association.

Broadley, M. R., White, P. J., Hammond, J. P., Zelko, I., & Lux, A. (2007). Zinc in plants. *New Phytologist, 173*(4), 677–702. https://doi.org/10.1111/j.1469-8137.2007.01996.x

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil, 302*(1–2), 1–17. https://doi.org/10.1007/s11104-007-9466-3

Chaudhary, M., Dwivedi, K., Sah, R., Gajghate, R., Ahmed, S., & Singh, K. (2021). Zinc biofortification of fodder oat (*Avena sativa* L.) through bioinoculant and synthetic fertilizers. *Range Management and Agroforestry, 42*(1), 181–185.

Dambiwal, D., Katkar, R. N., Kumawat, K. R., Hakla, C. R., Bairwa, B., Kumar, K., & Lakhe, S. R. (2017). Effect of soil and foliar application of zinc on sorghum (*Sorghum bicolor* (L.) Moench) yield, agronomic efficiency and apparent recovery efficiency. *International Journal of Chemical Studies, 5*(4), 435–438.

Kumar, B., & Ram, H. (2021). Biofortification of maize fodder with zinc improves forage productivity and nutritive value for livestock. *Journal of Animal and Feed Sciences, 30*(2), 149–158. https://doi.org/10.22358/jafs/135932/2021

Madesh, M., Kishore, K. R., Kumar, D. S., & Anitha, A. (2021). Nutrient intake, digestibility and rumen fermentation parameters in buffalo bulls fed Cumbu Napier (CO (BN) 5) fodder. *Indian Journal of Animal Nutrition, 38*(2), 195–200. https://doi.org/10.5958/2231-6744.2021.00031.1

Mir, N. H. (2020). Yield and quality assessment of fodder maize–legume intercropping systems with zinc fortification. *Journal of Plant Nutrition*. (In press)

Prasad, R., Shivay, Y. S., & Kumar, D. (2016). Interactions of zinc with other nutrients in soils and plants: A review. *Indian Journal of Fertilisers, 12*(5), 16–26.

Rahman, R., Sofi, J. A., Javeed, I., Malik, T. H., & Nisar, S. (2020). Role of micronutrients in crop production. *International Journal of Current Microbiology and Applied Sciences, 8*(11), 2265–2287.

Ramakrishna, C. H., Madhavi Lata, A., Murali, B., Madhavi, A., & Venkateswarlu, M. (2022). Yield and silage quality of fodder maize (*Zea mays* L.) as influenced by zinc fertilization. *The Pharma Innovation Journal, 11*(5), 1799–1802.

Singh, C., Singh, B., Satpal, P. K., Ankush, M., Gora, K., & Kumar, A. (2019). Micronutrient management for enhancing production of major fodder crops: A review. *Forage Research, 45*(2), 95–102.

Singh, S., & Singh, V. (2017). Productivity, quality and nutrient uptake by maize (*Zea mays* L.) as affected by sources and levels of zinc. *Annals of Plant and Soil Research, 19*(1), 95–99.