



Identification of Soil Fertility in Tobacco-growing Areas in Nandyal District, Andhra Pradesh, India

**K. Sathish Babu ^a, Y. S. Sathish Kumar ^{b*}, T. Pullibhai ^a,
K. Arun Kumar ^a, M. Jaya Lakshmi ^a, M. Johnson ^b,
K. Kasturi Krishna ^c, K. Sarala ^c and M. Sheshu Madhav ^c**

^a Regional Agricultural Research Station, Nandyal, ANGRAU, Andhra Pradesh, India.

^b Agricultural College, Mahanandi, ANGRAU, Andhra Pradesh, India.

^c National Institute for Research on Commercial Agriculture, Rajahmundry, Andhra Pradesh, India.

Authors' contributions

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

Article Information

DOI: <https://doi.org/10.9734/ijpss/2026/v38i106390>

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://pr.sdiarticle5.com/review-history/168638>

Original Research Article

Received: 30/08/2026

Accepted: 22/10/2026

Published: 28/10/2026

Abstract

Soil fertility evaluation provides a basis for nutrient management in bidi tobacco-growing areas where spatial variation in soil properties may affect nutrient availability. This study assessed the physicochemical characteristics and available macro- and micronutrients of soils in Nandyal district, Andhra Pradesh, India. During kharif 2024–25, 150 soil samples were collected from farmers' fields across 15 villages, with 10 samples per village. Samples were analysed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium, and DTPA-extractable zinc, iron, manganese and copper. Results summarised for five locations showed alkaline soil reaction (pH 7.86–8.21) and low electrical conductivity (0.05–0.07 dS m⁻¹). Mean organic carbon was 0.324%, while mean available nitrogen was 178.6 kg ha⁻¹. Available phosphorus and potassium averaged 61.6 and 513.8 kg ha⁻¹, respectively, and were classified as relatively high at the reported locations. Mean available zinc was 0.52 mg kg⁻¹; four of five location means were below the study's 0.60 mg kg⁻¹ critical limit. Iron averaged 5.02 mg kg⁻¹, with one location mean below 5.0 mg kg⁻¹, whereas manganese and copper values exceeded the stated critical limits. Reported tobacco yields

*Corresponding author: E-mail: ys.sathishkumar@angrau.ac.in;

ranged from 1,950 to 2,350 kg ha⁻¹. Exploratory correlations based on five location means did not establish causal nutrient–yield relationships. These findings support location-specific soil testing, attention to organic matter and nitrogen management, and field evaluation of zinc correction measures.

Keywords: Soil fertility; bidi tobacco yield; macro nutrients; micro nutrients and Nandyal District.

1. Introduction

Tobacco is a quality-sensitive commercial crop cultivated in Kurnool district, Andhra Pradesh. Assessment of soil fertility, including micronutrient status, in commercial crop-growing regions is essential for effective natural resource management, promoting crop diversification and enhancing agricultural productivity. The physicochemical properties and micronutrient status of soils exhibit considerable variability, influencing the type, grade and quality of tobacco produced. Among the various factors affecting tobacco productivity, soil fertility and fertiliser application contribute nearly 50% to improvements in crop yield and quality. A comprehensive understanding of soil fertility constraints is therefore necessary for developing appropriate fertiliser recommendations and enhancing the productivity of tobacco and other major crops cultivated in the region. Considering these factors, an assessment of soil fertility in the tobacco-growing areas of Kurnool district is essential.

Soil plays a fundamental role in maintaining the sustainable productivity of agroecosystems, primarily through its capacity to supply essential nutrients required for crop growth and development. However, continuous nutrient removal through crop cultivation without adequate replenishment has resulted in the progressive depletion of soil macro- and micronutrients. It is well established that optimum plant growth and crop yields depend on the availability of nutrients in the soil rather than their total concentrations (Singh *et al.*, 2013).

The quality of leaves produced by flue-cured Virginia (FCV) tobacco is of considerable commercial importance. Nitrogen and potassium are essential nutrients that play significant roles in improving tobacco leaf quality. Consequently, their efficient utilisation and appropriate management are crucial for achieving optimum tobacco growth, yield and quality. Similarly, the application of micronutrients is important for enhancing tobacco productivity and maintaining desirable leaf quality. Hoppe (1988) reported that a higher rate of copper (Cu) fertilisation resulted in the highest proportion of superior-quality tobacco leaves. Furthermore, Baber *et al.* (1987) observed that the application of zinc (Zn) and boron (B) increased FCV tobacco yield, whereas Cu fertilisation enhanced the potassium and sugar contents of tobacco leaves.

The relatively high soil pH observed in tobacco-growing fields in Chenzhou may be attributed to the application of superphosphate fertilisers and the traditional practice of incorporating fired soil to improve soil quality (Li *et al.*, 2020). Additionally, the occurrence of tobacco-growing fields in the limestone hills and mountainous regions of Chenzhou may contribute to the elevated soil pH (Li *et al.*, 2019). The continued increase in soil phosphorus levels may be associated with the excessive and prolonged application of phosphate fertilisers by farmers in China, primarily because of their relatively low cost and beneficial effects on crop yield (Liu *et al.*, 2020). Similarly, increasing potassium levels have been associated with substantial potassium fertiliser application to produce high-quality tobacco leaves, which generally contain high concentrations of potassium (Cao, 1991). In contrast, soil sulphur (S) content declined from 51.92 mg/kg in 2000 to 39.42 mg/kg, potentially reflecting the reduced application of potassium sulphate in tobacco cultivation due to soil acidification. Furthermore, excessive sulphur concentrations may adversely influence tobacco leaf quality (Kissel *et al.*, 2020). A recent field study of flue-cured Virginia tobacco evaluated phosphorus management in relation to nutrient uptake and post-harvest soil properties (Soumya *et al.*, 2026).

Tobacco (*Nicotiana tabacum* L.) is an important commercial crop cultivated in different agroclimatic regions of India. In Andhra Pradesh, bidi tobacco cultivation provides an important source of income and employment to farming communities, particularly in the traditional tobacco-growing areas of the erstwhile Kurnool district, which includes the present Nandyal district. Tobacco is a nutrient-demanding crop, and its productivity and leaf quality are greatly influenced by soil fertility and nutrient availability. Balanced nutrition is essential not only for achieving higher leaf yields but also for maintaining desirable chemical and physical characteristics of tobacco leaves. Both nutrient deficiencies and excessive nutrient availability can adversely affect tobacco growth, yield and quality. A village-level soil fertility assessment in Maharashtra evaluated soil reaction, electrical conductivity, organic carbon and available nitrogen, phosphorus and potassium to identify local nutrient constraints (Patil *et al.*, 2026).

The soils of tobacco-growing regions in Nandyal district exhibit considerable variability in fertility characteristics due to differences in parent material, soil type, cropping history, fertiliser management and environmental conditions. Many agricultural soils in this region are neutral to alkaline in reaction, and variations in soil organic carbon, available nitrogen, phosphorus, potassium and micronutrients may influence crop performance. Low organic carbon and nitrogen availability, along with deficiencies of micronutrients such as zinc and iron, are important concerns in intensively cultivated soils. In alkaline soils, the availability of certain micronutrients may be restricted due to reduced solubility, even when their total concentrations are relatively high. Research in northeastern India has combined soil physicochemical characteristics and plant-available micronutrient measurements to delineate nutrient management zones (Shukla *et al.*, 2024). Long-term nutrient management research in a pearl millet–wheat system has also documented changes in soil zinc fractions and DTPA-extractable zinc (Saroja *et al.*, 2024). A related soil fertility assessment has been reported for FCV tobacco-growing soils in Andhra Pradesh (Prasad *et al.*, 2021).

The continuous cultivation of tobacco and other commercial crops, coupled with the application of fertilisers without adequate consideration of soil test values, may contribute to nutrient imbalances. Excessive application of certain nutrients and insufficient replenishment of others can result in reduced fertiliser-use efficiency, increased cultivation costs and deterioration of soil fertility. Hence, a systematic evaluation of soil fertility in tobacco-growing areas is necessary to identify the spatial variability of nutrients

and formulate site-specific fertiliser recommendations. Although soil fertility assessment is essential for sustainable tobacco production, location-specific information on the distribution and availability of soil nutrients in the major bidi tobacco-growing villages of Nandyal district remains important for improving nutrient management practices. A comprehensive evaluation of soil chemical properties and available nutrient status can provide valuable baseline information for identifying fertility constraints and developing appropriate soil management strategies. For the selected bidi tobacco-growing locations in Nandyal district, a comparable baseline of soil physicochemical properties, available macronutrients and DTPA-extractable micronutrients is needed to identify location-level fertility constraints without inferring causal relationships with yield.

Keeping these considerations in view, the present investigation was undertaken to assess the fertility status of soils in the major tobacco-growing areas of Nandyal district, Andhra Pradesh. A total of 150 surface soil samples were collected from farmers' fields across 15 villages, with 10 samples representing each village, during the post-Kharif and pre-Rabi period. The soil samples were analysed for important physicochemical properties and the availability of major and micronutrients to assess the fertility status of the study area. The findings are expected to provide useful information for identifying nutrient deficiencies and imbalances, promoting balanced fertiliser application and improving the productivity and sustainability of tobacco-based cropping systems.

2. Materials and Methods

2.1 Study Area under Bidi Tobacco

The study area, located in Nandyal district of Andhra Pradesh, falls within the state's scarce-rainfall zone. The region is recognised as one of the major bidi tobacco-producing areas in India, with soils suitable for the cultivation of export-quality bidi tobacco. The area receives a normal annual rainfall of approximately 1,045 mm. The major physiographic units comprise alluvial plains and uplands, while the predominant geological formations include Alluvium, Tertiaries, Gondwanas, Deccan Traps and Archeans. The soils exhibit considerable variation in texture and characteristics, ranging from red sandy loams to sandy clay loams in the upland regions and from clay loams to clay soils in the deltaic alluvial plains. According to soil taxonomy, the predominant soils are classified as Rhodustalfs, Ustochrepts and Haplusterts, which have developed from parent materials comprising red sandstones, crystalline metamorphic rocks and alluvial deposits. The agricultural production systems in the study area are diverse, with irrigated bidi tobacco being an important commercial crop. Other major crops cultivated in the region include cotton, maize, Bengal gram, chillies, groundnut and paddy. In addition, mango, citrus and banana are the predominant horticultural crops grown in the area.

2.2 Sample Collection and Analysis

Soil sampling was carried out in bidi tobacco-growing villages of Nandyal district during the kharif season of 2024–2025. Representative villages were selected to ensure adequate spatial coverage and account for variations in soil types across the study area. Soil samples were collected from the fields of different farmers in 15 villages distributed across the Nandikotkur, Kottapalli, Orvakal, Gadivemula and Atmakur mandals, representing the southern light-soil region under bidi tobacco cultivation.

Representative soil samples were collected from a depth of approximately 15 cm (6 inches) below the soil surface with the assistance of local farmers. Following collection, the samples were air-dried, ground and passed through a 2 mm sieve to obtain uniform samples for laboratory analysis. The processed soil samples were analysed for important physicochemical properties, including soil pH, electrical conductivity (EC) and organic carbon (OC) content, as well as the availability of major nutrients, namely nitrogen (N), phosphorus (P) and potassium (K). Available nitrogen was determined using the method described by Subbiah and Asija (1956), available phosphorus was estimated following Olsen *et al.* (1954), and available potassium was determined according to Jackson (1973).

The concentrations of available micronutrients, namely zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu), were determined using the diethylenetriaminepentaacetic acid (DTPA) extraction method described by Lindsay and Norvell (1978). Soil micronutrients were extracted using a solution containing 0.005 M DTPA, 0.1 M triethanolamine and 0.01 M calcium chloride (CaCl_2), followed by quantification using atomic absorption spectrophotometry (AAS).

The critical limits adopted for identifying micronutrient deficiencies were 0.60 mg kg⁻¹ for DTPA-extractable Zn, 5.0 mg kg⁻¹ for DTPA-extractable Fe, 0.20 mg kg⁻¹ for DTPA-extractable Cu and 2.0 mg kg⁻¹ for DTPA-extractable Mn. Based on the established soil critical limits, the analysed soil samples were classified into five categories to assess their nutrient status and identify potential soil fertility constraints in the bidi tobacco-growing areas of Nandyal district.

3. Results and Discussion

3.1 Soil Reaction and Electrical Conductivity

The soil reaction of bidi tobacco-growing areas of Nandyal district varied from slightly to moderately alkaline, with pH values ranging from 7.86 to 8.21 (Table 2). The highest soil pH was recorded in Nandikotkur (8.21), followed by Gadivemula (8.16), Kothapalli (8.06), Velugodu (8.02) and Atmakur (7.86). The mean soil pH was 8.06, indicating predominantly alkaline conditions. Alkaline soil reaction may reduce the solubility of micronutrients, particularly zinc and iron. Electrical conductivity ranged from 0.05 to 0.07 dS m⁻¹, with a mean of 0.062 dS m⁻¹. All locations were non-saline, suggesting that soluble salts were not a major soil constraint (Poorna Bindu *et al.*, 2025).

3.2 Organic Carbon Status

Soil organic carbon ranged from 0.30 to 0.36%, with a mean of 0.324%, indicating generally low organic carbon status. The highest value was recorded in Velugodu (0.36%), followed by Atmakur and Kothapalli (0.33% each); the lowest values occurred in Gadivemula and Nandikotkur (0.30% each). Low organic carbon may reflect limited organic residue inputs and rapid decomposition under warm conditions, although management histories were not recorded. The addition of organic manures, compost and crop residues may improve soil aggregation, moisture retention and nutrient cycling (Poorna Bindu *et al.*, 2025).

3.3 Available Nitrogen Status

Available nitrogen varied from 166 to 189 kg ha⁻¹, with a mean of 178.6 kg ha⁻¹. Nandikotkur recorded the highest nitrogen (189 kg ha⁻¹), followed by Velugodu (184), Gadivemula (178), Kothapalli (176) and Atmakur (166 kg ha⁻¹). All five location means fell within the low nitrogen category under commonly used soil-test limits. Low nitrogen coincided with low organic carbon and suggests restricted nitrogen-supplying capacity. Nitrogen is important for tobacco leaf development, but excess supply can alter maturity and leaf quality. Balanced, soil-test-based nitrogen management and organic nutrient additions are therefore appropriate priorities (R. Prasad *et al.*, 2016; Singh *et al.*, 2013; Poorna Bindu *et al.*, 2025).

3.4 Available Phosphorus Status

Available phosphorus (P₂O₅) ranged from 59.2 to 65.2 kg ha⁻¹, averaging 61.6 kg ha⁻¹. Nandikotkur had the highest concentration (65.2 kg ha⁻¹), followed by Atmakur (62.8), Gadivemula and Velugodu (60.4 each) and Kothapalli (59.2 kg ha⁻¹). The values indicate relatively high soil-test phosphorus reserves. Residual phosphorus from earlier fertiliser application is a possible explanation, although fertilizer histories were unavailable. Phosphorus accumulation in tobacco soils following sustained fertilizer inputs has been discussed by Liu *et al.* (2020). Soil-test-based phosphorus application could avoid unnecessary inputs.

3.5 Available Potassium Status

Available potassium (K₂O) ranged from 486 to 537 kg ha⁻¹, with a mean of 513.8 kg ha⁻¹. Gadivemula recorded the highest value (537 kg ha⁻¹), followed by Atmakur (531), Velugodu (521), Nandikotkur (494) and Kothapalli (486 kg ha⁻¹). All five-location means were in the high potassium category under conventional rating limits. Potassium contributes to stomatal regulation, water relations and tobacco leaf quality (Cao, 1991; Poorna Bindu *et al.*, 2025). Despite these high reserves, fertiliser recommendations should consider crop demand and local soil tests.

3.6 Available Micronutrient Status

DTPA-extractable iron ranged from 4.62 to 5.17 mg kg⁻¹ (mean 5.02 mg kg⁻¹). Atmakur had the highest iron content and Gadivemula the lowest. Using the study's critical limit of 5.0 mg kg⁻¹, Gadivemula was marginally deficient, while the remaining four location means were slightly above the threshold. Alkaline reaction may contribute to limited iron solubility.

Available zinc ranged from 0.40 to 0.67 mg kg⁻¹, averaging 0.52 mg kg⁻¹. Velugodu had the highest zinc concentration (0.67 mg kg⁻¹), while Kothapalli had the lowest (0.40 mg kg⁻¹). Four of the five location means (80%) were below the study's critical limit of 0.60 mg kg⁻¹. Zinc was therefore the most widespread micronutrient constraint at the location-mean level. High soil pH may restrict zinc availability. Baber *et al.* (1987) described micronutrient responses in flue-cured Virginia tobacco, although responses in the present bidi tobacco system need field validation. Similar results were reported by L. K. Prasad *et al.* (2016), Prasad *et al.* (2017) and Poorna Bindu *et al.* (2025).

Available manganese ranged from 8.24 to 11.67 mg kg⁻¹ (mean 10.13 mg kg⁻¹). All values exceeded the stated critical limit of 2.0 mg kg⁻¹. Available copper ranged from 5.88 to 8.22 mg kg⁻¹ (mean 6.94 mg kg⁻¹), and all values exceeded the stated 0.20 mg kg⁻¹ critical limit. Thus, routine manganese or copper application is not supported by the reported soil tests. Hoppe (1988) investigated copper fertilization in tobacco, but the present results do not establish a need for additional copper.

3.7 Location-wise Bidi Tobacco Yield

Bidi tobacco yield ranged from 1,950 to 2,350 kg ha⁻¹, with a mean of 2,068 kg ha⁻¹ (Table 4). Nandikotkur recorded the highest yield (2,350 kg ha⁻¹), followed by Kothapalli (2,100), Gadivemula (1,990), and Atmakur and Velugodu (1,950 kg ha⁻¹ each). The Nandikotkur yield was 20.51% higher than the lowest observed yield and 13.64% higher than the overall mean. Nandikotkur also had the highest nitrogen and phosphorus among the surveyed locations. However, Velugodu had the highest organic carbon and zinc but one of the lowest yields. Differences in yield cannot therefore be attributed to any single measured nutrient; irrigation, crop management, pests and other factors were not documented. Similar results were reported by Krishna Reddy *et al.* (2009) and Meghana *et al.* (2025).

3.8 Relationships between Soil Fertility and Yield

Exploratory Pearson correlations were calculated using the five location-level means. Positive associations were observed between yield and soil pH, available nitrogen and phosphorus; negative associations were observed with potassium and manganese. Zinc had an approximately zero linear association with yield. Comparable findings have been discussed by L. K. Prasad *et al.* (2016),

Krishna Reddy *et al.* (2017) and Poorna Bindu *et al.* (2025). These correlations are descriptive only: five aggregated observations are insufficient to establish nutrient effects or causation. In particular, the weak correlation between zinc and yield does not negate the soil-test evidence of low zinc availability. Replicated field experiments and individual sample-level analyses are needed to evaluate nutrient responses.

Table 1. Exploratory Pearson correlations between soil parameters and tobacco yield (n = 5 location means)

Soil parameter	Pearson r with yield
Soil pH	+0.682
Organic carbon	-0.569
Available nitrogen	+0.636
Available phosphorus	+0.635
Available potassium	-0.728
Available iron	+0.165
Available zinc	-0.011
Available manganese	-0.829
Available copper	-0.510

Table 2. Physico chemical properties of soils of bidi tobacco growing areas of Nandyaldistrict

Location	pH	E.C (dS/m)	O.C (%)	N (kg/ha)	P O ₂ (kg/ha)	K ₂ O (kg/ha)
Gadivemula	8.16	0.07	0.30	178	60.4	537
Atmakur	7.86	0.06	0.33	166	62.8	531
Nandikotkur	8.21	0.07	0.30	189	65.2	494
Velugodu	8.02	0.06	0.36	184	60.4	521
Kothapalli	8.06	0.05	0.33	176	59.2	486

Table 3. Micro nutrient status of soils of bidi tobacco growing areas of Nandyal district

Location	Iron (ppm)	Zinc (ppm)	Manganese (ppm)	Copper (ppm)
Gadivemula	4.62	0.55	11.67	5.88
Atmakur	5.17	0.42	9.86	7.26
Nandikotkur	5.10	0.56	8.24	6.12
Velugodu	5.13	0.67	11.23	8.22
Kothapalli	5.09	0.40	9.64	7.23

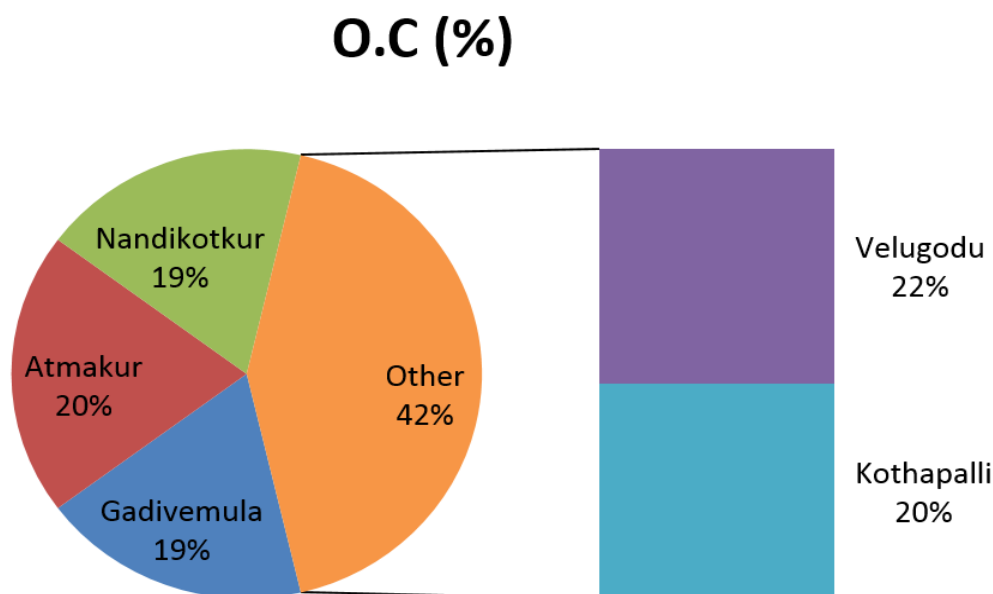


Fig. 1. Distribution of organic carbon (%) in bidi tobacco soils of Nandyal district

3.9 Implications for Nutrient Management

The surveyed soils were alkaline and non-saline, with low organic carbon and nitrogen, relatively high phosphorus and potassium, and widespread zinc values below the stated critical limit. Location-specific nutrient management should prioritise organic matter

improvement, balanced nitrogen supply and field validation of zinc correction. Iron status warrants attention where concentrations are near or below the critical limit. Recommendations for fertiliser rates should be established through soil testing (Parker *et al.*, 1951) and replicated field trials rather than inferred from these observational location means.

Table 4. Location wise yield of bidi tobacco growing areas of Nandyal district

Location	Yield (kg/ha)
Gadivemula	1990
Atmakur	1950
Nandikotkur	2350
Velugodu	1950
Kothapalli	2100

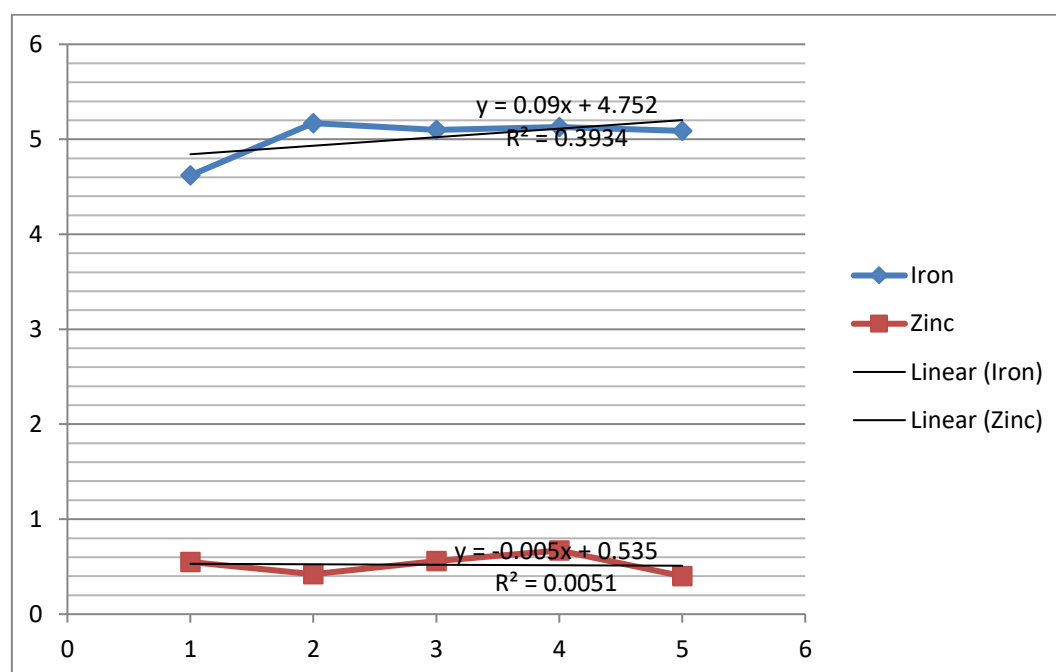


Fig. 2. Distribution of iron and zinc in bidi tobacco soils of Nandyal district

4. Conclusion

The soil fertility assessment of bidi tobacco-growing areas of Nandyal district indicated alkaline, non-saline soils with low mean organic carbon (0.32 %) and available nitrogen (178.6 kg ha⁻¹). Available P₂O₅ and K₂O averaged 61.6 and 513.8 kg ha⁻¹, respectively. Four of the five location means were below the critical limit for zinc; Gadivemula was marginally deficient in iron, whereas manganese and copper exceeded their stated critical limits throughout. Bidi tobacco yield ranged from 1,950 to 2,350 kg ha⁻¹, with the highest yield in Nandikotkur. The results provide baseline evidence for location-specific soil testing and nutrient management, but causal nutrient-yield relationships require field experiments.

5. Limitations

The fertility assessment was observational, and the results presented are aggregated for five locations despite collection of 150 soil samples. Consequently, within-village and field-level variability cannot be evaluated from the reported summaries. The exploratory correlations used only five location means and cannot establish causal relationships between soil nutrients and tobacco yield. Fertiliser application histories, irrigation, crop management and pest pressures were not documented, limiting interpretation of the observed yield differences. The study did not include replicated nutrient-response trials; therefore, site-specific application rates and expected yield benefits require further validation.

Acknowledgements

The author is highly thankful to Acharya N.G.Ranga Agricultural University Lam-Guntur, Andhra Pradesh, and ICAR–National Institute for Research on Commercial Agriculture (ICAR–NIRCA) Rajahmundry, for providing the necessary facilities to carry out this experiment.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

References

- Baber, S. A., Gul, H., & Haq, L. (1987). The yield and quality of flue-cured Virginia tobacco as affected by the application of micronutrients. In *Proceedings of the National Seminar on Micronutrients in Soils and Crops in Pakistan* (pp. 191–195). *NWFP Agricultural University, Peshawar*.
- Cao, Z. H. (1991). Soil and fertilization for production of high-quality flue-cured tobacco. *Jiangsu Science and Technology Press*.
- Hoppe, B. R. (1988). Effect of different rates of copper on flue-cured tobacco. In *Proceedings of the 9th International Tobacco Scientific Congress* (pp. 126–127). Guangzhou, China.
- Jackson, M. L. (1973). Soil chemical analysis. *Prentice-Hall of India*. <https://www.spices.res.in/opac/cgi-bin/koha/opac-detail.pl?biblionumber=179>
- Kissel, D. E., Bock, B. R., & Ogles, C. Z. (2020). Thoughts on acidification of soils by nitrogen and sulfur fertilizers. *Agrosystems, Geosciences & Environment*, 3(1), e20060. <https://doi.org/10.1002/agg2.20060>
- Krishna Reddy, S. V., Kasturi Krishna, S., Damodar Reddy, D., Chandrasekhara Rao, C., & Nageswara Rao, K. (2017). Productivity, leaf quality and nutrient-use efficiency of FCV tobacco (*Nicotiana tabacum*) genotypes to levels of N and K application under irrigated Alfisols of Andhra Pradesh. *Indian Journal of Agronomy*, 62(4), 510–518. <https://doi.org/10.59797/ija.v62i4.5560>
- Krishna Reddy, S. V., Kasturi Krishna, S., Deo Singh, K., Harishu Kumar, P., & Krishnamurthy, V. (2009). Integrated nutrient management in FCV tobacco (*Nicotiana tabacum*) in irrigated Alfisols. *Indian Journal of Agronomy*, 54(1), 74–79. <https://doi.org/10.59797/ija.v54i1.4770>
- Li, Q., Yan, C. B., Liu, Y. J., Li, J., Rang, Z. W., Xiao, Y. S., Li, H. G., & Peng, S. G. (2019). Preliminary study on spatial distribution and influencing factors of tobacco-growing soil pH in Chenzhou. *Acta Tabacaria Sinica*, 25(4), 50–58. <https://doi.org/10.16472/j.chinatobacco.2018.276>
- Li, X. C., Li, H. G., Xiao, Y. S., Song, W. J., Zheng, X. B., & Dong, J. X. (2020). Effects of fired soil on root growth and rhizosphere nutrients of tobacco at seedling stage. *Chinese Tobacco Science*, 41(5), 43–48. <https://doi.org/10.13496/j.issn.1007-5119.2020.05.005>
- Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal*, 42(3), 421–428. <https://doi.org/10.2136/sssaj1978.03615995004200030009x>
- Liu, J. G., Luo, J. X., Yang, L., Yu, Y., Meng, F., Xiao, H. Q., Peng, S. G., & Liu, Y. J. (2020). Analysis of phosphorus status in tobacco planting soils in Hunan. *Journal of Henan Agricultural University*, 54(1), 125–132. <https://doi.org/10.16445/j.cnki.1000-2340.20200215.002>
- Meghana, K., Poorna Bindu, J., Damodar Reddy, D., Sheshu Madhav, M., Usha Rani, I., & Sreenivasulu, K. N. (2025). Optimizing flue-cured Virginia (FCV) tobacco productivity through soil inversion and innovative potassium management strategies. *International Journal of Environment and Climate Change*, 15(1), 25–38. <https://doi.org/10.9734/ijec/2025/v15i14671>
- Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate (Circular No. 939). U.S. Department of Agriculture. <https://agris.fao.org/search/en/providers/122535/records/65dded244c5aef494fd7641c>
- Parker, F. W., Nelson, W. L., Winters, E., & Miles, I. E. (1951). The broad interpretation and application of soil test information. *Agronomy Journal*, 43(3), 105–112. <https://doi.org/10.2134/agronj1951.00021962004300030001x>
- Patil, H. R., Kuchanwar, O. D., Ghodpage, R. M., Potdar, S. S., Pagari, P. C., Bhosale, A. D., & Virutkar, V. V. (2026). Assessment of the fertility status and available macronutrients in soils of Khemjai village, Chandrapur district, Maharashtra, India. *Journal of Global Agriculture and Ecology*, 18(3), 197–208. <https://doi.org/10.56557/jogae/2026/v18i310968>
- Poorna Bindu, J., Sheshu Madhav, M., Damodar Reddy, D., Mahadevaswamy, M., Chandrasekhara Rao, C., Prasad, L. K., Kasturi Krishna, S., Hema, B., Rajasekhara Rao, K., & Veda Vyas, R. D. (2025). Potassium schoenite: A sustainable potassium source for flue-cured Virginia (FCV) tobacco production. *Plant Science Today*, 12(2), 1–8. <https://doi.org/10.14719/pst.8309>
- Prasad, L. K., Damodar Reddy, D., Chandrasekhara Rao, C., Poorna Bindu, J., & Johnson, N. (2016). Assessment of soil micronutrient status of southern light soils under flue-cured Virginia tobacco in Prakasam district of Andhra Pradesh. *International Journal of Tropical Agriculture*, 34(8), 2397–2401. https://serialsjournals.com/abstract/17341_1-lk_prasad.pdf
- Prasad, L. K., Poorna Bindu, J., Damodar Reddy, D., Chandrasekhara Rao, C., & Ravisankar, H. (2021). Assessment of soil fertility under northern light soil area of FCV tobacco in Andhra Pradesh. *Journal of AgriSearch*, 8(2), 95–98. <https://doi.org/10.21921/jas.v8i2.7290>
- Prasad, L. K., Poorna Bindu, J., Damodar Reddy, D., Chandrasekhara Rao, C., & Johnson, N. (2017). Assessment of soil micronutrient status of Karnataka light soils under flue-cured Virginia tobacco in Mysore district of Karnataka. *Tobacco*

- Research, 43(1), 38–42. <https://gender.cgiar.org/publications/assessment-soil-micronutrient-status-karnataka-light-soils-under-flue-cured-virginia>
- Prasad, R., Singh, G., Shivay, Y. S., & Pathak, H. (2016). Need for determining ecofriendly optimum fertilizer nitrogen level for better environment and for alleviating hunger and malnutrition. *Indian Journal of Agronomy*, 61(1), 1–8. <https://doi.org/10.59797/ija.v61i1.4322>
- Saroha, D., Yadav, N., Mukhopadhyay, R., Raj, D., Sharma, M. K., Kumar, R., & Duhan, A. (2024). Geochemical interaction and bioavailability of zinc in soil under long-term integrated nutrient management in a pearl millet–wheat system. *CLEAN – Soil, Air, Water*, 52(11), e202400232. <https://doi.org/10.1002/clen.202400232>
- Shukla, A. K., Behera, S. K., Basumatary, A., Sarangthem, I., Mishra, R., Dutta, S., Sikaniya, Y., Sikarwar, A., Shukla, V., & Datta, S. P. (2024). PCA and fuzzy clustering-based delineation of soil nutrient (S, B, Zn, Mn, Fe, and Cu) management zones of sub-tropical Northeastern India for precision nutrient management. *Journal of Environmental Management*, 365, 121511. <https://doi.org/10.1016/j.jenvman.2024.121511>
- Singh, A. K., Singh, K. A., Bharati, R. C., & Chandra, N. (2013). Response of intercrops and nutrient management on the performance of a tobacco-based intercropping system and assessment of system sustainability. *Bangladesh Journal of Botany*, 42(2), 343–348. <https://doi.org/10.3329/bjb.v42i2.18040>
- Soumya, T. M., Siddagangamma, K. R., Mahadevaswamy, M., & Subishan, M. (2026). Influence of phosphorus levels, phosphorus-solubilizer and phosphorus-mobilizers on growth, yield and nutrient uptake of FCV tobacco. *Journal of Advances in Biology & Biotechnology*, 29(8), 146–160. <https://doi.org/10.9734/jabb/2026/v29i84169>
- Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, 25(8), 259–260. <https://www.currentscience.ac.in/Volumes/25/08/0259.pdf>

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2026): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here: <https://pr.sdiarticle5.com/review-history/168638>