International Journal of Plant & Soil Science

Volume 38, Issue 9, Page 165-171, 2026; Article no.IJPSS.164691
ISSN: 2320-7035

A Study on Adoption of Soil Amendments and Micro Nutrients by Grape Growers in Karnataka, India

K. M. Chethan Kumar [a++], M. T. Lakshminarayan [b#], T. P. Bharath Kumar [c†], P. Arun Kumar [d‡] and C. V. Sanketh [e‡*]

[a] Department of Agricultural Extension, University of Agricultural Sciences, Bangalore, Karnataka, India.
[b] Department of Social Sciences and Languages, College of Agriculture, VC-Farm, Mandya, University of Agricultural Sciences, Mandya, Karnataka, India.
[c] University Communication Center, University of Agricultural Sciences, Mandya, Karnataka, India.
[d] Directorate of Extension, University of Agricultural Sciences, Mandya, Karnataka, India.
[e] Department of Agricultural Extension Education, College of Agriculture, VC-Farm, Mandya, University of Agricultural Sciences, Mandya, 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: https://doi.org/10.9734/ijpss/2026/v38i96278

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/164691

Original Research Article

Received: 27/05/2026
Accepted: 17/08/2026
Published: 21/08/2026

Abstract

Soil amendments and micronutrients are important for maintaining soil fertility and supporting sustainable grape production. However, the extent to which grape growers adopt recommended practices may vary, particularly with respect to the quantity, method, and timing of application. This study assessed the adoption of soil amendments and micronutrients among grape growers in Chikkaballapura district, Karnataka, and examined the relationship between growers' profile characteristics and adoption. The study was conducted in Chikkaballapura and Shidlaghatta taluks during 2023–2024. Twelve villages were randomly selected, and 120 grape growers, comprising equal numbers of small and big farmers, were interviewed using a pre-tested schedule. Adoption

---

[++] Ph. D Scholar (Agricultural Extension); [#] Professor and Head; [†] Associate Editor; [‡] Assistant Professor (Agricultural Extension);
**Corresponding author: E-mail: cv.sanketh172@gmail.com;*

Cite as: *Kumar, K. M. C., Lakshminarayan, M. T., Kumar, T. P. B., Kumar, P. A., & Sanketh, C. V. (2026). A Study on Adoption of Soil Amendments and Micro Nutrients by Grape Growers in Karnataka, India. International Journal of Plant & Soil Science, 38(9), 165–171. https://doi.org/10.9734/ijpss/2026/v38i96278*

was measured using responses on the recommended application of gypsum and micronutrient mixtures, and the data were analysed using frequency, percentage, mean, standard deviation, and zero-order correlation. Among growers whose soils were affected by alkalinity, 56.12% partially adopted the recommended quantity of gypsum, whereas 43.88% completely adopted it. All growers who applied gypsum followed the recommended method and timing. For micronutrient mixtures, 61.67% partially adopted the recommended quantity and 38.33% completely adopted it; 55.83% applied the mixture as a foliar spray before flowering or at fruit set. The findings further showed that several socio-personal, psychological, communication, and extension-related characteristics were significantly associated with adoption. Overall, the results indicate that partial adoption was common, particularly for recommended input quantities, while method and timing were more consistently followed. Strengthening practical extension support on dose, diagnosis, and stage-specific application may help improve the completeness of adoption among grape growers.

Keywords: Adoption; grape growers; soil amendments; micronutrients; gypsum; soil fertility; foliar application; extension contact.

1. Introduction

Grape (*Vitis vinifera* L.) cultivation is one of the remunerative farming enterprises in India. Grapes are widely consumed as fresh fruit in India. They are also used for producing raisins, wine, juice, juice concentrates, squash, beverages, jams, and marmalades. Grapes are a good source of minerals such as calcium, phosphorus, and iron and are also rich in vitamins B1 and B2. Grape juice has a mild laxative effect and acts as a stimulant to the kidneys. Grape peel is a source of essential oil and pectin. It can also serve as a raw material for the production of cattle feed and the preparation of candies. Raisins are a rich source of sugar and antioxidants. In India, about 78.00 per cent of grapes are used for table purposes, 17.20 per cent are dried for raisin production, 1.50 per cent are used for juice, and 0.50 per cent are used for wine production (Angon *et al.,* 2023; Directorate of Economics and Statistics, 2024).
Grapes are grown under a variety of soil and climatic conditions in three distinct agro-climatic zones in India, namely subtropical, hot tropical, and mild tropical regions. Grapes are harvested almost throughout the year because, although all varieties are not available at all times, one or more varieties are available at any given time. However, the major proportion of the produce consists mainly of Anab-e-Shahi, Thompson Seedless, and its clones, which are harvested during March-April in the hot tropical region and contribute more than 70 per cent of the total harvest (Ganur *et al.,* 2018; Nanjappanavar *et al.,* 2024). Soil amendments and micronutrients play a crucial role in grape cultivation by enhancing soil fertility, improving nutrient uptake, and supporting grapevine health.

Recent peer-reviewed evidence indicates that micronutrient nutrition and soil amendment decisions should be considered jointly in grape-based systems because berry yield and quality responses are influenced by micronutrient availability, soil chemical constraints, and the capacity of farmers to use technical information (Ali et al., 2021; Kiprotich et al., 2024; Shaygan & Baumgartl, 2022). In this context, the present adoption study is relevant because soil amendment and micronutrient practices are not only agronomic interventions but also knowledge-intensive decisions that depend on locally available advisory support and farmer-level interpretation of soil fertility problems (Spurk et al., 2025; Tadesse & Assefa, 2025).

Recent grapevine research further indicates that nutrient-management outcomes can vary with the form, timing, and method of nutrient application (Yogaswathy et al., 2023; Göttmann et al., 2026). Studies of agricultural technology adoption also indicate that education, extension contact, and practical production constraints can be associated with farmers' uptake of recommended soil-fertility and grape-production practices (Sileshi et al., 2024; Raut et al., 2026).

Despite the recognised importance of soil amendments and micronutrients in grape cultivation, the extent to which grape growers in the selected taluks adopt these practices, and the relationship between growers' profile characteristics and adoption, require specific examination within the present study.

Against this background, the present study was undertaken with the following specific objectives:

1. To determine the adoption of soil amendments and micronutrients by grape growers
2. To determine the relationship between the profile characteristics of grape growers and their adoption of soil amendments and micronutrients

2. Methodology

The study was carried out in Chikkaballapura and Shidlaghatta taluks of Chikkaballapura district in Karnataka State during 2023-2024. Six villages in Chikkaballapura taluk and six villages in Shidlaghatta taluk were randomly selected for the study. From each sampled village, five small farmers and five big farmers growing grapes were randomly selected for the study. Thus, the total sample comprised 120 grape growers (60 small farmers and 60 big farmers) from 12 villages in the two taluks of Chikkaballapura district.

Adoption was defined as the decision to make full use of an innovation as the best course of action available. It was operationally defined as the degree of actual use of integrated nutrient management practices by grape growers. The questions pertaining to the adoption level were carefully designed in consultation with horticultural scientists.

The adoption test included questions on the application of soil amendments and micronutrients. Responses were elicited on a three-point continuum, namely complete adoption, partial adoption, and non-adoption of integrated nutrient management practices in grapes, and were assigned scores of 2, 1, and 0, respectively.

The total score for all aspects of adoption was computed for each grape grower and ranged from 0 to 12. After computing the adoption scores, the respondents were grouped into low, medium, and high categories using the mean and standard deviation as classification criteria.

Chart 1. Criteria for classification of grape growers into low, medium, and high adoption categories based on adoption scores

Adoption category	Criteria	Score
Low	< (Mean – ½ SD)	<6.19
Medium	(Mean ± ½ SD)	6.19-8.17
High	> (Mean + ½ SD)	>8.17
Mean		7.18
Standard deviation		1.08

Information regarding 15 profile characteristics, namely age, education, experience in grape cultivation, family size, knowledge regarding soil fertility, cropping intensity, material possession, annual income, cosmopoliteness, economic orientation, innovativeness, risk orientation, mass media participation, extension participation, and extension contact, was collected using a structured schedule with suitable scales. The adoption level was considered the dependent variable, and the profile characteristics of grape growers were considered the independent variables for the present study.

The collected data were scored and analysed using frequency, percentage, mean, standard deviation, and a zero-order correlation test. The relationships between the dependent and independent variables were analysed using the zero-order correlation test.

3. Results and Discussion

3.1 Adoption of Soil Amendments and Micronutrients by Grape Growers

The findings regarding the adoption of soil amendments and micronutrients by grape growers are presented in Table 1.

3.1.1 Application of Gypsum

A large majority of grape growers (81.67%) had soils affected by alkalinity. A simple majority of these grape growers (56.12%) had partially adopted the recommended quantity of gypsum, while 43.88 per cent had completely adopted it to reclaim alkaline soils. All grape growers who applied gypsum followed the recommended method and timing of application by applying gypsum around the root zone at pre-pruning and post-harvest.

The results indicate that the majority of grape growers had soils affected by alkalinity, which necessitated the use of gypsum as a soil amendment. Among them, a majority had partially adopted the recommended quantity of gypsum, while fewer grape growers had completely adopted the recommended dose of gypsum to reclaim alkaline soils. A lack of awareness of the recommended dosage of gypsum was the main reason why the majority of grape growers partially applied gypsum to alkaline soils.

The observed reliance on gypsum is agronomically plausible where alkalinity or sodicity constrains root-zone conditions, because calcium-based amendments can displace exchangeable sodium and improve the chemical environment for root activity; however, the magnitude of response is influenced by soil depth, drainage, amendment rate and complementary organic amendments (Green et al., 2023; Sheoran et al., 2021; Shaygan & Baumgartl, 2022). Therefore, the partial adoption recorded in the present study should be interpreted as a potential advisory gap rather than as unwillingness to use the practice, since gypsum requirement and timing are site-specific and require diagnostic soil information for precise recommendation (Green et al., 2023; Shaygan & Baumgartl, 2022).

3.1.2 Application of Micronutrient Mixture (Iron, Zinc, Boron and Manganese)

A majority of grape growers (61.67%) had partially adopted the recommended quantity of micronutrient mixture, while 38.33 per cent had completely adopted the recommended quantity. All grape growers who applied the micronutrient mixture followed the recommended method and timing of application by applying it in trenches during pruning as a soil application. A majority of grape growers (55.83%) applied the micronutrient mixture as a foliar spray before flowering or at the time of fruit set.

Due to a lack of knowledge of the recommended dose of the micronutrient mixture and the foliar spray to be applied before flowering or at the time of fruit set, a majority of grape growers partially applied the recommended dose of the nutrient mixture and did not follow the recommended foliar spray schedule before flowering or at the time of fruit set.

The partial adoption of micronutrient mixture and foliar spraying is consistent with the technical specificity of grapevine micronutrient management. Experimental evidence in grapes indicates that foliar application of Fe, Zn, and B, as well as selected micronutrients such as Zn and B, can improve yield and berry quality under specific varietal and agro-climatic conditions, but

responses depend on concentration, phenological stage, and the presence of deficiency symptoms (Ali et al., 2021; Pal & Ghosh, 2018). Hence, the present findings support the need for more precise extension messages on dose, timing, and diagnostic use of micronutrients, particularly before flowering and around fruit set (Ali et al., 2021; Pal & Ghosh, 2018).

Soil amendments and micronutrients play a crucial role in improving soil quality, correcting nutrient deficiencies, and enhancing crop productivity**.** Soil amendments such as gypsum help in managing soil alkalinity, ensuring better root growth and nutrient uptake. Micronutrients such as iron, zinc, boron, and manganese are essential for plant metabolism and contribute to improved yield and quality. Their proper application ensures balanced soil health, better plant resilience, and long-term agricultural sustainability.

Taken together, the practice-wise results suggest that farmers are more likely to follow visible operational steps such as placement and timing once they decide to apply an input, while quantitative precision in dose remains more variable. This pattern is consistent with adoption literature indicating that knowledge quality, extension access, innovation orientation, and perceived relevance influence whether farmers move from partial to complete use of soil fertility practices (Kiprotich et al., 2024; Spurk et al., 2025; Tadesse & Assefa, 2025).

Table 1. Adoption of soil amendments and micronutrients by grape growers

(n=120)

SI. No.	Particulars	Grape growers	
		No.	%
I.	Application of gypsum		
a.	Soils not affected by alkalinity	22	18.33
b.	Soils affected by alkalinity	98	81.67
A.	Quantity of gypsum applied(200g/plant)		
1.	Complete adoption	43	43.88
2.	Partial adoption	55	56.12
3.	Non adoption	0	0
B.	Method and time of application of gypsum		
1.	Apply around the root zone at pre-pruning	98	100.00
2.	Apply around the root zone at post-harvest	98	100.00
II	Application of micronutrient mixture (Iron, Zinc, Boron and Manganese)		
A.	Quantity of micronutrient mixture applied (15kg/acre)		
1.	Complete adoption	46	38.33
2.	Partial adoption	74	61.67
3.	Non adoption	0	0
B.	Method and time of application of micronutrient mixture		
1.	Applied in trenches during pruning as soil application	120	100.00
2.	Foliar spray before flowering/at the time of fruit set	67	55.83

3.2 Overall Adoption of soil Amendments and Micronutrients by Grape Growers

It is observed from Table 2 that 35.00 per cent of grape growers had a low level of overall adoption of soil amendments and micronutrients, whereas 33.33 and 31.67 per cent had medium and high levels of overall adoption, respectively. The findings of this study are in line with those of Maurya *et al.* (2017), Maratha and Badodiya (2018), and Pyasi *et al.* (2012).

The results in Table 2 reveal that 68.33 per cent of grape growers were in the low-to-medium overall adoption categories for soil amendments and micronutrients. Therefore, there is a need to promote awareness of soil amendments and micronutrients among grape growers to enhance soil fertility and achieve sustainable grape production.

The concentration of respondents in the low-to-medium adoption categories suggests that technical recommendations have reached many growers, but complete implementation may be constrained by knowledge, cost, perceived risk, or access to reliable advice. Similar adoption studies on integrated soil fertility management have shown that awareness, extension services, formal training, information access, and farmer innovativeness can shape both the decision to adopt and the intensity of adoption (Kiprotich et al., 2024; Spurk et al., 2025; Tadesse & Assefa, 2025). Therefore, interventions for grape growers may need to combine demonstrations with soil-test-based recommendations, input-use calculations, and follow-up advisory contact rather than relying only on general awareness campaigns.

Table 2. Overall adoption of soil amendments and micro nutrients by grape growers

(n=120)

Sl. No.	Category	Grape growers	
		No.	%
1.	Low (< 6.19 score)	21	35.00
2.	Medium (6.19-8.17 score)	20	33.33
3.	High (>8.17 score)	19	31.67
Total		**120**	**100.00**

3.3 Relationship Between Profile Characteristics of Grape Growers with Their Adoption of Soil Amendments and Micronutrients

Table 3 presents data on the relationship between the profile characteristics of grape growers and their adoption of soil amendments and micronutrients.

Variables such as family size, cropping intensity, material possession, and annual income of grape growers did not show a significant relationship with the adoption of soil amendments and micronutrients, while age, experience in grape cultivation, cosmopoliteness, risk orientation, and mass media participation were significantly associated with the adoption level at the 5 per cent level. Education, knowledge regarding soil fertility, economic orientation, innovativeness, extension participation, and extension contact exhibited highly significant relationships with the adoption of soil amendments and micronutrients at the 1 per cent level. The results of the study are consistent with the findings reported by Shambharkar *et al.* (2017), Desai *et al.* (2018), Sanketh *et al.* (2019), Nanjappanavar *et al.* (2024), and Kambar and Kumar (2025).

The significant and highly significant relationships observed for education, soil fertility knowledge, innovativeness, extension participation, and extension contact are consistent with the broader adoption literature, which indicates that information capacity and advisory exposure are important determinants of soil fertility management uptake (Kiprotich et al., 2024; Spurk et al., 2025; Tadesse & Assefa, 2025). The non-significant association of annual income and material possession in the present study should be interpreted cautiously because adoption of nutrient-management practices can be influenced not only by resource ownership but also by the perceived technical reliability of the recommendation, access to timely advice, and confidence in expected benefits (Spurk et al., 2025; Tadesse & Assefa, 2025).

Table 3 Relationship between profile characteristics of grape growers with their adoption of soil amendments and micronutrients

(n=120)

Sl. No.	Profile characteristics	Correlation co-efficient (r value)
1	Age	0.1970*
2	Education	0.2668*
3	Experience in grape cultivation	0.2000*
4	Family size	0.0967^{NS}
5	Knowledge regarding soil fertility	0.4168**
6	Cropping intensity	0.1111^{NS}
7	Material possession	0.0881^{NS}
8	Annual income	0.0780^{NS}
9	Cosmopoliteness	0.2111*
10	Economic orientation	0.2682*
11	Innovativeness	0.3081*
12	Risk orientation	0.1997*
13	Mass media participation	0.2112*
14	Extension participation	0.5698*
15	Extension contact	0.4999**

*NS=Non-significant, *=Significant at 5%, **= Significant at 1%*

4. Conclusion

The research results revealed that 68.33 per cent of grape growers were in the low-to-medium adoption categories for soil amendments and micronutrients. Grape growers can be educated about the importance and application of soil amendments and micronutrients by horticultural scientists and extension personnel through demonstrations, field visits, and training programmes. Awareness campaigns highlighting their role in soil health management may be conducted through farmer meetings and the distribution of extension publications. Encouraging grape growers to adopt self-diagnosis techniques for soil deficiencies and facilitating the availability of soil amendments through agricultural cooperatives and government support may further improve the adoption of soil amendments and micronutrients.

The findings also indicate that future extension strategies should differentiate between awareness of the practice and precision in implementation. Emphasis on soil diagnosis, locally calibrated gypsum requirements, micronutrient doses, and stage-specific foliar application may help convert partial adoption into more complete adoption while avoiding overgeneralised recommendations (Ali et al., 2021; Green et al., 2023; Pal & Ghosh, 2018).

5. Limitation

The study was confined to 12 villages in Chikkaballapura and Shidlaghatta taluks and included 120 grape growers; therefore, the findings should be interpreted within the study area. Adoption information was obtained through personal interviews using a structured schedule and may reflect respondents' reported practices. The analysis relied on descriptive statistics and zero-order correlation, which identify associations but do not establish causal relationships between grower characteristics and adoption.

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

Ali, I., Wang, X., Abbas, W. M., Hassan, M. U., Shafique, M., Tareen, M. J., Fiaz, S., Ahmed, W., & Qayyum, A. (2021). Quality responses of table grapes 'Flame Seedless' as effected by foliarly applied micronutrients. *Horticulturae, 7*(11), 462. https://doi.org/10.3390/horticulturae7110462

Angon, P. B., Mondal, S., Jahan, I., Datto, M., Antu, U. B., Ayshi, F. J., & Islam, M. S. (2023). Integrated pest management (IPM) in agriculture and its role in maintaining ecological balance and biodiversity. *Advances in Agriculture, 2023*, 5546373. https://doi.org/10.1155/2023/5546373

Desai, V. D., Patel, J. K., & Patel, H. A. (2018). Constraints experienced by the farmers in adoption of integrated nutrient management. *Gujarat Journal of Extension Education, 29*(1), 80–82. https://www.gjoee.org/papers/916.pdf

Directorate of Economics and Statistics. (2024). *Agricultural statistics at a glance 2024*. https://desagri.gov.in/en/document-report-category/agriculture-statistics-at-a-glance

Ganur, A. S., Hipparagi, K., Patil, D. R., Sandhya, G. C., & Suhansini, S. C. (2018). Influence of cane regulation on yield of wine grapes under northern dry zone of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences, 7*(5), 194–200. https://doi.org/10.20546/ijcmas.2018.705.025

Göttmann, J., Kunz, R., Dries, L., Löhnertz, O., & Geilfus, C.-M. (2026). Evaluation of the impact of different nitrogen fertilisation forms and techniques on yeast-assimilable nitrogen (YAN) in *Vitis vinifera* L. cv. Riesling: A three-year field study. *OENO One, 60*(1), 9449. https://doi.org/10.20870/oeno-one.2026.60.1.9449

Green, H., Larsen, P., Koci, J., Edwards, W., & Nelson, P. N. (2023). Long-term effects of gypsum on the chemistry of sodic soils. *Soil and Tillage Research, 233*, 105780. https://doi.org/10.1016/j.still.2023.105780

Kambar, P. S., & Kumar, K. P. (2025). A study of economic analysis of grape farming in Vijayapura District in Karnataka. *International Journal of Research Publication and Reviews, 6*(8), 520–523. https://ijrpr.com/uploads/V6ISSUE8/IJRPR51572.pdf

Kiprotich, S., Mogaka, H., Ndirangu, S. N., & Nyambane Onyari, C. (2024). Determinants of adoption and adoption intensity of integrated soil fertility management technologies among sorghum farmers in Upper Eastern Kenya. *Soil Use and Management, 40*(1), e12958. https://doi.org/10.1111/sum.12958

Maratha, P., & Badodiya, S. K. (2018). Study on adoption of eco-friendly management practices by vegetable growers at Ladpura block of Kota district in Rajasthan. *International Journal of Pure & Applied Bioscience, 6*(1), 1356–1361. https://doi.org/10.18782/2320-7051.2912

Maurya, A. S., Yadav, R. N., Narain, S., Kaushal, P., & Parmar, K. (2017). Adoption level of bio-pesticides by brinjal growers in Bulandshahr district of western Uttar Pradesh, India. *International Journal of Current Microbiology and Applied Sciences, 6*(10), 2642–2646. https://doi.org/10.20546/ijcmas.2017.610.312

Nanjappanavar, A. G., Pooja Shree, S., Patil, D. R., Kukanoor, L., & Basavarajappa, M. P. (2024). Influence of cane regulation and growth regulators on yield and quality parameters of grapes cv. KR White. *Plant Archives, 24*(2), 969–985. https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.137

Pal, R., & Ghosh, S. N. (2018). Influence of micronutrients on growth dynamics, fruit yield and quality of Arka Neelamani grape. *Indian Journal of Horticulture, 75*(1), 149–152. https://doi.org/10.5958/0974-0112.2018.00027.0

Pyasi, R., Jaiswal, A., & Chaurasaia, P. C. (2012). Adoption of eco-friendly management practices by vegetable growers. *Journal of Plant Development Sciences, 4*(1), 77–80. https://jpds.co.in/adoption-of-eco-friendly-management-practices-by-vegetable-growers/

Raut, V. K., Jadhav, R. M., & Gaikar, P. S. (2026). Constraints in adoption of recommended grape cultivation practices among farmers in Maharashtra, India. *Journal of Global Agriculture and Ecology, 18*(3), 98–105. https://doi.org/10.56557/jogae/2026/v18i310759

Sanketh, C. V., Raghuprasad, K. P., & Ahmed, T. (2019). Constraint analysis of the farm innovators in Southern Karnataka. *International Journal of Current Microbiology and Applied Sciences, 8*(4), 13–22. https://doi.org/10.20546/ijcmas.2019.804.002

Shambharkar, Y. B., Mankar, D. M., Katole, R. T., & Khade, A. H. (2017). Constraints faced by Bt cotton growers in adoption of integrated nutrient management practices in Yavatmal District of Vidarbha Region. *Asian Journal of Extension Education, 35*(1), 30–37. https://www.ajeeakola.in/pdf/Journal-Volume-35-2017.pdf

Shaygan, M., & Baumgartl, T. (2022). Reclamation of salt-affected land: A review. *Soil Systems, 6*(3), 61. https://doi.org/10.3390/soilsystems6030061

Sheoran, P., Basak, N., Kumar, A., Yadav, R. K., Singh, R., Sharma, R., Kumar, S., Singh, R. K., & Sharma, P. C. (2021). Ameliorants and salt tolerant varieties improve rice-wheat production in soils undergoing sodification with alkali water irrigation in Indo-Gangetic Plains of India. *Agricultural Water Management, 243*, 106492. https://doi.org/10.1016/j.agwat.2020.106492

Sileshi, M., Feyisa, B. W., Eshetu, S. B., Kadigi, R. M. J., Mutabazi, K., & Sieber, S. (2024). Impact of integrated soil fertility management practices on the welfare of smallholder farmers in Ethiopia. *Food Security, 16*(6), 1445–1457. https://doi.org/10.1007/s12571-024-01492-7

Spurk, C., Koch, C., Bürgin, R., Chikopela, L., Konaté, F., Nyabuga, G., Sarpong, D. B., Sousa, F., & Fliessbach, A. (2025). Farmers' innovativeness and positive affirmation as main drivers of adoption of soil fertility management practices—Evidence across sites in Africa. *The Journal of Agricultural Education and Extension, 31*(1), 4–28. https://doi.org/10.1080/1389224X.2023.2281909

Tadesse, S., & Assefa, T. (2025). Drivers of integrated soil fertility management adoption among smallholder farmers in Bure District, Ethiopia. *Applied and Environmental Soil Science, 2025*, 6819012. https://doi.org/10.1155/aess/6819012

Yogaswathy, D., Jegadeeswari, D., Suganya, S., & Kavitha, C. (2023). Foliar application of liquid micronutrient formulation for improving quality of Panner grapes. *International Journal of Environment and Climate Change, 13*(10), 1163–1171. https://doi.org/10.9734/ijecc/2023/v13i102766

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/164691