**Advance Techniques in Soil Health and Nutrient Management: A Comprehensive Review**

**Abstract**

 As a key practice that has developed through scientific and technological advancements, conservation agriculture, precision farming, organic farming, and integrated nutrient management are highlighted. Interdisciplinary collaborations between soil science, agronomy, biotechnology, microbiology, and environmental science are examined, showcasing their collective impact on soil management strategies. Traditional soil management practices, while effective, often lack the integration of interdisciplinary approaches necessary to address contemporary agricultural challenges. The research additionally examines how socio-economic and policy viewpoints support sustainable soil management techniques. Case examples and real-world applications are provided to highlight the useful advantages and results of these cutting-edge techniques. In order to further optimize crop production and soil management, the review highlights present issues and suggests future research avenues. The implementation of integrated nutrient management (INM) strategies, such as adding organic soil amendments in addition to fertilizer, has demonstrated benefits for preserving and restoring soil quality, which in turn reduces overuse of fertilizer in agricultural areas. Thus, the impact of fertilizer and compost on broadacre crop yield and nitrogen usage efficiency (NUE) was contextualized in this review. The results highlight the need for a comprehensive strategy that incorporates environmental, socioeconomic, scientific, and technical aspects in order to create sustainable agricultural systems.

**Keywords**

Agricultural policy; soil management; crop production; biotechnology; conservation agriculture; soil health

**Introduction**

For agricultural systems to be sustainable and for crop output to be maximized, soil health is essential. It includes all of the physical, chemical, and biological characteristics of soil that work together to determine how well it supports plant growth, functions as a living ecosystem, and offers necessary ecosystem services. Robust crop yields depend on healthy soils because they improve root development, water retention, and nutrient availability. The fact that over 95% of food production worldwide depends on soil highlights the significance of soil health [1]. Food security and agricultural productivity are directly threatened by soil health degradation, whether it is from pollution, nutrient depletion, or erosion. Approximately 33% of the world's soils are already deteriorated, impacting an estimated 2 billion hectares of land, according to the UN [2,3]. It is commonly known that crop yield and soil health are related [[4], [5]]. One study by Lal [6] shows, for example, that increasing soil organic matter by 1% can boost wheat yields by 0.1–0.2 tons per hectare. According to a thorough assessment by Schjønning et al. [7], well-managed soils with better structure and a greater organic matter content improve water infiltration and storage, which increases crop resilience during droughts. Additionally, the biodiversity of soil, which includes microorganisms like fungi and bacteria, is essential to plant health and nutrient cycling. According to a study by Peralta et al. [8,9], a variety of soil microbial communities improve plant disease resistance and nutrient availability, which greatly increases agricultural output. Two essential elements of long-term agriculture are nutrient control and soil health. Plant growth [2,3], crop yield [4,5], and environmental sustainability [6,7] are all directly impacted by the quality of this ecosystem, which is the living habitat that forms the basis for agricultural production [1]. In order to preserve soil fertility and prevent fertilizer overuse, which can have negative environmental effects, proper nutrient management is essential [8,9]. In order to support profitable and ecologically conscious agriculture, this chapter explores the importance of soil health and the best nutrient management techniques [10,11].

Centuries of practical knowledge and experience have led to the development of traditional soil management techniques, which have long formed the foundation of agriculture [12, 13]. The major goal of these activities is to prolong crop output by preserving the fertility, structure, and general health of the soil. The most widely used conventional methods for managing soil include tillage, crop rotation, cover crops, and the use of organic amendments like compost and manure [14, 17]. For example, planting a variety of crops in the same place throughout a series of growing seasons is known as crop rotation [15, 16, 18]. This method breaks the cycles of pests and illnesses, controls soil fertility, and lessens soil erosion. According to a lengthy study by Drinkwater et al. [19], crop rotation can greatly increase soil organic matter and nitrogen cycling, which will increase crop yields. In particular, it has been demonstrated that switching up the legumes and cereals naturally raises the soil's nitrogen content, which lessens the requirement for synthetic chemicals [20]. On the other hand, cover crops like rye, vetch, and clover are sown in the off-season when the land may otherwise be left naked. These crops boost the amount of organic matter in the soil, enhance its structure, and prevent soil erosion. Cover crops can raise soil organic carbon levels by up to 0.5 tons per acre annually and prevent soil erosion by up to 90%, citing a study by [21]. Furthermore, cover crops can improve water retention and infiltration, which will improve crop resilience and root growth [18].

**Effects of various soil types on management techniques**

 Agricultural results and soil management strategies are greatly influenced by the types of soil that are present [22]. Proper water management strategies is necessary to avoid compaction in clay soils, which are characterized by high water retention but poor drainage [23]. Although they are fruitful, poor management practices can cause waterlogging, which lowers crop yields. Sand soils, on the other hand, drain rapidly and retain little water or nutrients, so they require regular irrigation and the addition of organic matter to enhance their structure [24]. In the absence of these measures, crops cultivated in sandy soils frequently experience drought stress and yield reductions. Because of their balanced texture, adequate drainage, and nutrient retention, loamy soils are thought to be perfect for agriculture [25]. Loamy soils often yield large amounts of crops when they are properly managed for water and nutrients. Even though silty soils are rich in nutrients, erosion is a common problem. Contour plowing and cover crops are two important erosion management techniques that are necessary to stop soil loss, which would otherwise reduce their agricultural potential [26]. Liming and drainage systems are necessary to increase productivity in peaty soils, which are rich in organic matter but frequently acidic and poorly drained [27]. Although waterlogging and acidity continue to be major obstacles, they can be extremely productive when correctly controlled.

**Effects of natural disasters on land use and soil management**

 Natural catastrophes like hurricanes, earthquakes, wildfires, droughts, and floods seriously impair land use and soil management, especially on farms [28]. Flooding frequently causes waterlogging, nutrient depletion, and significant topsoil erosion, making it challenging for farmers to sustain crop productivity and restore soil health [29]. Droughts cause compaction and decreased fertility by increasing soil salinity and lowering moisture levels [30]. When organic matter is burned in wildfires, erosion increases and water infiltration decreases, which can harm the impacted lands' long-term productivity [31]. Because they destabilize soils and reduce arable area, earthquakes cause landslides in hilly farming zones [32]. Similarly, storm surges and strong winds caused by hurricanes and cyclones lead to soil salinization and farmland devastation [33, 34]. In order to lessen their effects, these occurrences collectively reduce agricultural productivity, necessitate intensive recovery efforts, and emphasize the necessity for resilient soil management techniques.

**Immediate Obstacles in the Way of Better Soil Management**

Although we hear about abundant crops every year, we are nonetheless beset by the enduring problems of underdeveloped farmer income and starvation. Insufficient knowledge and comprehension of soil nutrient imbalances is frequently the underlying cause of this phenomenon [35]. These persistent issues are largely caused by differences in soil nutrients, even in the face of rising agricultural yields. One of the many urgent issues facing soil health are listed below

**Erosion of the Soil:** A serious danger to soil health is soil erosion, which can be caused by both wind and water. It causes topsoil, which is abundant in nutrients and organic matter, to disappear. Poor land management techniques, deforestation, and extreme weather events frequently make erosion worse.

**Soil degradation:** A wide range of processes, including erosion, compaction, salinization, and acidity, are included in the general phrase ‘soil degradation’. The soil's capacity to sustain plant development is diminished by these processes, which may result in a decline in agricultural output [36].

**Decline of Organic Matter in the Soil:** The amount of organic matter in many soils is declining as a result of intensive farming, excessive use of synthetic fertilizers, and poor crop residue assimilation. Microbial activity, nutrient retention, and soil structure all depend on the organic matter in the soil.

**Nutrient Depletion:** Nitrogen, phosphorus, and potassium are among the vital nutrients that are frequently lost from the soil as a result of intensive agriculture. This may lead to diminished crop yields and nutritional imbalances.

**Soil Contamination:** Pollutant contamination of soil can result from mining, industrial operations, and the application of pesticides and herbicides. Hazards to human and environmental health can arise from contaminants such as heavy metals and chemical residues, which can also damage soil health.

**Loss of Biodiversity**: A wide variety of creatures, such as insects, fungus, bacteria, and earthworms, are found in soil ecosystems. This biodiversity can be disrupted by pollution, habitat destruction, and changes in land use, which can have an impact on nitrogen cycling and soil health in general [37].

**Climate Change:** By changing precipitation patterns, raising temperatures, and encouraging extreme weather events, climate change can make problems with soil health worse. These modifications may have an effect on carbon sequestration, microbial activity, and soil moisture [38, 39].

**Urbanization:** Natural soil habitats and fertile agricultural land are frequently lost as a result of infrastructure development and urban area growth. Urbanization can decrease the amount of arable land available and disturb soil ecosystems.

**Land Conversion and Deforestation:** Valuable soils and their distinctive qualities may be destroyed when forests and other natural landscapes are turned into agricultural land. Particularly, deforestation can result in decreased soil health and increased erosion [32].

**Poor Soil Management:** Inadequate irrigation, excessive tillage, and the abuse of chemical inputs are examples of poor soil management techniques that can negatively impact soil health. In order to solve these problems, sustainable soil management techniques are essential.

**Water shortage:** In dry areas, water shortage can result in excessive irrigation and salinization, which further deteriorates soil health. To avoid these problems, effective water management is crucial.

**Developments in soil management techniques**

**Conservation Agriculture**

 A revolutionary approach to soil management, conservation agriculture (CA) seeks to improve environmental protection, agricultural sustainability, and soil health [40]. The fundamental tenets of CA include varied crop rotations, permanent soil cover, and little soil disturbance [41, 42]. CA reduces erosion, protects soil organic matter, and maintains soil structure by minimizing soil disturbance. When seeds are sown into undisturbed soil, no-till techniques can reduce soil erosion by up to 90% in comparison to conventional tillage [43]. There are several benefits to using cover crops, crop rotation, and no-till for sustainable agriculture [44]. No-till farming improves soil fertility and water retention by preserving soil structure and increasing soil organic carbon [45,46].

**Precision agriculture**

Precision agriculture (PA) adapts farming methods to the particular circumstances of each location by utilizing cutting-edge technologies such as the Geographic Information System (GIS), Remote Sensing, Global Positioning System (GPS), and data analytics. GPS pinpoints precise positions, GIS combines this spatial data to map field variability, and remote sensing uses drones and satellites to in real-time monitor crop health, soil moisture, and fertilizer distribution [47]. Additional information about soil characteristics, such as texture, pH, nutrient levels, and organic matter content, is provided by soil mapping. Variable Rate Technology (VRT) uses this information to apply inputs, such as water, fertilizer, and pesticides, precisely where they are needed, maximizing resource use and minimizing environmental impact [48].

**Organic farming and agroecology**

Sustainable soil management techniques like organic farming and agroecology place an emphasis on biodiversity preservation, soil health, and environmental stewardship. By avoiding synthetic inputs like pesticides, fertilizers, and genetically modified organisms, organic farming promotes natural alternatives including crop rotation, compost, and cover crops to improve soil fertility and control pests [49]. Additionally, it seeks to increase soil organic matter and biological activity, both of which enhance soil structure and nutrient cycling [50]. In contrast, agroecology concentrates on biodiversity, nutrient cycling, and ecosystem resilience while applying ecological concepts to agriculture.

**Nano concept biochar**

A promising soil amendment is biochar, a stable form of carbon created by pyrolysis, the thermal breakdown of organic material under low oxygen conditions [51]. Applying biochar to soils improves nutrient availability, cation exchange capacity, and water retention, all of which increase soil fertility. More microbial activity and nutrient retention are made possible by its porous nature, which may lessen the requirement for artificial fertilizers. Furthermore, because biochar can store carbon in soils for hundreds to thousands of years, it is being investigated more and more as a method for carbon sequestration, which helps to mitigate the effects of climate change [52].

**Cross-slope cultivation**

 Instead of following up and down slopes, cross-slope farming, sometimes referred to as contour farming, is an erosion management technique in which agricultural operations are in line with the landscape's natural contours [53]. By slowing down water flow, increasing water infiltration, and minimizing topsoil loss which is essential for preserving soil fertility this technique dramatically lowers soil erosion [54]. Particularly in steep or sloping areas, farmers can improve water use efficiency and preserve moisture by plowing, planting, and cultivating in accordance with the land's contours [55].

**Integrated Nutrient management**

 A comprehensive approach to soil fertility, Integrated Nutrient Management (INM) combines organic and inorganic nutrients to improve agricultural yields, nutrient efficiency, and environmental stewardship. INM promotes the thoughtful application of inorganic fertilizers in conjunction with organic inputs such as manure and compost to address the unique nutrient requirements of crops and adjust to soil conditions. Nutrient balance, enhanced soil health, and long-term agricultural productivity are the goals of this approach [56]. INM promotes environmentally friendly farming methods, strengthens soil organic matter, and fills nutrient deficiencies by combining different nutrient sources [57].

**Nutrient Management Practices**

**Balanced Fertilization:** Applying the right nutrients in the right amounts is essential. The 4Rs approach (Right source, Right rate, Right time, Right place) ensures efficient nutrient use.

**Organic Matter Management:** Incorporating organic matter through crop residues or organic amendments enhances soil health. It improves soil structure, water retention, and nutrient availability.

**Crop Rotation:** Crop rotation helps break pest and disease cycles and can improve nutrient management by diversifying nutrient demands.

**Crop Cover:** Planting cover crops between cash crops or during fallow times can help to improve the health of the soil. They improve organic matter, fix nitrogen, and prevent erosion.

**Reduced Tillage:** Lowering tillage reduces soil disturbance and preserves soil structure, both of which are critical for soil health.

**Technologies for Nutrient Application:** Applying nutrients with accuracy ensures uniform distribution, minimizing overuse and environmental effect [58, 59].

**Issues and Alternatives**

**Water contamination due to nutrient runoff:** Overuse of nutrients can result in nutrient pollution. Fertilizers with controlled release and precise nutrient management can help to lessen this problem.

**Erosion of the soil:** Erosion weakens the soil and depletes topsoil. Terracing and contour farming are two conservation techniques that might lessen erosion.

**Degradation of the Soil:** Intense farming methods and continued monoculture can cause soil degradation. Restoring soil health can be aided by the implementation of crop rotation and organic matter management.

**The effects of advanced soil management techniques on the economy**

 The economic impact of advanced soil management techniques on agriculture and society is substantial. Using conservation, integrated nutrient management, and precision agricultural techniques can increase crop yields, lower input costs, and boost farm profitability [60]. Techniques like cover crops and reduced tillage help to conserve water, limit soil erosion, and cycle nutrients, which lowers production risks and improves resource use efficiency [61]. In rural areas, sustainable soil management techniques can encourage economic diversification by creating new markets for certified organic products, carbon credits from soil carbon sequestration, and payments for ecosystem services [62, 63].

**Policy's function in advancing sustainable soil management**

 In order to promote sustainable soil management, effective policies are essential. Governments encourage farmers to adopt sustainable practices and apply soil conservation measures by enacting land-use restrictions, criteria for soil quality, and incentives for doing so [64]. Farmers’ adoption and investment in soil health is also greatly aided by government grants, subsidies, and tax incentives for sustainable techniques including organic farming, agroforestry, and cover crops [65]. Furthermore, policies that support farmer education, extension services, and platforms for knowledge sharing greatly increase grassroots awareness and adoption of sustainable soil management techniques [66].

**International policies for soil conservation**

 Enhancing financial and technical support for sustainable land management methods, especially in developing nations, should be the main goal of international policy recommendations for soil protection. For instance, by promoting the adoption of sustainable soil management techniques at the local level and assisting national soil information systems, the FAO's Global Soil Partnership (GSP) works to enhance soil governance [21]. The preservation and repair of terrestrial ecosystems, particularly soils, is another priority of UN SDG 15. Incentives for conservation agriculture techniques, investment in regenerative agriculture, and the promotion of carbon credits for soil sequestration are among the suggested courses of action [67]. To guarantee long-term sustainability, cooperative international frameworks that connect soil health to more general climate and food security objectives ought to be reinforced.

**Current challenges in implementing advanced soil management practices**

A number of formidable obstacles stand in the way of the broad acceptance and efficacy of sophisticated soil management techniques in a variety of agricultural systems. First off, high upfront expenditures and insufficient infrastructure, especially in environments with limited resources, continue to hinder the adoption of cutting-edge technology like remote sensing, soil sensors, and precision agriculture tools [68]. Second, there is a significant knowledge and awareness gap about the advantages and appropriate application of these approaches among farmers and stakeholders. Adoption is further hampered by limited access to training, information, and extension services. Thirdly, scaling up these techniques is significantly hampered by inconsistent policies, lax regulatory frameworks, and a lack of institutional backing. In order to encourage adoption and guarantee long-term results, it is imperative to achieve policy coherence and create institutional frameworks that support it [69].

**Prospective developments and innovations in soil management technology**

Technological developments have the potential to transform sustainable agriculture methods, which bodes well for the future of soil management. Predictive models that evaluate crop performance, weather trends, and soil health metrics in real-time are made possible by artificial intelligence (AI) and machine learning (ML) [70]. Farmers can make data-driven decisions by integrating sensor technology and Internet of Things (IoT) devices to enable continuous monitoring of soil health indicators like moisture levels and nutrient content [71]. By using precision agricultural techniques, such as variable rate application (VRA) of nutrients and fertilizers based on soil variability maps, nutrient use efficiency is increased while environmental consequences are reduced [72]. Enhancing soil fertility and water retention capacity, nanotechnology holds promise for fertilizer delivery systems and soil remediation [32]. Climate-smart techniques that improve soil structure and biodiversity while reducing climate risks include agroforestry and the use of biochar [2]. By guaranteeing accountability from farm to fork, blockchain technology has the potential to improve agricultural practices' transparency and traceability [35]. It will take teamwork to overcome technical, financial, and regulatory obstacles in order to adopt these developments and guarantee resilient and sustainable soil management techniques over the world.

**Conclusion**

In order to maximize crop output through interdisciplinary approaches, this review has summarized recent developments, difficulties, and potential paths forward in soil management techniques. Important conclusions stress the interdependence of biological, chemical, and physical soil characteristics and the vital role that soil health plays in agricultural sustainability. Carbon sequestration, water efficiency, and soil fertility are all being improved by cutting-edge techniques including integrated nutrient management, precision farming, and conservation agriculture. It is essential to address issues including knowledge gaps, policy inconsistencies, socioeconomic effects, climate variability, and technology obstacles. Longitudinal studies, incorporating cutting-edge technologies like artificial intelligence and nanotechnology, and investigating socioeconomic factors affecting adoption rates should be the main objectives of future study. Scaling up sustainable practices internationally requires strong institutional support and effective policy frameworks. The advancement of agricultural resilience and food security depends on the multidisciplinary integration of soil science, agronomy, biotechnology, and environmental sciences. This ensures that creative soil management techniques maintain and improve productivity while reducing environmental effects. The foundation of sustainable agriculture is the management of nutrients and the health of the soil. Long-term food security and environmental preservation depend on maintaining healthy soils through conservation measures, organic matter management, and balanced fertilization. By comprehending the soil ecology and putting best practices into practice, farmers can guarantee sustainable and productive agriculture for future generations.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**References**

1. FAO. Status of the world’s soil resources. Food Agric. Organ Unit. Nation. (2015) ISBN 978-92-5-109004-6
2. T. Gomiero. Soil degradation, land scarcity and food security: reviewing a complex challenge. Sustainability, 8 (3) (2016), p. 281
3. UNCCD. Global land outlook. United Nations convention to combat desertification.
4. R. Hijbeek, M.K. van Ittersum, H.F.M. tenBerge, G. Gort, H. Spiegel, A.P. Whitmore. Do organic inputs matter – a meta-analysis of additional yield effects for arable cropping systems. Soil Use Manag., 33 (2) (2017), pp. 188-202.
5. G.S. Yadav, A. Das, R. Lal, S. Babu, M. Datta, R.S. Meena, R. Singh. Impact of no-till and mulching on soil carbon sequestration under rice (Oryza sativa L.)-rapeseed (Brassica campestris L. var. rapeseed) cropping system in hilly agro-ecosystem of the Eastern Himalayas, India. Agric. Ecosyst. Environ., 275 (2019), pp. 81-92
6. R. Lal. Soil carbon sequestration impacts on global climate change and food security Science, 304 (5677) (2004), pp. 1623-1627, [10.1126/science.10973](https://doi.org/10.1126/science.10973)
7. P. Schjønning, J.L. Jensen, S. Bruun, L.S. Jensen, B.T. Christensen, L.J. Munkholm, L. Knudsen. The role of soil organic matter for maintaining crop yields: evidence for a renewed conceptual basis. Adv. Agron., 150 (2018), pp. 379, [10.1093/biosci/biw052](https://doi.org/10.1093/biosci/biw052)
8. A.L. Peralta, Y. Sun, M.D. McDaniel, J.T. Lennon. Crop rotational diversity increases disease suppressive capacity of soil microbiomes. Ecosphere, 9 (5) (2018), Article e02235
9. Ayushi Trivedi, S.K. Pyasi and Galkate, R.V. 2018. Estimation of Evapotranspiration using CROPWAT 8.0 Model for Shipra River Basin in Madhya Pradesh, India. Int.J.Curr.Microbiol.App.Sci. 7(05): 1248-1259.
10. Ayushi Trivedi, S.K. Pyasi and Galkate, R.V. 2018. A review on modelling of rainfall – runoff process. The Pharma Innovation Journal 7(4): 1161-1164.
11. Ayushi Trivedi, Avinash Kumar Gautam and Harshita Vyas. 2017. Comparative analysis of dripper. Agriculture Update TECHSEAR 12(4): 990-994.
12. Ayushi Trivedi and Avinash Kumar Gautam. 2017. Hydraulic characteristics of micro-tube dripper. LIFE SCIENCE BULLETIN 14 (2): 213-216.
13. Araya-Alman M, Olivares B, Acevedo-Opazo C. et al. Relationship between soil properties and banana productivity in the two main cultivation areas in Venezuela. J Soil Sci Plant Nutr. 2020;20(3):2512-2524.Available:https://doi.org/10.1007/s42729-020-00317-82.
14. Calero J, Olivares BO, Rey JC, Lobo D, Landa BB, Gómez JA. Correlation of banana productivity levels and soil morphological properties using regularized optimal scaling regression. Catena. 2022;208:105718.Available:https://doi.org/10.1016/j.catena.2021.1057183.
15. Olivares B, Vega A, Calderón MAR, Rey JC, Lobo D, Gómez JA, Landa BB. Identification of soil properties associated with the incidence of banana wilt using supervised methods. Plants, 2022a;11(15):2070.Available:https://doi.org/10.3390/plants111520704.
16. Campos BO. Banana production in venezuela: Novel solutions to productivity and plant health. Springer Nature; 2023.Available:https://doi.org/10.1007/978-3-031-34475-6
17. Avinash Kumar Gautam, Atul Kumar Shrivastava and Ayushi Trivedi. 2017. Effect of raised bed, zero and conventional till system on performance of soybean crop in vertisol. Agriculture Update 12 (4): 923-927.
18. Ayushi Trivedi and Avinash Kumar Gautam. 2019. Temporal Effects on the Performance of Emitters. Bulletin of Environment, Pharmacology and Life Sciences 8 (2): 37-42.
19. Olivares B, Rey JC, Lobo D, Navas-Cortés JA, Gómez JA, Landa BB. Machine learning and the new sustainable agriculture: Applications in banana production systems of venezuela.
20. Surbhi Suman, Ankita Sharma and Ayushi Trivedi. 2020. Bioactive Phytochemicals in Rice Bran: Processing and Functional Properties: A Review. Int.J.Curr.Microbiol.App.Sci Special Issue-11: 2954-2960.
21. Ayushi Trivedi, S. K. Pyasi, R.V. Galkate and Vinay Kumar Gautam. 2020. A Case Study of Rainfall Runoff Modelling for Shipra River Basin. nt.J.Curr.Microbiol.App.Sci Special Issue-11: 3027-3043.
22. Bhanu Pratap Singh, Pradeep Srivastava, Ayushi Trivedi, Deepesh Singh. 2021. Application of Geospatial Techniques for Hydrological Modelling. International Journal of Multidisciplinary Research and Analysis : 181-192.
23. Ayushi Trivedi and Manoj Kumar Awasthi. 2020. A Review on River Revival. International Journal of Environment and Climate Change 10(12): 202-210.
24. Vinay Kumar Gautam, M. K. Awasthi and Ayushi Trivedi. 2020. Optimum Allocation of Water and Land Resource for Maximizing Farm Income of Jabalpur District, Madhya Pradesh. International Journal of Environment and Climate Change 10(12): 224-232. Agricultural Research Updates. 2022b;42: 133-157.
25. Nova Science Publishers, Inc.6.Rey JC, Olivares BO, Perichi G, Lobo D. Relationship of microbial activity with soil properties in banana plantations in venezuela. Sustainability. 2022;14:13531.Available:https://doi.org/10.3390/su142013531
26. Rodríguez-Yzquierdo G, Olivares BO, González-Ulloa A, León-Pacheco R, Gómez-Correa JC, Yacomelo-Hernández M, Carrascal-Pérez F, Florez-Cordero E, Soto-Suárez M, Dita M, et al.. Soil predisposing factors to Fusarium oxysporumf.sp cubense tropical race 4 on banana crops of la guajira, Colombia. Agronomy. 2023;13:2588.Available:https://doi.org/10.3390/agronomy13102588
27. Montenegro E, Pitti-Rodríguez J, Olivares-Campos B. Identification of the main subsistence crops of Teribe: A case study based on multivariate techniques. Idesia (Arica). 2021;39(3):83-94.Available:https://dx.doi.org/10.4067/S0718-34292021000300083
28. Rodríguez MF, Olivares B, Cortez A, Rey JC, Lobo D. Natural physical characterization of the indigenous community of Kashaama for the purposes of sustainable land management. Acta Nova. 2015;7(2):143-164.Available:https://n9.cl/hakdx
29. Hernández R, Olivares B, Arias A, Molina JC, Pereira Y. Agroclimatic zoning of corn crop for sustainable agricultural production in Carabobo, Venezuela. Revista Universitaria de Geografía. 2018a;27 (2):139-159.Available:https://n9.cl/l2m83
30. Hernandez R, Olivares B, Arias A, Molina JC, Pereira Y. Eco territorial adaptability of tomato crops for sustainable agricultural production in Carabobo, Venezuela. Idesia. 2020;38(2):95-102.Available:http://dx.doi.org/10.4067/S071834292020000200095
31. Doran JW, Zeiss MR. Soil health and sustainability: Managing the biotic component of soil quality. Applied Soil Ecology. 2000;15:3-11.
32. Chen S, et al. Plant diversity enhances productivity and soil carbon storage. Proceedings of the Na-tionalNational Academy of Sciences. 2018;115:4027-4032.
33. Diacono M, F. Montemurro. Long-term effects of organic amendments on soil fertility. In E. Lichtfouse, M. Hamelin, M. Navarrete, and P. Debaeke (Eds.), Sustainable Agriculture Volume. Dordrecht, The Netherlands: Springer. 2011;2:761–786.
34. Batey T. Soil compaction and soil management-A review. Soil Use Manag. 2009;25:335–345.DOI: 10.1111/j.1475-2743.2009.00236
35. Bedano JC, Dominguez A, ArolfoR. Assessment of soil biological degradation using mesofauna. Soil Tillage Res. 2011;117:55–60.DOI: 10.1016/j.still.2011.08.007
36. Berendsen RL, Pieterse CMJ, Bakker PAHM. The rhizosphere microbiome and plant health. Trends in Plant Science. 2012;17:478-486.
37. Bhardwaj T, Sharma JP. Impact of pesticides application in the agricultural industry: An Indian Scenario. Int. J. Agri. Food Sci. Technol. 2013;4:817–822.Available:http://www.ripublication.com/ijafst.html
38. Brevik EC. Soil health and productivity, in soils, plant growth and crop production. Encyclopedia of life support systems (EOLSS), developed under the auspices of the UNESCO, ed W. Verheye (Oxford: EOLSS Publishers); 2009.Available:http://www.eolss.net
39. Brivik EC. A brief history of soil health concept; 2018.Available:http://profile.soil.org/posts/field-and-hostorical-notes/a-brife-historyof-soil-health-concept.
40. Hernández R, Olivares B, Application of multivariate techniques in the agricultural land’s aptitude in carabobo, Venezuela. Tropical and Subtropical Agroecosystems. 2020;23(2):1-12.Available:https://n9.cl/zeedh
41. López-Beltrán M, Olivares B, Lobo-Luján D. Changes in land use and vegetation in the agrarian community Kashaama, Anzoátegui, Venezuela: 2001-2013. Revista Geográfica De América Central. 2019;2(63):269-291.Available:https://doi.org/10.15359/rgac.63-2.10
42. Magdoff F, H. Van Es. Building soils for better crops. Brentwood, MD: SARE Outreach Publications; 2000.
43. Ayushi Trivedi, Bhanu Pratap Singh and Nirjharnee Nandeha. 2020. Flood Forecasting using the Avenue of Models. JISET - International Journal of Innovative Science, Engineering & Technology 7(12) : 299-311.
44. Malay Singh, Y. K. Tiwari, M. K. Awasthi and Ayushi Trivedi. 2020. Analysis of Geospatial Causes for Lowering Discharge in Kanari River. Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: 2840-2853.
45. Ayushi Trivedi, S. K. Pyasi and R. V. Galkate. 2019. Impact of Climate Change Using Trend Analysis of Rainfall, RRL AWBM Toolkit, Synthetic and Arbitrary Scenarios. Current Journal of Applied Science and Technology 38(6): 1-18
46. Ayushi Trivedi. 2019. Reckoning of Impact of Climate Change using RRL AWBM Toolkit. Trends in Biosciences 12(20) : 1336-1337.
47. Ayushi Trivedi and Manoj Kumar Awasthi. 2021. Runoff Estimation by Integration of GIS and SCS-CN Method for Kanari River Watershed. Indian Journal of Ecology 48(6): 1635-1640.
48. Ayushi Trivedi, Vinay Kumar Gautam, S.K.Pyasi and Galkate R.V. 2020. Development of RRL AWBM model and investigation of its performance, efficiency and suitability in Shipra River Basin. Journal of Soil and Water Conservation 20(2) : 1-8.
49. Deepak Katkani, Anita Babbar, Vipin Kumar Mishra, Ayushi Trivedi, Shweta Tiwari and Rohit Kumar Kumawat. 2021. A Review on Applications and Utility of Remote Sensing and Geographic Information Systems in Agriculture and Natural Resource Management. International Journal of Environment and Climate Change 12 (4): 1-18.
50. Ayushi Trivedi, K.V.R. Rao, Yogesh Rajwade, Deepika Yadav and Neelendra Singh Verma. 2022. Remote Sensing and Geographic Information System Applications for Precision Farming and Natural Resource Management. Indian Journal of Ecology 49(5): 1624-1633.
51. Ayushi Trivedi and Vinay Kumar Gautam. 2022. Decadal analysis of water level fluctuation using GIS in Jabalpur district of Madhya Pradesh. Journal of Soil and Water Conservation 21(3) : 250-259.
52. Neelendra Singh Verma, KV Ramana Rao, Yogesh Rajwade, Deepika Yadav and Ayushi Trivedi. 2023. Growth and yield of strawberry (Fragaria x ananassa Duch) under different mulches in vertisols of Madhya Pradesh. The Pharma Innovation Journal 12(11): 1324-1327.
53. Nirjharnee Nandeha, Ayushi Trivedi, Neelendra Singh Verma, Neha Kushwaha and Satish Kumar Singh. 2023. Benefits and Challenges of Indian Organic Farming: A Comprehensive Review. International Journal of Environment and Climate Change 13(9): 2142-2151.
54. Deepika Yadav, Yogesh Rajwade, K.V. Ramana Rao, Ayushi Trivedi and Neelendra Singh Verma. 2023. Adoption of Plastic Mulching Techniques for Enhancing African Marigold ( L.) Production. Indian Journal of Ecology 50(3): 685-689.
55. Vinay Kumar Gautam , Ayushi Trivedi and M.K. Awasthi. 2023. Optimal water resources allocation and crop planning for Mandla district of Madhya Pradesh. Indian Journal of Soil Conservation 51(1): 68-75.
56. Ayushi Trivedi, M. K. Awasthi, Vinay Kumar Gautam, Chaitanya B. Pande and Norashidah Md Din. 2023. Evaluating the groundwater recharge requirement and restoration in the Kanari river, India, using SWAT model. Environment, Development and Sustainability. Doi: https://doi.org/10.1007/s10668-023-03235-8
57. Deepika Yadav, K V Ramana Rao, Ayushi Trivedi, Yogesh Rajwade and Neelendra Verma. 2023. Reflective mulch films a boon for enhancing crop production: A review. Environment Conservation Journal 24 (1):281-287.
58. Nirjharnee Nandeha, Ayushi Trivedi, M L Kewat, S.K Chavda, Debesh Singh, Deepak Chouhan, Ajay Singh, Akshay Kumar Kurdekar and Anand Dinesh Jejal. 2024. Optimizing bio-organic preparations and Sharbati wheat varieties for higher organic wheat productivity and profitability. AMA 55(1): 16739- 16760.
59. Ashwini Kumar, Ayushi Trivedi, Nirjharnee Nandeha, Girish Patidar, Rishika Choudhary and Debesh Singh. 2024. A Comprehensive Analysis of Technology in Aeroponics: Presenting the Adoption and Integration of Technology in Sustainable Agriculture Practices. International Journal of Environment and Climate Change 14(2): 872-882.
60. Smita Agrawal, Amit Kumar, Yash Gupta and Ayushi Trivedi. 2024. Potato Biofortification: A Systematic Literature Review on Biotechnological Innovations of Potato for Enhanced Nutrition. Horticulturae 2024, 10, 292. https://doi.org/10.3390/horticulturae10030292. 1-17.
61. Ashwini Kumar, Ayushi Trivedi, Nirjharnee Nandeha and Niveditha MP. 2024. Sustainable Agriculture Development and Optimim Utilization of Natural resources: Striking a Balance. Journal of Scientific Research and Reports. 30(5): 477-486.
62. Vikas Gupta, Ayushi Trived, Nirjharnee Nandeha, Duyu Monya, K. Dujeshwer, Amit Kumar Pandey and Ashutosh Singh. 2024. Micro Plastic Pollution in Soil Environment: A Comprehensive Review. Journal of Scientific Research and Reports. 30(6): 412-419.
63. Ashwini Kumar, Dibyajyoti Mahanta, Mohini M. Dange, Ayushi Trivedi, and Nirjharnee Nandeha. 2024. “Global Challenges Facing Plant Pathology: A Review on Multidisciplinary Approaches to Meet the Food Security”. Journal of Scientific Research and Reports 30 (6):884-92. https://doi.org/10.9734/jsrr/2024/v30i62106.
64. Prabha Haldkar, Mohini M. Dange, Ayushi Trivedi, Nirjharnee Nandeha, and Suneel Kumar Rathour. 2024. “A Review on Nanotechnology in Food Science: Functionality, Applicability and Safety Assessment”. Journal of Scientific Research and Reports 30 (6):876-83. <https://doi.org/10.9734/jsrr/2024/v30i62105>
65. Ayushi Trivedi, M. K. Awasthi, Nirjharnee Nandeha, Vinay Kumar Gautam and Mukesh Kumar Mehla. 2024. Addressing water security challenges through groundwater recharge for revival of Kanari River using AHP and geospatial techniques. Discover Water. Springer Nature. 4:59. https://doi.org/10.1007/s43832-024-00124-7
66. Nandeha N and Kewat ML. 2018. Evaluation of bio-organic preparations on yield of Sharbati wheat varieties under Kymore plateau and Satpura hill zone of Madhya Pradesh. International Journal of Current Microbiology and Applied Sciences 7(6):619-626
67. Nandeha N, Dewangan, YK and Sahu PL. 2016. Effect of crop geometry and nutrient management on yield performance of sweet corn (Zea mays l. Saccharata) under Chhattisgarh plain ecosystem. The Bioscan,11(4): 2293-2295.
68. Nandeha N, Dewangan, YK and Sahu PL. 2016. Response of sweet corn (Zea mays l. saccharata) under vayring crop geometry and nutrient management on nutrient uptake and economics under Chhattisgarh plain ecosystem. Progressive Research– An International Journal 11: 3738-3740.
69. Nandeha N, Sahu J and Sahu PL. 2017. Panchgavya: gift from the Indian breed cow. Progressive Research – An International Journal. Volume 12 (Special-I): 1070-1075.
70. Sahu H, GS Tomar and Nandeha N.2017. Effect of planting density and levels of nitrogen on yield and yield attributes of sweet sorghum (Sorghum bicolor L. Monech) varieties. International journal ofchemical studies. 6(1):2098-2101
71. Sahu PL, Chitale S, Nandeha N, Kurrey D and Kanwar PC.2015.Effect of different combination of organic materials and biofertilizers on growth and economics on scented rice (Oryza sativa L.) varieties.
72. Kumar R, Shrivastava S.K., Sahu P.L and Nandeha N., 2017. Efficacy of adjuvants on npv persistency against helicoverpa armigera (hubner) on tomato crop. Progressive Research – An International Journal. Volume 12 (Special-I) : 878-880