Vol. 02, No. 04 (2024) 209 -214, doi:10.61552/JEMIT.2024.04.006 - http://jemit.aspur.rs

SOIL NUTRIENT ENRICHMENT IN THE INDIAN SUBCONTINENT WITH MATHEMATICAL INTERPRETATIONS: MISTRAL ALGORITHM

Baidyanath Ram[1]
Vikash Kumar Singh

Received 21.01.2024.
Revised 22.02.2024.
Accepted 01.04.2024.

Keywords:

Macro-nutrients, Micro-nutrients, Minerals, MISTRAL, Nutrients, Soil.

Original research

A B S T R A C T

Soil consists of particulate matter like loose earth, minerals, and essential nutrients, all required to cultivate botanical species carefully. The varying presence of soil attributes like alkalinity, humus, topsoil, Farm Yard Manure (FYM), organic matter, and Phyto-nutrients is an active area of research. Macro-nutrients and micro-nutrients present in soil overlook the amount of water consumed or produced as part of an agricultural process. Specific standard measures of soil attributes have been considered in past research. Forestation is also necessary to sustain agricultural land by providing rain-fed irrigation while ensuring low soil erosion levels. It is ascertained that a certain amount of the earth's well-being is linked to crop cycles and agricultural production levels. In this research work, an algorithm called MISTRAL (Soil nutrient enrichment in the Indian Subcontinent with Mathematical Interpretations) is presented, which can be utilized to enrich soil nutrients and soil well-being levels leading to an overall increase in the net agricultural output in the Indian subcontinent.

© 2024 Journal of Engineering, Management and Information Technology

1. INTRODUCTION

The landmass contained in the Indian subcontinent is composed of the Great Indian Northern Plains (The Indo-Gangetic Region), the Deccan Plateau, the Western Ghats, the Coromandel coast, and the Islandic Regions. Large rivers like the Ganges and the Yamuna and others like those in Punjab – Satluj, Ravi, Chenab, Beas, and Jhelum drain the Great Northern Plains. In the Deccan Plateau, the rivers like Cauvery, Krishna, and Godavari drain. Rivers in the Indian Subcontinent (historically called Gondwana) deposit topsoil (humus), the essential layer needed for agriculture.

Traditionally Farm Yard Manure was the source of fertilization of agricultural land. In the recent past, Farm Yard Manure has acquired importance as the persistence of Organic Farming over Synthetic Farming (that involves NPK fertilizers) has prevailed over the Indian population. There is a growing need in the Indian agricultural system for a mechanism to increase soil nutrient absorption to meet the needs of a consumer society.

In this research article, we propose an algorithm named (MISTRAL) to help achieve increased soil nutrient absorption and maintenance to help guarantee optimal production levels in the agricultural sector. MISTRAL presents specific mathematical interpretations of archaic and current technologies, striking a balance between traditional and modern agriculture so that the rural population in India can better understand the earth's needs in the Indian subcontinent.

[1]Corresponding author: Baidyanath Ram
Email: baidyanathram@gmail.com

2. LITERATURE REVIEW

A group of authors (Montgomery & Biklé, 2021; Montgomery et al., 2022) discuss the earth's well-being and mineral strength by considering natural and traditional agriculture. Natural and conventional methods of agriculture affect the earth's mineral strength. Synthetic fertilizers can affect the earth's mineral uptake and phytonutrient absorption. Natural farming methods have more benefits than traditional agriculture mechanisms as the tillage and phytonutrient absorption tend to be better in the former. Also, humus and topsoil additives can help alleviate some of the problems faced in traditional agriculture. When comparing natural and conventional farming methods, micro-mineral concentration levels tend not to vary too much. Also observed is that in conventional farming, many compounds are absorbed. In contrast, in natural agriculture, there is a significant presence of phyto-minerals, leading to a better concentration of essential amino acids and alkaline and acidic micro-minerals.

A micro-mineral is traditionally required in the earth for growth and survival, while natural farming also deems it necessary for vigor and immunity. So the primary concern when evaluating various farming practices that affect soil health is the presence of phyto-minerals and micro-minerals, which impact the health of an ecosystem in general.

The scientists (Mahler et al., 2015) elaborate on the essence of the earth's well-being in crop yield. Nutrient absorption and management are essential to feed the world's population. Soil examination and mineral analysis are the primary processes in mineral management concerning the earth's health. The main objective of this research is the following:

1. Examine the Net Present Utility of the earth's well-being for crop production.
2. Research the usage of earth examination for mineral proforma.
3. We are exploring the role of key decision-makers in the Regional Approaches to Climate Change (REACCH) evaluation region that recommends fertilizers on arable land.

In a study, the scholars (Adolph et al., 2002) evaluate the social and ethical capital facets of earth mineral management in the Indian subcontinent. This survey focuses on the well-being management of the earth in various parts of the Indian subcontinent.

The research document tries to cover facets of the role of earth well-being management in farming output with a straightforward take on monsoon-fed farming and the means of income of rural agricultural households who may not have capital assets like land etc. but are nonetheless active participants in earth mineral, management as producers, traders and processors of farming output.

Although the dialogue ensues for monsoon-fed agriculture, looking at irrigated and semi-arid land is essential to comprehend the flow of minerals. The second part of the survey focuses on natural farming, which has less available research material than traditional farming. Natural farming uses organic fertilizers, while conventional farming focuses on chemical compound-based nutrition. Also, this survey tends to derive its knowledge base from experience and experienced hands in agriculture rather than literary sources. This research focuses on the geographical region of Karnataka and Andhra Pradesh while at the same time also taking into account dry and semi-dry parts of the Indian subcontinent.

The technologists (Amara et al., 2017) develop an evaluation of the earth's well-being status by applying the mineral density mechanism. They undertook a comprehensive earth review in a mini rainshed in Karnataka, India, to assess the earth's well-being status by applying the mineral density mechanism. Around 120 surface specimens were harvested on a collective basis with shovels from a depth of around 10-30 cm and assessed for electrical conductance, minerals, and micro-minerals levels. Based on well-being levels, the earth is both acidic and alkaline. Electrical conductance is within normal levels. The mineral content was medium, with approximately 70% of the experimental regions in the high strata. The available micro-minerals were also present in the medium range. The general amount of Nitrogen, Potassium, Sulphur, Zinc, and Iron is evaluated as the most critical determinants of maintainable agricultural harvest in the experimental region. Therefore, The sampling zone demands the necessary measures to increase the earth's well-being. Some suitable practices are region-particular mineral management, more significant natural mineral sources, pragmatic asset utilization, and crop cycles following utilitarian agricultural norms.

The researchers (Moral & Rebollo, 2017) describe the attribution of earth's well-being by applying the Rasch model. It measures the net earth well-being level that sums the essential soil constitutional and organic features using several metrics. The constituents of the Rasch equation illustrate a means to evaluate the earth's well-being acumen, accumulating various earth attributes (silt, mud and gravel content, minerals, essential vitamins, carbon, electrical components, etc.) evaluated at around 80 positions in a field.

In the study, the approximated earth coefficients are a good measure for the model while expecting a decent contribution to the earth's well-being. Also, ordering all the earth samples based on their well-being potential and the denomination of each coefficient on earth well-being are furnished. Rasch model determines itself to apply to approximately selected positions in a field where considerable earth well-being measure exists and later evaluates whether there are earth samples with faults. These bits and pieces of information lead to a better and more durable agrarian management scheme.

A team of investigators (Navarro et al., 2020) experimented on Farm Yard Manure and Bio-waste to enhance earth-based ecological implements under yam harvesting in a rainfed tropical climate. The state of Texas lies in a sub-tropical rain-fed zone. As a result of hot weather and average rains, agrarian workers decide to leave their land under little cultivation during the summer, leading to the loss of soil matter. The investigators assessed whether yam harvesting and manual irrigation could improve the earth's well-being rather than leaving the land fallow. As yam has high demands on earth, particularly a high potassium requirement, the mineral needs of amended soil were evaluated. Yam is harvested in Texax under minimum fertilizer, artificial fertilizer, FYM, compost, and biowaste, and each sample is triplicated, and soil is amended at varying amounts. Earth biomass indices, standard NPK amounts, and biowaste measures were assessed as critical indicators of yam harvest performance. Earth pH and Na levels increased in the various earth treatments mainly due to fresh water sourced irrigation.

Overall, it can be argued from the observations that plant yield increased the earth's well-being compared to when the land is kept fallow. Also, it would be essential to recognize and nurture management policies that lead to the slightest increase in soil alkalinity and saline levels for better results in yam.

The researchers (Drechsel et al., 2004) help examine the value of minerals and nutrients in earth and water. The authors describe that the importance of earth minerals in plant growth and farming output is closely tied to water availability. Also, water production in agricultural output is closely linked to the supply of minerals and nutrients. All evaluations of the benefits of water supply do not consider the costs of the export of minerals by application of crop production. A good study of the combined symbiotic relationship between water supply and nutrient levels is essential. To conduct such a study, it is necessary that a method of measuring and valuing soil nutrient levels be present.

The various methods considered for evaluating soil nutrient valuations include assistive value, growth alteration, structured payment, value-based pricing, and net attributed productivity. The research considers a comparison of the costs of mineral extraction in two African farming schemes, an assessment of minerals in rain-fed irrigation in Mexico, an evaluation of mineral depletion in Africa, and a thorough analysis of evaluating earth and biomass along with its various usages.

The authors (Shrestha et al., 2020) discuss the role played by minerals and essential nutrients in rice cultivation by performing a survey. Essential nutrients and minerals play a vital role in the growth and development of plants. The duo of largo and pinto are critical kinds of nutrients in the developmental cycle of paddy plants. Every particular nutrient has its traits and actively participates in the varying metabolic schemes of botanical life. Nutrients are required for building immunity in botanical species. Also, a balance has to be attained in the nutrient quantities for stable growth cycles. Developmental nutrient policies are critical for the earth's well-being and maintainable agrarian output. The data in this research article is suitable for paddy cultivators and scientists to achieve steady production and sustain the environment.

The technologist (Kramer, 2008) evaluates the effects of fertilizers on the earth's alkalinity, well-being, minerals, and essential nutrient levels in rural America. There is a growing need for the reforestation of valleys and swamps in the Missouri River Basin amongst forest rangers and wildlife managers. The focal point of interest is rehabilitating these regions with Oak, Rhododendron, and Black walnut species. Many ecological preserves in the Missouri River basin have been lost to agricultural practices, catchment areas, and drainage. Flooding of the basin and the delta region led to the deposition of sand in the farming areas. It is now essential that the land be reclaimed for agricultural use by reforesting it with hardened wood species.

The scholars (Sivasankaran et al., 2022) study earth mineral forecasting and beneficial fertilizer suggestions for the maintainable cultivation of groundnuts using improved CNNs. The net output of agricultural land is immensely affected by the nutrient uptake in the geographical area. The main ingredients of the earth's well-being are minerals and essential nutrients in the soil. A balanced infusion of life-giving fertilizers, mainly those rich in Nitrogen (N), Phosphorus (P), and Potassium (K), is necessary to sustain equitable and profitable agriculture.

This study uses an evolved CNN to predict the earth's nutrient levels and suggests the optimal fertilizer application. The Nitrogen (N), Phosphorus (P), and Potassium (K) levels are classified by a CNN into low, medium, and high groups. A correlation between various largo and pinto nutrients is then established based on the heat map that has been generated. The proposed model outperforms existing models based on ANN, Naive Bayes, and SVM by achieving an accuracy of 98%.

3. METHODOLOGY

The process for employing the MISTRAL algorithm for soil nutrient analysis involves several interconnected steps aimed at comprehensively understanding and managing soil health. Initially, soil samples are collected from diverse locations and subjected to laboratory tests to determine the concentrations of micro-nutrients (metals and salts) and macro-nutrients (gaseous matter, nitrous content, organic elements). Following data preprocessing to ensure quality and consistency, suitable mathematical models such as Support Vector Machines (SVM), Convolutional Neural Networks (CNN), or Deep Belief Networks (DBN) are chosen and trained on the preprocessed data. These models are then interpreted to discern the significance of different nutrient levels within habitable environments, thereby informing soil management practices. Concurrently, experimental stoichiometry analysis provides insight into the mineral composition of the soil, validating and refining the mathematical models. Transformation techniques are applied to manipulate nutrient levels, fostering strategies for sustaining optimal soil health. Rationalization of soil well-being integrates insights from mathematical models, stoichiometry analysis, and transformation techniques, culminating in the formulation of the MISTRAL mechanism as a set of algebraic equations. These equations are further expressed in First Order Predicate Calculus, formalizing the logic underpinning soil nutrient analysis and management. The methodology is then validated and refined through independent soil sample analysis, with results documented in a comprehensive report outlining findings, insights, and recommendations for soil nutrient management. Through this systematic approach, the MISTRAL algorithm facilitates informed decision-making and sustainable soil stewardship.

The MISTRAL algorithm utilizes the following subsystems

1. **M**athematical Models – A mathematical model like an SVM, CNN, DBN, etc., can be developed.
2. **I**nterpretations – The model can have suitable interpretations within a habitable environment.
3. **S**toichiometry – The various mineral levels can be understood experimentally.
4. **T**ransforms – Certain transforms can be applied to generate or regenerate minerals to sustain nutrient levels.
5. **R**ationalization – The overall soil well-being can be rationalized
6. **A**lgebra – The MISTRAL mechanism can then be defined as a set of algebraic equations.
7. **L**ogic – The MISTRAL process can finally be written down as statements in First Order Predicate Calculus.

4. RESULTS

The following is an outline of one particular implementation of the MISTRAL algorithm. We randomly chose an array of 12 nutrients, where the number values in the collection are individual probabilities of nutrients.

We experimented using Python as a programming language and Notepad++ as an IDE. In the following discussion, the plots contained inside figures plot the mean, median, and mode of the nutrient probability values. Also, the Mathematical model that is applied is the Naive Bayes which depends on conditional probabilities. So the values of the initial array are A (1) = [0.1, 0.3, 0.2, 0.7, 0.5, 0.8, 0.4, 0.9, 0.2, 0.7, 0.4, 0.8]

The following figure 1 shows a plot of the initial nutrient probability values.

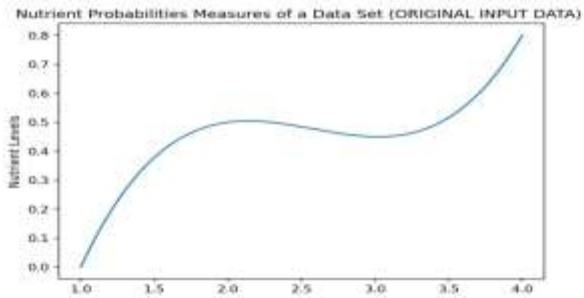

Figure 1. Nutrient Probability Values (Initial)

For the interpretation phase of MISTRAL, we add the absolute difference of the following two numbers to the current number in the array. It is the resultant array of Phase 2 and the array in the previous phase.

A (1) = [0.1, 0.3, 0.2, 0.7, 0.5, 0.8, 0.4, 0.9, 0.2, 0.7, 0.4, 0.8]

A (2) = [0.2, 0.8, 0.4, 1.0, 0.9, 1.3, 1.1, 1.4, 0.5, 1.1, 0.9, 1.1]

The following figure 2 shows a plot of the nutrient values after the second phase of MISTRAL.

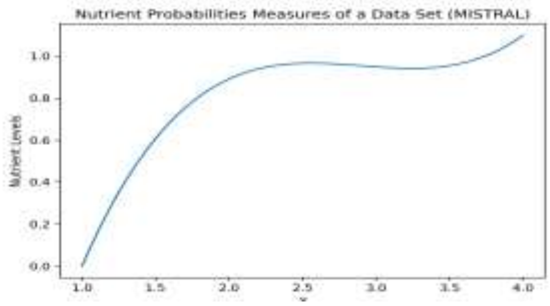

Figure 2. Nutrient values (Phase 2)

For the stoichiometry phase of MISTRAL, we set the current number to its average with the following number. It is the resultant array of Phase 3 and the array in the previous phase.

A (2) = [0.2, 0.8, 0.4, 1.0, 0.9, 1.3, 1.1, 1.4, 0.5, 1.1, 0.9, 1.1]

A (3) = [0.5, 0.6, 0.7, 0.95, 1.1, 1.2, 1.25, 0.95, 0.8, 1.0, 1.0, 1.0]

The following figure 3 shows a plot of the nutrient values after the third phase of MISTRAL

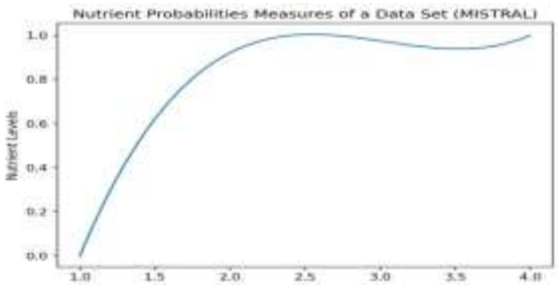

Figure 3. Nutrient values (Phase 3)

For the transform phase of MISTRAL, we multiply the current number with the number at the current index + 4.

It is the resultant array of Phase 4 and the array in the previous phase

A (3) = [0.5, 0.6, 0.7, 0.95, 1.1, 1.2, 1.25, 0.95, 0.8, 1.0, 1.0, 1.0]

A (4) = [0.55, 0.72, 0.88, 0.9, 0.88, 1.2, 1.25, 0.95, 0.88, 1.2, 1.25, 0.95]

The following figure 4 shows a plot of the nutrient values after the fourth phase of MISTRAL

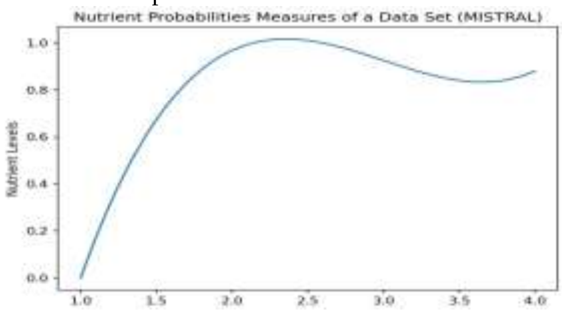

Figure 4. Nutrient values (Phase 4)

For the rationalization phase of MISTRAL, we normalize with the following number.

It is the resultant array of Phase 5 and the array in the previous phase

A (4) = [0.55, 0.72, 0.88, 0.9, 0.88, 1.2, 1.25, 0.95, 0.88, 1.2, 1.25, 0.95]

A (5) = [0.43, 0.45, 0.49, 0.51, 0.42, 0.49, 0.57, 0.52, 0.42, 0.49, 0.57, 0.43]

The following figure 5 shows a plot of the nutrient values after the fifth phase of MISTRAL

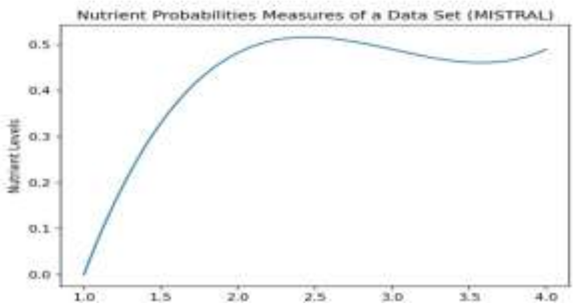

Figure 5. Nutrient values (Phase 5)

For the algebra phase of MISTRAL, we multiply the current number with (1 + next number)

It is the resultant array of Phase 6 and the array in the previous phase

A (5) = [0.43, 0.45, 0.49, 0.51, 0.42, 0.49, 0.57, 0.52, 0.42, 0.49, 0.57, 0.43]

A (6) = [0.62, 0.67, 0.74, 0.72, 0.63, 0.77, 0.87, 0.74, 0.63, 0.77, 0.82, 0.68]

The following figure 6 shows a plot of the nutrient values after the sixth phase of MISTRAL

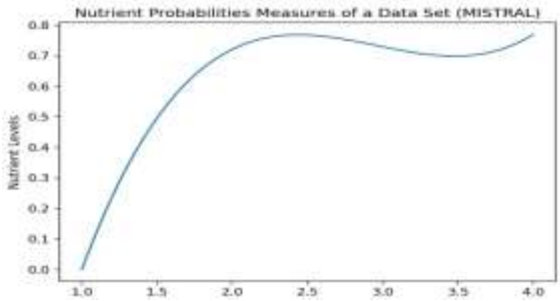

Figure 6. Nutrient values (Phase 6)

For the logic phase of MISTRAL, we multiply the following number by ten and take first place of the resultant number, say x, make it 1. x, and then multiply 1. x * current number * 0.5

It is the resultant array of Phase 7 and the array in the previous phase

A (6) = [0.62, 0.67, 0.74, 0.72, 0.63, 0.77, 0.87, 0.74, 0.63, 0.77, 0.82, 0.68]

A (7) = [0.5, 0.57, 0.63, 0.58, 0.54, 0.69, 0.74, 0.59, 0.54, 0.69, 0.66, 0.61]

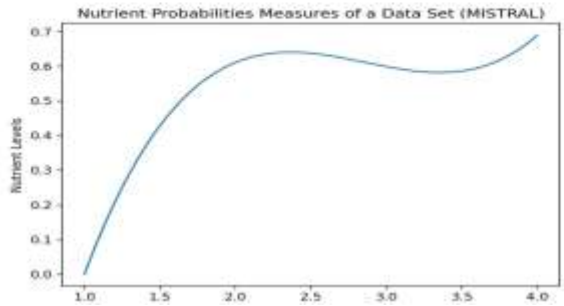

Figure 7. Nutrient values (Phase 7)

The figure 7 shows a plot of the nutrient values after the seventh phase of MISTRAL

5. DISCUSSION

The MISTRAL algorithm seems to be operating normally at a reasonable speed. In a test run, the MISTRAL algorithm took a sample of 12 nutrient values and refined them over 7 phases until the values looked increasingly more regular with each passing step. It is observed that the plots of mean, median, and mode of the nutrient probability values tend to smoothen out with the application of MISTRAL.

It can be surmised that the MISTRAL algorithm would lead to a net overall benefit in the aggregate nutritional content of earth in the Indian subcontinent.

6. CONCLUSIONS

Recent work on soil nutrient levels and other related areas like water management and agricultural output and production levels have been documented in this research work.

A new algorithm called MISTRAL (Soil nutrient enrichment in the Indian Sub-continent with Mathematical Interpretations) is recommended so holistic soil amendment can be done by applying organic and inorganic (NPK) fertilizers. It is expected that with the advent of the MISTRAL algorithm, farmers in the Indian Diasporas can achieve a significant overall gain in the number of agricultural production levels.

Acknowledgement:

We gratefully acknowledge the invaluable support of family and friends whose time has been put into producing this article. Additionally, we appreciate the ongoing support and encouragement from our readers, authors, and the broader academic community.

References:

Adolph, B., Butterworth, J., Satheesh, P. V., Reddy, S., Reddy, G. N. S., Karoshi, V., & Indira, M. (2002). Soil fertility management in semi-arid India: its role in agricultural systems and the livelihoods of poor people. Natural Resources. Institute UK.

Amara, D. M. K., Patil, P. L., Kamara, A. M., & Saidu, D. H. (2017). Assessment of soil fertility status using nutrient index approach. *Academia Journal of Agricultural Research*, 5(2), 28-38.

Drechsel, P., Giordano, M., & Gyiele, L. (2004). Valuing nutrients in soil and water: concepts and techniques with examples from IWMI studies in the developing world (Vol. 82). Iwmi.

Kramer, M. J. (2008). Fertilizer effects on soil pH, soil nutrients, and nutrient uptake in swamp white and pin oak seedlings on an alkaline Missouri River bottomland. University of Missouri-Columbia.

Mahler, B., Pan, B., & Wysocki, D. (2015). The importance of soil fertility in crop production. Regional Approaches to Climate Change for Northwest Agriculture, Climate Science Northwest Farmers Can Use, eds K. Borrelli, D. Daley Laursen, S. Eigenbrode, B. Mahler, and R. Pepper (Moscow, ID: University of Idaho).

Montgomery, D. R., & Biklé, A. (2021). Soil health and nutrient density: beyond organic vs. conventional farming. *Frontiers in Sustainable Food Systems*, 5, 417.

Montgomery, D. R., Biklé, A., Archuleta, R., Brown, P., & Jordan, J. (2022). Soil health and nutrient density: preliminary comparison of regenerative and conventional farming. *Peer J*, 10, e12848.

Moral, F. J., & Rebollo, F. J. (2017). Characterization of soil fertility using the Rasch model. Journal of soil science and plant nutrition, 17(2), 486-498.

Navarro, J., Salazar, J., Kang, J. J., Parsons, J., Cheng, C. L., Castillo, A., & Pujol Pereira, E. I. (2020). Compost and biochar to promote soil biological activities under sweet potatoes cultivation in a subtropical semiarid region. *Applied and Environmental Soil Science*, 2020, 1-11.

Shrestha, J., Kandel, M., Subedi, S., & Shah, K. K. (2020). Role of nutrients in rice (Oryza sativa L.): A review. *Agrica*, 9(1), 53-62.

Sivasankaran, S., Mohan, K. J., & Nazer, G. M. (2022). Soil Nutrients Prediction and Optimal Fertilizer Recommendation for Sustainable Cultivation of Groundnut Crop using Enhanced-1DCNN DLM. *International Journal of Advanced Computer Science and Applications*, 13(4).

Baidyanath Ram
Indira Gandhi National Tribal University,
Amarkantak, M. P., India.
baidyanathram@gmail.com
ORCID 0000-0002-6799-1318

Vikash Kumar Singh
Indira Gandhi National Tribal University,
Amarkantak, M.P., India.
vikash.singh@igntu.ac.in
ORCID 0009-0003-1438-149X