**Parametric Investigations of Agricultural Farming Soil Fertility and Its Effect on Paddy Crops Yield: A Case Study**

**Abstract**:

The aim of this paper is to present a comprehensive case study, conducted at an agricultural land of ASPEE Agricultural Research & Development Foundation (ARDF) based in north Konkan region of Maharashtra, India, which investigates the key factors affecting soil fertility and their impact on paddy crop yield. The entire study comprises was of four main steps: soil sample collection, testing and compilation of soil test reports, use of recommended doses of fertilizers (RDF), and data collection on test crops yield. In the crop years 2021 and 2022, before sowing the paddy seeds, the specific soil parameters such as pH, Electrical Conductivity (EC), Organic carbon (OC), Nitrogen (N), Phosphorous (P) and Potassium (K) was estimated and maintained within their advisable ranges.

Findings of the present study revealed that crops yield production was significantly increased from 2850 kg/ha in 2021 to 4102.5 kg/ha in 2022. It would be helpful for researchers, practitioners and farmers for providing them with the necessary insights to manage soil-related issues efficiently.

**Keywords:** Agronomy, ARDF, DSS, Paddy crops, STR, Soil fertility

**INTRODUCTION**

The last few decades were observed a rapid industrial growth and colonization that contributed greatly encroachment of available farming land making it dimensionally contracted. Particularly, in recent years major part of the world affected by any of the natural calamities either facing draught or flood situations or any other kind of natural disasters. On the other hands developing countries like China and India currently account for about 37% of the world population of roughly 7.7 billion (UNO,2022).

An estimate says a big population around 783 million people is suffering from starvation. Consequently, existing lands has put under extreme load to meet the increased demand of grain for world community. Unfortunately, farmers are using excessive quantity of fertilizers for getting more yield from same part of the land. The quality of soil may get adversely affected causing many other consequences like imbalance of nutrients of soil, chronic disease such as gastric, cancer etc. to the grain food consumers. The good thing is that now, India is the second highest rice producing countries in the world (FAO,2011). Therefore, yield of paddy crops would be helpful in providing the food security cover of millions of people.

Soil sampling is arguably the most crucial step in any soil analysis process, as it directly determines the accuracy and reliability of the results. Given that only a minuscule portion of the vast soil mass is collected and analyzed, ensuring that this small sample accurately represents the entire field is essential. A representative sample reflects the true condition of the soil, including its nutrient content, pH, and texture, thereby serving as the foundation for informed decision-making.

Soil test-based nutrient management has gained significant attention in the quest to enhance agricultural productivity and sustainability. By tailoring nutrient application to the specific needs of the soil, as determined through analysis, farmers can achieve optimal crop yields while reducing the overuse or underuse of fertilizers. This approach not only boosts productivity but also minimizes nutrient wastage, reducing the risk of leaching and other forms of environmental degradation. In this way, effective soil sampling and analysis contribute to sustainable farming practices, striking a balance between maximizing production and preserving environmental health.

Proper soil sample handling is essential to ensure accurate and reliable analysis results. Once collected, soil samples must be placed in clean, labeled containers to avoid contamination and maintain traceability. It is crucial to store and transport samples promptly to the testing facility, protecting them from extreme temperatures, moisture, and sunlight that could alter their properties. Before testing, the samples should be air-dried in a clean, dust-free environment to remove excess moisture without introducing external contaminants. Sieving the dried samples through a 2 mm mesh ensures uniformity by removing debris, rocks, and large particles, making them suitable for precise analysis. These careful handling practices preserve the integrity of the soil's chemical and physical characteristics, ensuring that the analysis accurately reflects the field's true condition.

The present study is intended to highlight the fertility issues of agricultural land situated at ASPEE Agricultural Research and Development Foundation (ARDF) in the North Konkan region of Maharashtra state of republic of India. The spread of the Konkan region is around 30846 km2 and 720 km long along the costa and comprises six districts Brihn Mumbai, Raigad, Ratnagiri, Sindhudurg, Thane and Palghar. The region has warm and humid climate with an average rainfall of 2515 to 3625 mm (Borkar et al. 2018; DBSKKV,2018).

Keeping in view of this, an intensive research work has been carried out to check the extent of certain physicochemical properties such as pH, Electrical Conductivity (EC) and organic carbon and contents of essentially required nutrients like Nitrogen, Phosphorus and Potassium in the soil of cultivating field. Importance of these properties and nutrients are briefly described as under:

**pH**

Soil pH is one of the driving forces effecting overall soil fertility and its management. It has both direct and or indirect effects on the ability of plants that utilizing soil nutrients. The pH also influences chemical solubility and availability of essential nutrients in plant, pesticide performance and organic matter decomposition (Prasad and Powar 1997). The pH value of soil greatly depends on relative amount of the absorbed hydrogen and metallic ions present in it. This provides a decisive information about the chemical nature of the soil. The pH range of soil in coastal areas of Konkan region of Maharashtra is 6.5-7.5 whereas the observed average of its value at experimental land is 7.1, which may be commendable and good for paddy crops in medium black soil (DBSKKV).

**Electrical Conductivity (EC)**

It is the measure of current carrying capacity and provides a clear idea about soluble salts present in soil. Determination of the EC of soil is a very quick, simple and inexpensive process to check health of soils. It is directly proportional to the concentration of ions present in the solution. The standard conductivity of coastal zone is 0-2 dSm-1. The all reported samples are within the standard range. Pipatpongsa and Jiro (2015) observed the the relationships between EC of soil and its effect on canopy, grain, and leaf of rice in northeastern Thailand.

**Organic Carbon (OC)**

OC is generally obtained from residue of plant & animals at various stages of decomposition. (Brady and Weil, 1999). It may helpful to increases the capacities of cation exchange and water holding that ultimately helpful to bind particles into aggregates. It also prevents nutrient leaching and is integral to organic acids that make minerals available to plants. The organic carbon percentage for a good soil is usually between 0.6 to 1 %. Nath et al. (2015) assessed the effect of soil OC in rain fed paddy growing soil.  Xue, et al (2015) studied the effects of tillage systems on soil OC and total nitrogen in a double paddy cropping system in Southern China.

**Nitrogen(N)**

Nitrogen is an integral component of amino acids that make up the requirements of protein and enzymes in all living organisms. (Camberato 2001). It is one of the basic nutrients and make up 1-4% of dry weight of plants and it forms chlorophyll, acetic acid, proteins, alkaloids and protoplasm. The alkaline permanganate method was used to determine the available contents of nitrogen in the test soil (Subbiah and Asija 1956).

**Phosphorus(P)**

Phosphorus is one of the most important elements present in every living cell. This micronutrient is essentially required for the substantial plant growth. It allows greater flexibility in plant. Here, phosphorus contents were determined by Olsen method (Olsen *et al.,* 1954).

**Potassium (K)**

Potassium (K) is one of the three main nutrients of balanced fertilizer along with nitrogen (N) and phosphorus (P) (Hasan 2002). Potassium plays a vital role in different physiological processes of plants such as metabolism reactions, formation of cellular structural components, for regulation of photosynthesis and production of plant sugars that are used for various plant metabolic needs. It is also associated with movement of water, nutrients and carbohydrates in plant tissue. In this study, available potassium was determined by Flame photometric method (Jackson, 1973).

**Topography of the experimental land**

Palghar district of Maharashtra state is spreading over around 112 km of linear sea rays with an average rainfall is about 2458 mm. The geographical structure of this region is a naturally beautiful terrain comprises of hills, some part coastal and remaining plain. The major agriculture crop of this region is rice with an average production of 2156 kg per/ha (KUKR, 2011).

**MATERIALS AND METHODS**

The present study considered the survey data of soil quality test for recent years 2021 & 2022 and the data is presented in Table 1. Ten different plots each having half an acre area owned by ARDF were selected for this study. A representative soil sample collected from each plot which represents soils of North *Konkan* Coastal Zone of Maharashtra. These representative soil samples were collected by following standard quadric procedure and taken in polythene bags. Before testing, all these samples were air dried under water proof shade. Then sample soil was grinded minutely enough to further pass it through 0.2 to 0.5 mm sieves.

In laboratory these samples were further tested for measuring different chemical parameters as per standard procedures (Jakson 1967). AR grade reagents and double distilled water was used for soil analysis. The obtained results were compared with their standard values as given in Table 2. Accordingly categorized as low or high nutrient's content present in the sample soil.

Based on the above results amount of nutrients is to be recommended for supplementary use before sowing (Miller and Donahue, 1995).

**RESULTS & DISCUSSION**

In the present reported study the entire cultivated field is divided into number of plots each of half acres and every plot conveniently being labeled as C, E, R & K series. All required soil tests such as pH, EC, organic carbon, N, P and K was duly conducted before sowing of crops in its in-house well equipped soil testing laboratory. After soil testing analysis as per recommendations appropriate fertilizer were given to respective plots. Findings of such ten numbers of plots belonging to E series have been analyzed and presented in Table 1.

It revealed that there is a significant increase in the crops yields was observed; as it increased from 2850 kg/ha in 2021 to 4102 kg/ha in 2022. The results of other parameter are described here in after.

Findings of the present results revealed that before sowing of paddy seeds in Kharif seasons of years 2021 and 2022, the average pH value of soil were found 7.14 and 7.13 respectively which is normal that should remain maintained.

The soil pH value indicates the acidity or alkalinity nature of the soil. Its normal value is lying between 6.5 to 7.5. Most suitable pH range of nutrients to a plant is 6.5 to 7.5 (MOAGOI 2011). Similar results (between 7 to 8 with the mean value of 7.5) were reported by Patidar *et al.,* (2017) in Madhya Pradesh, India.

The standard value of EC in normal soil should be less than 0.8 dsm-1. If it exceeds beyond 1.6 dsm-1, it may be injurious to the crops.

Table 1 show that in both years EC were less than 0.8 dsm-1 (0.46 & 0.25 dsm-1) that means EC also normal of these plots and soil is suitable for cultivation. Nath *et al*., (2014) reported that the EC of soil varied from 0.09-0.42 dSm-1 in field of the Shivanagar district (Assam) this validates the reported values of EC in present study.

Organic carbon was determined by rapid titration Method. Before paddy sowing in 2021 organic carbon of each plot was found 0.69% which is moderately good. In next year *i.e.* in 2022 it was maintained by adding organic matter and again reported as 0.84%. The reports of the status of OC in the soils of Assam, India were 1.11% that validates the present result on OC.

Findings of availabilities of N, P and K are given in Table 1. From the obtained data it has been observed that before paddy sowing in kharif 2021 average available Nitrogen were 208.2 kg/ha which is comparatively low. As per STR its dose was increased by 25% to make it balanced. Similar result was repeatedly observed in 2022, an average available Nitrogen were reported as 115.6 kg/ha which is too low then as per STR, this time as a remedial action increased its dose by 50%. In similar conditions Prasuna *et al.*, (1992) and Chalwade *et al.* (2006) reported lower available nitrogen in soil of their respective experimental lands.

As far as Phosphorous is concerned, the soil test report indicates that average available phosphorus of plots soil in 2021 is 19.7 kg/ha which is low then as per STR, it was increased by 25% as supplemented dose of phosphorus to fulfill paddy crop requirement. In year 2022 again, found that 32.1 kg/ha average available phosphorus which is moderately high so as per STR, applied recommended dose of phosphorus only.

Similar results were noticed by Ashokkumar and Prasad (2010) and Rajeshwar and Ramulu, 2016.

In 2021, an average available potassium values was observed 329.9 kg/ha that is too high, so as per STR decreases its doses by 50% to make it normal. Similarly in 2022, average available potassium was obtained 271.9 kg/ha which is again high so as per STR decrease by 25%.

More and Gavali (2000) evaluated Potassium in swell shrink soil at Parbhani district of Maharashtra. It was found in range of 120 to 370 kg/ha with its mean value of 228.50 kg/ha.

**Table 1.** Study of Presence of pH, EC, OC, N, P, K, in the test field soil at ARDF

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Nomenclature****of plots** | **Year** | **pH** | **E.C. (dSm-1)** | **O.C.****(%)** | **N (kg/ha)** | **P (kg/ha)** | **K (kg/ha)** | **Yield (kg/ha)** |
| **E1** | 2021 | 7.0 | 0.44 | 0.35 | 138 | 26.8 | 444.9 | 2125 |
| 2022 | 7.18 | 0.17 | 0.87 | 117.9 | 22.3 | 330.6 | 3375 |
| **E2** | 2021 | 6.61 | 0.41 | 0.44 | 363.8 | 27 | 301.6 | 3000 |
| 2022 | 7.12 | 0.28 | 0.86 | 105.37 | 19.27 | 396.88 | 5125 |
| **E3** | 2021 | 6.79 | 0.79 | 0.56 | 388.9 | 24.58 | 576.1 | 2875 |
| 2022 | 6.88 | 0.23 | 0.79 | 120.4 | 24.1 | 376.6 | 4375 |
| **E4** | 2021 | 7.11 | 0.43 | 0.51 | 188.2 | 12.07 | 129.5 | 2875 |
| 2022 | 6.97 | 0.25 | 0.65 | 130.5 | 29.01 | 344.5 | 4250 |
| **E5** | 2021 | 7.73 | 0.64 | 0.48 | 200.7 | 19.53 | 171.7 | 3250 |
| 2022 | 7.47 | 0.32 | 0.78 | 70.25 | 34.3 | 29.8 | 3775 |
| **E6** | 2021 | 7.16 | 0.35 | 0.89 | 150.5 | 22.17 | 184.98 | 3375 |
| 2022 | 6.93 | 0.19 | 0.79 | 122.9 | 43.3 | 15.2 | 4250 |
| **E7** | 2021 | 7.08 | 0.29 | 1.19 | 250.9 | 21.07 | 487.73 | 3000 |
| 2022 | 7.46 | 0.25 | 0.98 | 72.75 | 57.64 | 231.95 | 4250 |
| **E8** | 2021 | 7.11 | 0.27 | 0.9 | 238.3 | 20.19 | 366.03 | 2500 |
| 2022 | 7.28 | 0.19 | 0.88 | 72.8 | 46.5 | 411.5 | 4345 |
| **E9** | 2021 | 7.47 | 0.64 | 0.85 | 100.3 | 10.53 | 219 | 2625 |
| 2022 | 7.09 | 0.303 | 0.9 | 200.7 | 22.35 | 282.83 | 3000 |
| **E10** | 2021 | 7.36 | 0.33 | 0.81 | 62.7 | 13.61 | 417.9 | 2875 |
| 2022 | 6.98 | 0.3 | 0.91 | 143 | 22.4 | 300.1 | 4250 |
| **Average** | 2021 | 7.14 | 0.46 | 0.69 | 208.2 | 19.7 | 329.9 | 2850 |
| 2022 | 7.13 | 0.25 | 0.84 | 115.6 | 32.1 | 271.9 | 4102.5 |

**Paddy** **Plots**

**Paddy Yield (kg/ha)**

**Figure 1:** Plot wise Paddy yield for the year 2021 and 2022.

**Table 2:** Recommendation for healthy soil

|  |  |  |
| --- | --- | --- |
| Sr. No. | Parameter | Average value |
| 1 | pH | 6.5-7.5 |
| 2 | EC (dSm-1) | <0.8 |
| 3 | Organic Carbon (%) | >0.61 |
| 4 | Available N (kg/ha) | 281-420 |
| 5 | Available P2O5 (kg/ha) | 21-30 |
| 6 | Available K2O (kg/ha) | 151-200 |

**CONCLUSION**

The rigorous study reveals that Soil pH levels remained stable over two years, indicating favorable conditions for paddy cultivation. A significant decrease in electrical conductivity (E.C.) from 2021 to 2022 suggests a positive trend, reducing soil salinity levels, which benefits crop production.

Organic carbon content remained consistent, providing a strong foundation for soil health. Nutrient levels, including N, P, and K, generally met paddy cultivation requirements, with minor fluctuations likely due to fertilization practices.

Crop yields varied significantly among all plots and obtained the highest yield with an overall good average of 4102.5 kg/ha. In the year 2022 From this study, it can be concluded that reports on pH, EC, OC and available N, P, K are health indicators of a farming land. Based on the soil testing report agronomists recommend doses of certain fertilizers that suitably applied to overcome the deficiency of nutrients. Recommendations for maintaining healthy soil are provided in Table 2.

The present report would also be helpful for researchers, practitioners and ultimately farmers to tackle the soil related issues efficiently. It would help in establishing a balance between production economy and use of fertilizers retaining the quality of soil.

**COMPETING INTERESTS**

* Authors have declared that no competing interests exist.

**CONTRIBUTIONS**

* Dr Swapnil Dekhane conducted the research, taken its observations and did analysis.
* Dr. Narendra Kumar contributed in drafting, editing of this manuscript, finally communicated to journal.

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Details of the AI usage are given below:

* 1. ChatGPT (Open source) and Meta

**REFERENCES:**

Ashokkumar HP, Prasad J. Some typical sugarcane growing soils of Ahmadnagar district of Maharashtra: Their characterization, classification and nutritional status of soils and plants. J Indian Soc Soil Sci.2010; 56 (3) : 257-266.

Brady NC, Weil RR. The Nature and Properties of Soils, 12th Edition. Upper Saddle River, NJ: Prentice-Hall, Inc. 1999: p 881.

Camberato JJ. Nitrogen in Soil and Fertilizers SC Turfgrass Foundation News, January-March 2001; 8(1): p 6-10.

Chalwade PB, Kulkarni VK, Ghuge SD. Physico-chemical and macronutrient status in soil of sugarcane-growing areas of Parabhani and Nanded district, Maharashtra, India, J. Soils & Crops, 2006;16 (1): 127-130.

Food and Agricultural Organization, FAO, United Nations, 2011. https://www.fao.org/

Hasan R. Potassium Status of Soils in India, Better Crops International November 2002; 16, (2).

Jackson, M. L. Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India, 1973; 498:151-154.

Krishi Utpadan Karyakramachi Rupresha (KUKR), Kharif and Rabi Hangam - 2010-11, Vibhagiy Sabha, Konkan Mahsul Vibhag. Dept. of Agriculture, Govt. of Maharashtra

Miller RW, Donahue RL. Soils in our Environment 7th edition Prentice Hall Ine, New Jersey-07362,1995; 67-68.

Ministry of Agriculture, Government of India, MOAGOI (2011) Methods manual, Soil testing in India. Department of Agriculture and Corporation, Ministry of Agriculture, Government of India. New Delhi. January 2011

More SD, Gavali SG. Potassium fractions in relation to soil properties in Vertisol. J. Maharashtra Agric. Univ., 2000;25 (3): 299-300.

Nath TN. Soil bulk density and its effect on soil texture, OC content and available micro-nutrients of tea cultivated soil in district of Assam, India. International J Dev Res.2014; 4(2):343-346.

Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorus in soil by sodium carbonate. Hand Book of USDA,1954; No. 60.

Patidar RK, Archana R, Sharma SK, Rahul T. Evaluation of basic properties of soil and major nutrient in soils of jhabua district of madhya Pradesh. International J of Agri. Env and Biotech Citation,2017; 10(1):45-52.

Prasad R, Power JF. Soil Fertility Management for Sustainable Agriculture. Boca Raton, FL: CRC Press LLC. 1997; 356p.

Prasuna RP, Pillai RN, Bhanuprasad V, Subbaiah GV. Clay mineralogy of Alfisols and associated soils of Kavali area under Somasila project in Andhra Pradesh. J Ind Soc Soil Sci,1992; 40 (4): 893-896.

Rajeshwar M, Ramulu V. Vertical distribution of available macro & micronutrients in soil profiles of ganapavaram pilot area. An Asian J of Soil Sci.2016; 2 (1):202-206.

Sharma YM, Jatav RC, Sharma GD, Thakur R. Status of Micronutrients in Mixed Red and Black Soils of Rewa District of Madhya Pradesh, India. Asian J of Chem.2013; 25(6):3109-3112

Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. Current Sci.1956; 25: 259.

UNO report, <https://www.un.org/en/global-issues/population>

Borkar VS, Gokhale NB, Dhopavkar RV, Khobragade NH, More SS and Kasture MC, (2018), International Journal of Chemical Studies, 2018; 6(1): 275-279.

Expert system for paddy, TNAU, Tamilnadu, <http://www.agritech.tnau.ac.in/>

Technical bulletin no 9, problem soils of Konkan and their management, DBSKKV, Dapoli, 2018,

Pipatpongsa T. and Jiro, T. The relationships between electrical conductivity of soil and reflectance of canopy, grain, and leaf of rice in northeastern Thailand, International Journal of Remote Sensing,2015; 36(4).

Nath, A. J., Bhattacharyya, T., Deka, J., Das, A. K., & Ray, S. K. Management effect on soil organic carbon pools in lowland rain-fed paddy growing soil. *Journal of Tropical Agriculture*,2015; *53*(2), 131-138.

Xue, Jian-Fu, Chao Pu, Sheng-Li Liu, Zhong-Du Chen, Fu Chen, Xiao-Ping Xiao, Rattan Lal, and Hai-Lin Zhang. "Effects of tillage systems on soil organic carbon and total nitrogen in a double paddy cropping system in Southern China." *Soil and Tillage Research* , 2015; 153: 161-168.