<u>Original Research Article</u>

Assessment and delineation of GPS-GIS based Soil Fertility Maps of Instructional Farm, Malegaon tehsil Baramati

ABSTRACT

The present investigation entitled "Assessment and delineation of GPS-GIS based fertility maps of Instructional Farm, Malegaon tehsil Baramati" was conducted in the year 2023-24 at division of Soil Science, Dr. Sharadchandra Pawar College of Agriculture, Baramati with an objectives to assess the soil available nutrient status and delineation of GIS based maps of soil available nutrients. Using Arc-GIS 10, Version 10.8, fertility maps of the available macro nutrients were created. The area under the Instructional Farm had soil pH ranged from 7.11 to 8.32, categorized into the slightly alkaline to moderately alkaline categories while the EC varied from 0.21 to 1.99 dSm^{-1}, indicating that most of the soils were non-saline. The soil's organic carbon and calcium carbonate contents ranged from 0.21 to 0.97 per cent and 1.50 to 19.75 per cent and they were classified into low to high and low to very high categories respectively. In the Instructional Farm, the ranges of available nitrogen, phosphorus and potassium content were 85.50 to 360.75, 23.29 to 80.08 and 202.5 to 968.68 kg ha^{-1} respectively. The Instructional Farm soils had very low to moderate levels of available nitrogen, moderately high to very high levels of available phosphorus and moderately high to very high levels of available potassium. The implementation of GPS-GIS-based techniques for soil sampling represents a significant advancement that will allow researchers and institute officials to track changes in soil fertility over the years. The soil fertility maps created for the Instructional Farm will be invaluable for establishing a scientifically sound fertilization schedule.

Key words: *Soil, Fertility maps, GPS-GIS, Instructional Farm*

1. INTRODUCTION

A necessary resource soil is referred to as the 'Soul of Infinite Life'. The most important and valuable natural resource that keeps life alive on earth is soil. An inch of top soil requires nearly ten thousand years to produce but in today's world, pollution and soil contamination are main issues. The development and application of soil nutrient management technologies that improves plant productivity and soil quality are biggest challenge for today. The adoption of green revolution technologies has led to dependence on different synthetic inputs predominantly fertilizers which are derived from fossil fuels. Excessive use of chemical fertilizers negatively impacts soil, leading to a significant decline in soil fertility.

Major nutrients also known as macronutrients are those that are needed in high amounts like C, H, O, N, P, K, Ca, Mg and S are some of them. C, H and O are known as structural elements which accounts for 95 percent of the plant's dry matter weight and provided through carbon dioxide (CO_2) and water (H_2O). Macronutrients includes both primary and secondary nutrients that are derived from soil, fertilizers and other sources. The key and vital primary nutrients nitrogen, phosphorus and potassium are introduced into the soil either during sowing or through subsequent intercultural operations. Imbalances in nutrient application either deficiency or excess can result in various disorders affecting both the plant and its fruit.

Retention and availability of nutrients, minerals content, presence of organic matter and soils environment are significantly influenced by the chemical characteristics of the soils. The chemistry of soils involves the chemical reactions that influence the development of plants, animals and humans (Tale, 2015). Chemical characteristics of soils are developed from weathering processes, parent material transportation and soil forming processes. The chemical properties of soils includes different parameters such as pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable Ca and Mg, organic carbon content and calcium carbonate content. The amount of organic matter, calcium carbonate, microbial activity, pH changes, amount of clay and soil moisture status all affect the soil's nutrient availability (Naphade*et al*. 2022).

The preparation of soil fertility maps is now possible through the applications of modern technologies such as GPS and GIS. The United States military administrated the Global Positioning System, a space-based navigation and tracking system that accurately determines the location of the object on earth's surface using geographical coordinates. A Geographic Information System (GIS) is a computer system used for capturing, querying and displaying geographic data. It is easy to change the data regarding to fertility status of an area even after the soil fertility maps are prepared (Surabhi *et al.* 2017).

2. MATERIAL AND METHODS

The Instructional Farm, Malegaon tehsil Baramati is located between 18° 08' N latitude and 74° 31' E longitude with an area of 110 acres. Soils are resultant of the igneous rocks viz. Basalt (Deccan trap) which is basic in nature containing mainly feldspars (plagioclase), augite and small amount of titaniferrous magnetite mineral. The climate is classified as semi-arid tropical. The soils of Instructional Farm are under cultivation of Maize, Sorghum, Soybean, Sugarcane and fruit crops like Mango, Guava, Sapota, Coconut as well as vegetables crops like Onion, Okra, Tomato, Brinjal etc. Total 104 Geo-referenced surface (0-22.5 cm) soil samples representing different textured soils were collected at 50 m^2 grid from Instructional Farm, Malegaon tehsil Baramati. The latitude and longitude of sampling sites were recorded with the help of differential Global Positioning System (GPS). The delineation of the area for mapping different nutrient levels in soils was carried out using Arc-GIS 10, Version 10.8 software.

The pH was measured by in 1:2.5 soil water suspension using glass electrode pH meter and EC (dSm^{-1}) was measured in the supernatant solution of 1:2.5 soil water suspension using conductivity meter (Jackson, 1973). Organic carbon by wet oxidation method (Walkely and Black, 1934). Available Nitrogen was estimated by alkaline permanganate method of (Subbiah and Asija, 1956). Available phosphorus was extracted with 0.5 M NaHCO3 solution buffered at pH-8.5. (Watanabe and Olsen 1965). Available Potassium was estimated by shaking the requisite amount of soil sample with 1 N neutral ammonium acetate solution at pH-7.0, (Jackson, 1973)

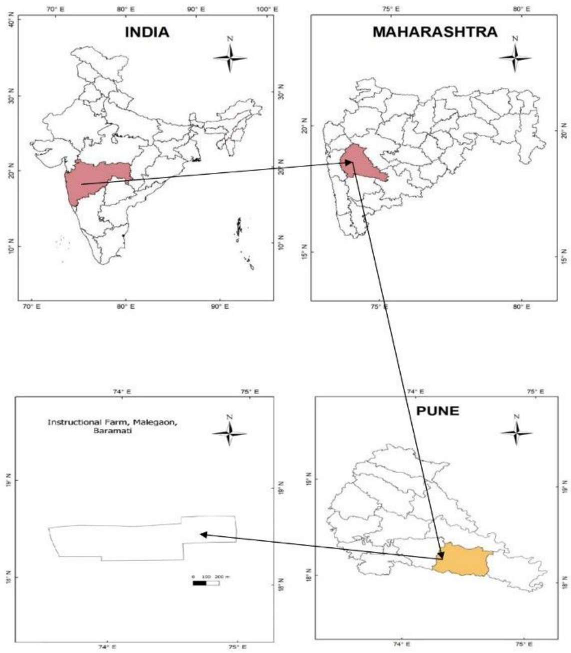


Fig. 1 Location map of Instructional Farm, Malegaon tehsil Baramati

3. RESULT AND DISCUSSION

3.1 Soil reaction (pH)

The Soil pH of the Instructional Farm ranged from 7.11 to 8.32 with mean of 7.8. The alkaline nature of the soil could be attributed to the semi arid climatic condition of study area, annual evaporation rate is higher in comparison to rainfall hence there is less possibility of leaching down of soluble salts which results in accumulation of salts in soil's root zone. The similar results were recorded by Shirgave *et al.* (2015) in soils around Arjunnagar of Kolhapur district, Jagtap *etal.* (2018) in Ajang village of Dhule tehsil of Dhule district (MH).

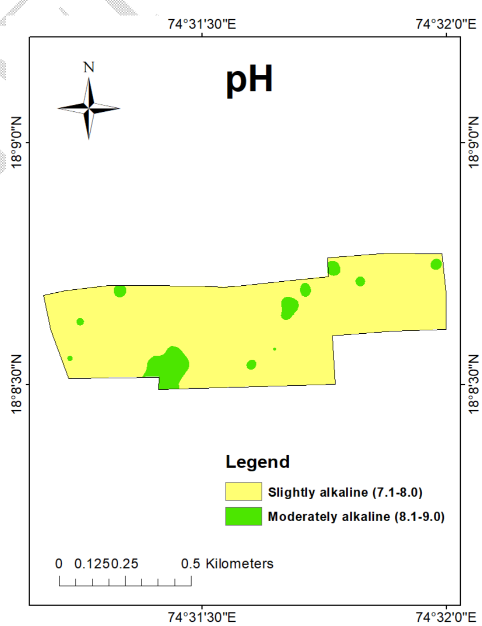


Fig. 2 Map of soil pH of Instructional Farm, Malegaon tehsil Baramati

3.2 Electrical conductivity (EC)

The range and mean of electrical conductivity of soils from the Instructional Farm were 0.21 to 1.99 dSm^{-1}, 0.73 dSm^{-1} respectively. The majority of the soils exhibited normal electrical conductivity, likely due to careful management of irrigation water. The accumulation of soluble salts on the surface of soil along with Ca^{+2} and Mg^{+2} carbonates may have led to increase EC greater than 1 dSm^{-1}. Naphade*et al.* (2022) reported comparable results in soils of Jalgaon district of Maharashtra and Ushasri *et al*. (2019) in soils of Bhudargad block, Kolhapur district. Similar observations were noted by Mandavgade*et al.* (2015) in soils of Jintur, Selu and Pathri tehsils of Parbhani district.

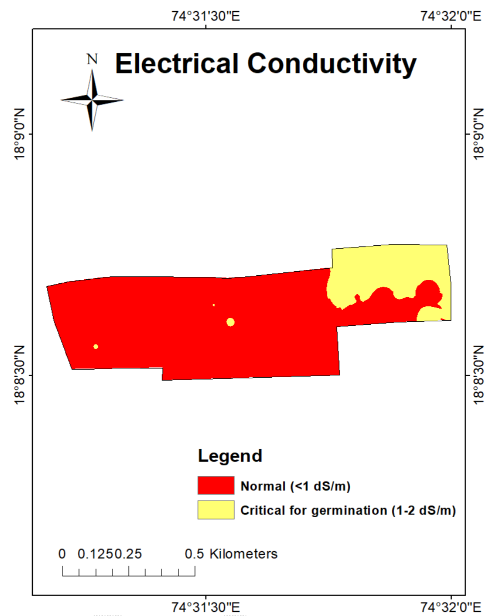


Fig. 3 Map of soil EC of Instructional Farm, Malegaon tehsil Baramati

3.3 Organic carbon

The organic carbon of soils from the Instructional Farm was ranged from 0.21 to 0.97 per cent with mean of 0.62 per cent. Moderate to moderately high levels of organic carbon in soils were observed which may be caused by the addition of organic residues in soil. Wide variation in content of organic carbon might be due to high temperature dominant during summer increase the decomposition rate of organic matter. Aich *et al.* (2017) reported corresponding results in the soil of Organic Farm at College of Agriculture, Pune. Kumar and Palwe (2017) documented similar observations in the soils of Girawali village of Ambegaon tehsil, Pune (MH). Kashiwar*et al.* (2023) also recorded similar findings in Pauni block of Bhandara district (MH).

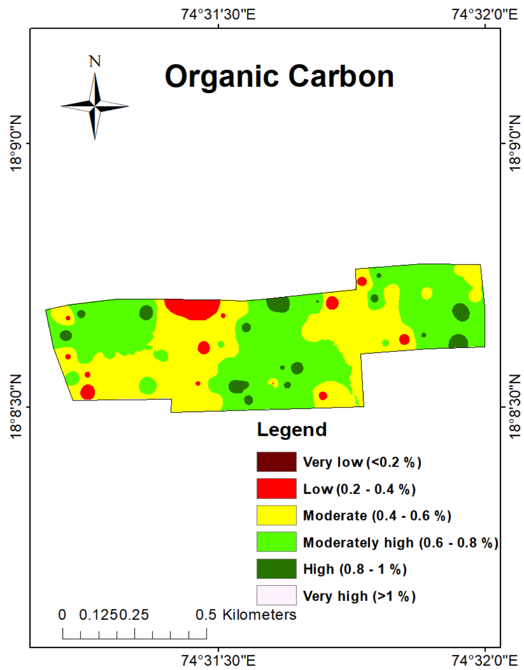


Fig. 4 Map of soil organic carbon of Instructional Farm, Malegaon tehsil Baramati

Table 1 Chemical properties status in soils of Instructional farm, Malegaon tehsil Baramati.

Particular	pH (1:2.5)	EC (dSm^{-1}) (1:2.5)	Organic Carbon (%)	$CaCO_3$ (%)
Mean	7.85	0.73	0.62	8.98
Standard Error	0.02	0.05	0.02	0.51
Standard Deviation	0.17	0.48	0.19	5.22
Minimum	7.11	0.21	0.21	1.50
Maximum	8.32	1.99	0.97	19.75
CV%.	2.18	65.39	30.05	58.12
Category	Slightly alkaline (84.61)	Normal (78.85)	Low (17.30)	Low (7.69)
	Moderately Alkaline (15.39)	Poor Seed emergence (21.15)	Moderate (27.20)	Moderate (21.16)
			Moderately high (38.25)	Moderately high (37.5)
			High (17.25)	Very high (33.65)

(Total no. soil samples analyzed - 104, Figures in Parenthesis are in Per cent)

3.4 Calcium carbonate

The content of calcium carbonate in the soils of the Instructional Farm ranged from 1.5 per cent to 19.75 per cent where mean was 8.98 per cent. Low precipitation and accelerated rate of evaporation in the semi-arid climatic condition within the study area led to more accumulation and precipitation of calcium carbonate resulting in high calcareousness in soil. Similar results revealed by Surabhi *et al.* (2017) in the soil of Shirol tehsil of Kolhapur district. Ingole *et al.* (2018) recorded similar findings in the soil of Nanded district (Maharashtra) and also reported by Hadole*et al.* (2019) in the soil of Jalgaon district (Maharashtra).

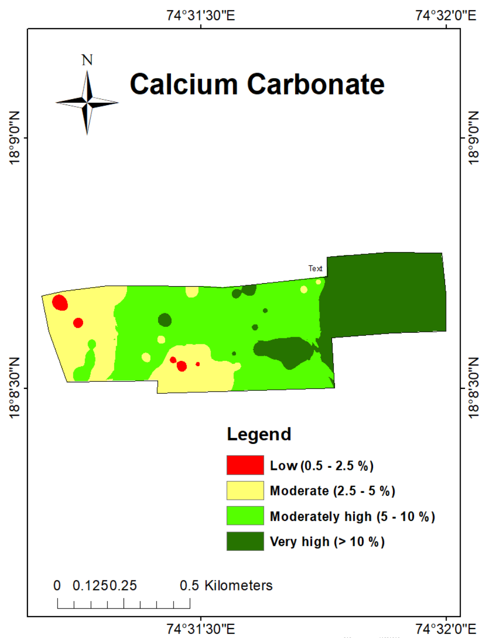


Fig. 5 Map of calcium carbonate of Instructional Farm, Malegaon tehsil Baramati

3.5 Available nitrogen

Range of available nitrogen was 85.5 to 360.5 kg ha^{-1} with mean of 244.23 kg ha^{-1} respectively.The low availability of nitrogen in most of the soils may be due to higher temperature in the semi-arid climate, which may have accelerated the rate of denitrification resulted in low levels of available nitrogen. The variation in soil nitrogen content may be related to management of soil, application of fertilizers and farm yard manure to previous crops etc. Similar results were recorded by Nagawade (2014) in Central Research Farm MPKV, Rahuri, Surabhi *et al.* (2017) in soils of Shirol tehsil of Kolhapur and Kondvilkar and Thakre (2018) in soils of Sakri tehsil of Dhule.

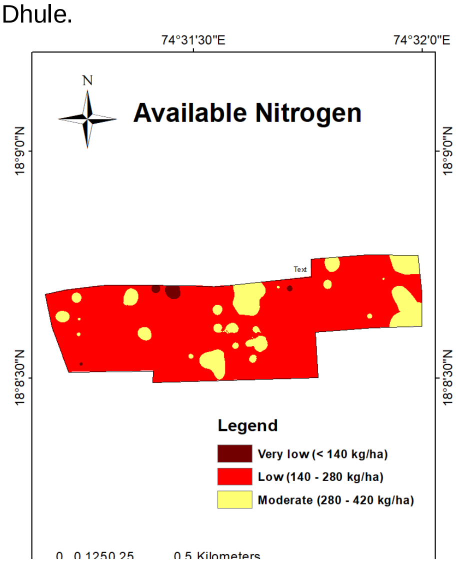


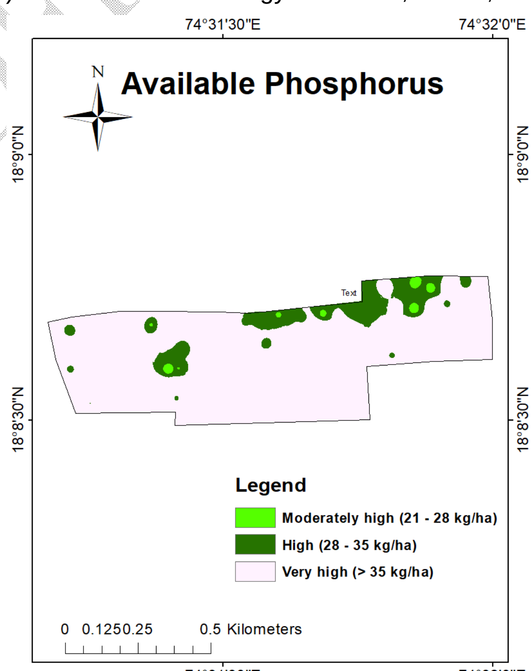
Table 2. Available nutrient status in soils of Instructional farm, Malagaon tehsil Baramati.

Particular	Available Nutrients (kg ha^{-1})		
	N	P	K
Mean	244.23	47.23	566.38
Standard Error	5.62	1.48	21.76
Standard Deviation	57.30	15.10	221.89
Minimum	85.50	23.29	202.5
Maximum	360.75	80.08	968.68
CV%.	23.46	31.98	39.18
Category	Very low (3.85)	Moderately high (7.69)	Moderately high (8.66)
	Low (65.38)	High (18.27)	High (4.80)
	Moderate (30.77)	Very high (74.04)	Very high (86.54)

(Total no. soil samples analyzed - 104, Figures in Parenthesis are in Per cent)

3.6 Available phosphorus

The status of available phosphorus in the soils of the Instructional Farm ranged from 23.29 to 80.08 kg ha^{-1} with mean of 47.23 kg ha^{-1}. The high range of soils available phosphorus under study area may be mostly caused by several factors including past fertilization practices, organic matter content, soil texture, various soil management practices, semi-arid environment with low rainfall. The continuous use of high-analysis fertilizers especially DAP, SSP has led to the phosphorus build up and resulted in high levels of available phosphorus in the soils. Similar findings were noted by Surabhi *et al.* (2017) in soils of the Shirol tehsil of Kolhapur district and Rajmani*et al.* (2020) in soils of the KrishiVigyan Kendra, Palem, Telangana.



3.7 Available potassium

The available potassium in soils of the Instructional Farm ranged from 202.50 to 968.68 kg ha^{-1} with mean of 566.38 kg ha^{-1}. The available potassium content of significant portion of the study areas soil was very high, this could be attributed to the predominance of mica and feldspar minerals in the parent materials. Similar outcomes of available potassium was documented by Pulkeshi*et al.* (2012) in soils of Mantagani village under northern zone of Karnataka, Palwe and Yelwe (2018) in soil of blocks A and B of central campus MPKV, Rahuri and also similar results recorded by Patil *et al*. (2016) in soil of Panhala tehsil of Kolhapur.

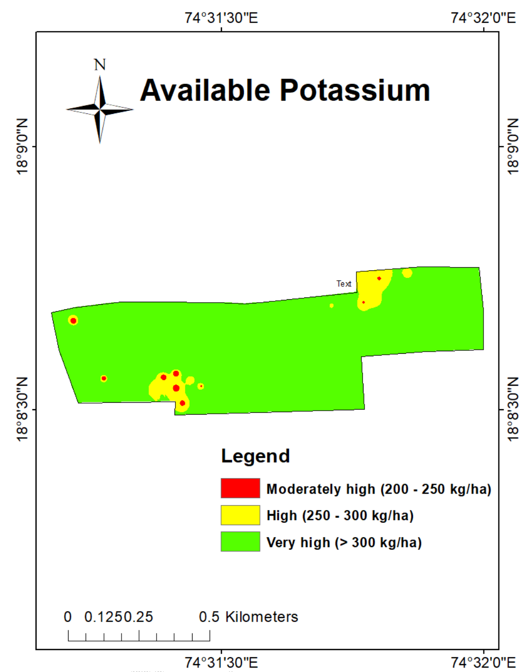


Fig. 8 Map of soil available potassium of Instructional Farm, Malegaon tehsil Baramati

CONCLUSIONS

The study reveals the several findings into the nutrient level of soils at the Instructional Farm, Malegaon tehsil Baramati. The soils were slightly alkaline with most samples showed suitable electrical conductivity and good for crop growth. Organic carbon content varied widely but a major proportion of soils were moderately high in organic carbon. calcium carbonate content was also moderate to very high.

Nitrogen levels were low, likely due to high temperatures accelerating denitrification processes. Availability of phosphorus levels were high to very high, possibly due to past fertilizer application practices. Potassium levels were also very high attributed to the presence of potassium rich minerals in the parent material.

Future Implications

Holistic survey and precise use of analytical techniques in this investigation have enabled the investigator to come out with soil fertility maps of the Instructional Farm, Malegaon tehsil Baramati. The use of GPS-GIS based technique for soil sampling is new land mark, which will enable the further researchers and Institute officials to monitor the changes in soil fertility status for years to come. The soil fertility maps of the Instructional farm will be of great utility for monitoring the fertilization schedule on sound scientific footing for improving the crop yields, Moreover, the timely monitoring of soil health deterioration can also be maintained by following appropriate soil reclamation techniques.

DISCLAIMER

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts. COMPETING INTERESTS: Authors have declared that no competing interests exist.

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Details of the AI usage are given below:

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