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Soil fertility status and nutrient recommendations based on soil analysis of Neemuch district of north western Madhya Pradesh, India

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ABSTRACT

The available forms of nutrients govern the fertility of soil and also control the productivity of crops but this is affected by pH, EC and OC status of soil. A study was conducted to assess available nutrients status and their relationship with chemical properties of soil of Neemuch District. The result depends on the quality of 10 representative soil samples were obtained and analyzed for its pH, electrical conductivity, Organic Carbon, Nitrogen, Phosphorus, Sulphur, Potassium, Iron, Manganese, Zinc, Copper and Boron content present in soil. The results indicated that all samples were slightly alkaline to moderately alkaline in soil (7.22 – 7.69), EC (0.20 -0.68 dS/m) and moderately high in organic carbon (0.69 - 0.96 %). Regarding primary nutrients, the available N, P and K which ranged between (260.2 - 321 kg ha^{-1}), (6.4 – 17.48 kg ha^{-1}) and (268 - 578 kg ha^{-1}), respectively, available S is ranged between (6.32 – 14.61 ppm) was slightly deficient in soil, whereas available Zn, Fe, Mn, Cu and B ranged between 0.48 – 0.93 ppm, 2.61 – 6.04 ppm, 10.64 – 19.68 ppm, 0.89 – 2.66 ppm and 0.31 – 0.78 ppm respectively. It is concluded that these soil data of Neemuch District can be effectively utilize with proper nutrient management and regular monitoring to avoid any nutrients deficiency on crop. In our investigations, we observed that due to the excessive use of fertilizer, the soil became slightly toxic and deficient in some nutrients. The soils of Neemuch Distirict are slightly below to moderate in nitrogen and phosphorus content whereas, excessive in potassium content. The availability of micronutrient Sulphur, Iron and Boron were low to medium whereas, copper and manganese were sufficiently available. We conclude that farmers should use organic manure along with chemical fertilizers, which will enhance soil fertility and crop yield.

Key words: Soil, Research farm, chemical properties etc.

INTRODUCTION

Objective

The objectives of soil analysis are as follows: to provide an index of nutrient availability or supply in a given soil- the soil extract is designed to evaluate a portion of the nutrients from different farms; to determine nutrient availability- Identify the level of nutrients available in the soil and determine if more are needed; to predict the probability of obtaining a profitable response to fertilizer application; Save resources: Apply the right amount of fertilizer to save money and conserve energy; to provide a basis for fertilizer recommendations for a given crop; to evaluate the fertility status of the soil and plan a nutrient management program.

Study Area

The arable land in Neemuch district is 181150 ha. The main crops of Neemuch district are Rabi and Kharif. Soyabeen, Maize, Bajara, Jwar, Sua, tur is under Kharif while Wheat, gram, Rai, Isabgol are Rabi crops. Tulsi, Mustard and Opium are the main crops of district Neemuch.

Geographical Location and Soil Status of Neemuch District

This experiment was conducted on research farms of Neemuch district. The total geographic area of Neemuch district is 40 km^2 (20 sq mi). It is positioned at latitude 24.45°N 74.87°E. Neemuch shares its border with Rajasthan in the west and north and by Mandsaur district in the east and south. Mainly four types of soil found in this area viz Medium Deep Black cotton soil, Red loamy soil, Laterite soil and Alluvial soil. Black cotton soil is derived from weathering and disintegration of basaltic lava flow. Major parts of the district are covered by medium deep black soils. Red loamy soils consist of sandy loam to clayey loam and brick in colour. This soil is derived from Vindhyan sandstone and shale and occurring in valley portion on the plateau and adjacent to hill

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composed of Vindhyan sandstone. This type of soil covers a Northern part of the district. Laterite soil dark brown to pink colored lateritic soil is found as capping over hillocks of basaltic terrain. Alluvial soils are grayish yellow to brownish yellow in colour and occupy along the major rivers. All the soils found in Neemuch District are known for making the land immensely fertile. As Mentioned in the report PMKSY (DIP), prepared by district level implementation committee, Neemuch (M.P.).

Agricultural sustainability depends upon maintenance or enhancement of soil health and quality. Soil quality is the major linkage between the strategies of conservation management practices and achievement of major goals of sustainable agriculture (Andrews, 2004). Soil characterization, particularly soil fertility assessment of an area is an important aspect in view of sustainable agricultural production (Singh *et al.,* 2017). As soil nutrients governs the fertility of soil and controls the productivity of crops grown on to soil (Bharti *et al.,* 2017). In recent years, efficiency of chemical fertilizer nutrients has declined tremendously under an intensive agricultural system (Meena *et al.,* 2017). The stagnation in crop productivity cannot be enhanced without use of the essential plant nutrients to overcome the existing deficiencies and stress (Lenka *et al.,* 2016). Soil quality and health not only determine agricultural sustainability but also environmental quality. Introduction of high yielding varieties and insufficient supply of fertilizer nutrient causes mining of nutrients from soil particularly potassium (Pathak *et al.,* 2010; AICRP-LTFE, 2013).

MATERIALS AND METHODOLOGY

The analysis work of present investigation was carried out during the year 2023 in the Department of Chemistry and Botany, Shri Sitaram Jajoo Government Girls college, Neemuch with collaboration of Department of Kisan Kalyan Evam Krishi, Soil Testing Laboratory, Krashi Upaj Mandi, Neemuch.

Sample Processing

Soil samples were collected during March 2023. Soil sampling was taken from ten different research farm of, Neemuch District, M.P. viz Jalodiya Khurd, Navalpura, Nipaniya Abad, Ranpur, Nalkheda, Kelukheda, Jamuniya Khurd, Dhaneriya Kalan, Peeth and Harnawada village. The soil samples were collected with the help of steel soil auger. Collected soil samples were dried and crushed and passed through 2 mm sieve.

Soil analysis Method

The experiment includes soil analysis of chemical properties of soil – Soil pH, EC (dSm^{-1}), Organic Carbon (%), available Nitrogen ($kgha^{-1}$), available Phosphorous ($kgha^{-1}$), available Potassium ($kgha^{-1}$), available Sulphur (ppm) and available Zinc (ppm) in soil. Micronutrients in Soil- available Iron (ppm), Manganese (ppm), available Boron (ppm) and available Copper in Soil (ppm).

Soil samples were analyzed for chemical characteristics by following standard analytical techniques. Soil reaction was determined using standard pH meter by Potentiometry. The soil pH and EC were estimated by the standard procedures as described by (Jackson, 1973). Organic carbon content in soil was estimated using the wet oxidation method (Nelson and Sommer, 1982). Available nitrogen was determined following the method of Subbiah and Asija 1956. Available phosphorus and potassium were determined by Ascorbic acid method for P by 0.5 M $NaHCO_3$ (Watanabe and Olsen, 1965) and flame photometric method (Toth and Prince, 1949) respectively. Available Sulphur was determined by the Turbidimetric determination method described by (Chesnin and Yien, 1951).

Diethylenetriamine penta aceticacid soil test (DTPA) extractable zinc, iron, manganese and copper contents in the soils were determined by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

SOIL HEALTH CARD

Table 1: This paper represent the result obtained during the investigations carried out in the field and laboratory, Department of Kisan Kalyan Evam Krishi, Soil Testing Laboratory, Krashi Upaj Mandi, Neemuch, Madhya Pradesh of Research Farms

Parameters	SOIL TESTING RESULT									
	Research Farm									
	Jalodiya Khurd	Navalpura	Nipaniya Abaad	Ranpur	Nalkheda	Kelukheda	Jamuniya Khurd	Dhaneriya Kala	Peeth	Harnawada
pH	7.64	7.49	7.38	7.52	7.67	7.68	7.38	7.69	7.22	7.58
Ec (dsm^{-1})	0.28	0.22	0.68	0.68	0.2	0.62	0.22	0.42	0.53	0.32
Organic Carbon (%)	0.91	0.96	0.84	0.78	0.91	0.78	0.81	0.92	0.69	0.69
Nitrogen (kg ha^{-1})	316	321	294	276.3	316	276.3	283.5	317	260.2	260.2
Phosphorus ((kg ha^{-})	12.61	9.6	14.4	9.62	17.48	12.84	11.44	12.41	12.6	6.4
Potassium ((kg ha^{-})	279	548	382	352	578	473	369	452	564	268
Sulphur (ppm)	12.91	11.64	11.32	6.94	14.61	9.32	12.69	15.6	14.4	9.62
Zinc (ppm)	0.51	0.53	0.48	0.64	0.84	0.62	0.59	0.93	0.62	0.84
Iron (ppm)	2.91	3.69	4.3	6.04	4.61	2.69	2.61	4.62	4.11	4.69
Manganese (ppm)	12.61	10.64	18.94	13.38	18.94	18.94	16.62	12.69	19.68	17.4
Copper (ppm)	1.32	1.91	1.28	1.72	2.66	0.89	1.92	2.11	2.13	1.28
Boron (ppm)	0.61	0.78	0.69	0.64	0.48	0.61	0.31	0.61	0.42	0.62

RESULTS AND DISCUSSION

During the present investigation, soil sample was taken from ten different research farm of Neemuch District, M.P viz Jalodiya Khurd, Navalpura, Nipaniya Abad, Ranpur, Nalkheda, Kelukheda, Jamuniya Khurd, Dhaneriya Kalan, Peeth and Harnawada village. These samples were analyzed for their various chemical properties of soil. The chemical characteristics i.e., soil pH, Electrical Conductivity, total soil Organic Carbon, total Nitrogen, Phosphorus, Potassium, Zinc, Sulphur, Boron, Manganese and Iron has been determined by routine standard procedure (Black, 1965).

Fertility of a soil can be assessed by analyzing various available nutrients present in the soil. Fertilizer recommendations for various crops and cropping sequences can be made on the basis of fertility status of a soil and targeted yield. Besides this, problematic soil can be

Table 2: Chemical standard levels of soil nutrients (Patil *et.al.,* 2016**)**

Nutrients	Fertility rating major nutrients		
	Low	Medium	High
Organic carbon (g kg^{-1})	<5	5-7.5	>7.5
Macronutrients (kg ha^{-1})			
Nitrogen (N)	<280	280-560	>560
Phosphorus (P_2O_5)	<22.5	22.5-55	>55
Potassium (K_2O)	<140	140-330	>330
Sulphur (S) (mg kg^{-1})	<10	10-20	>20
Micronutrients (mg kg^{-1})	Deficient	Sufficient	Excess
Zinc (Zn)	<0.6	0.6-1.5	>1.5
Iron (Fe)	<2.5	2.5-4.5	>4.5
Copper (Cu)	<0.2	0.2-5.0	>5.0
Manganese (Mn)	<2.0	2-4	>4.0

ameliorated on the basis of soil test values. Before interpretation of the data set proper identification of the sources is required. However, soil being the major source of nutrients for crops can also provide support to the plant growth. Hence, soil health and its maintenance are the key issues to sustain crop productivity, which is assessed by the quality indicators and sustenance of the crops grown on them. The genetic difference in soil properties produces differential production response, which eventually determines the soil quality (Srivastava and Singh, 2001). It is a concept that describes soil in terms of its capacity to perform three major functions, viz., enhanced productivity, environmental protection, and health (Srivastava *et. al.* 2022).

Primary nutrients

The available N content (Table 3) of the soils of Neemuch district ranged from 260.20 to 321.0 kg ha^{-1} with an average value of 292.05 kg ha^{-1}. Considering the soil test rating for available N (<280 as low, 280-560 as medium and >560 as high in the status of N) the soils of Neemuch District fall under low to medium status in the available nitrogen content. The statistics calculated from soil samples revealed that the standard deviation and coefficient of variation (CV %) are 24.06 and 8.24 respectively for available N content. The reason for low to medium content of available nitrogen might be due to the Nitrogen lost like volatilization, runoff, nitrification, denitrification and leaching mechanism, which resulted in low amount of available N in soil. The variation in N content may be related to soil management, application of FYM and fertilizer to previous crop etc. (Kumar, 2000). The total N content of soils depend upon temperature, rainfall and altitude. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and low vegetation facilitate faster degradation and removal of organic matter leading to N deficiency (Patidar et.al. 2017). Kumar *et al.* (2009) in Dumka and Lachimpur series.

The available phosphorus in soil samples were ranged from 6.4 to 17.48 kg/ha, with an average of 11.94 kg ha^{-1}. The general statistics calculated from analyzed soil samples revealed that the available P content with a mean value of 11.94 kg ha^{-1}, standard deviation 2.99 and coefficient of variation 25.04 % (Table 3). Low to medium status of available P under study area in soil might be affected by past fertilization, pH, organic matter content, texture various soil management and agronomic practices (Verma *et al.* 2005). Nirawar *et al.* (2009) and Kumar *et al.* (2009) in Dumka and Lachimpur series of Jharkhand were medium in phosphorus content. Kumar *et al.* (2014) also showed that these soil samples were analyzed for P categorized as medium as per criteria followed in the soil testing laboratory.

The available potassium content in the study area was under high category. The available potassium in soils ranged from 268 to 578 kg ha^{-1} with an average of 426.5 kg ha^{-1}. High available Potassium in soils may be due to the prevalence of potassium-rich minerals like Illite and Feldspars (Sharma *et al.,* 2008). The mean values, standard deviation and coefficient of variation of available potassium were recorded 426.5 kg ha^{-1}, 114.09 and 26.75 % respectively in region of Neemuch district (Table 3).

pH of Soil Sample

The pH of soils of Neemuch District ranges from 7.22 – 7.69 with a mean value of 7.52, standard deviation 0.16 and coefficient of variation 2.10 % (Table 3). All soil samples were slightly alkaline in nature. The pH of Dhaneriya Kalan is highest at 7.69.

Table 3: A Salient soil properties of the Neemuch District

Analysis	Range	Mean	SD	Variance	CV (%)
pH	7.22 - 7.69	7.525	0.16	0.02	2.10
EC (dS/m)	0.2 - 0.68	0.417	0.20	0.04	46.97
Organic Carbon (%)	0.69 - 0.96	0.829	0.10	0.01	11.55
Available Nitrogen (kg ha^{-1})	260.20 - 321.0	292.05	24.06	578.85	8.24
Available Phosphorus (Kg / Hectare)	6.4 - 14.4	11.94	2.99	8.94	25.04
Available Potassium (kg ha^{-1})	268 - 578	426.5	114.09	13016.50	26.75
Available Sulphur (ppm)	6.94 - 15.6	11.905	2.70	7.31	22.71
Available Zinc (ppm)	0.48 - 0.93	0.66	0.16	0.02	23.58
Available Iron (ppm)	2.61 - 6.04	4.027	1.08	1.16	26.72
Available Manganese (ppm)	10.64 - 19.68	15.984	3.33	11.10	20.84
Available Copper (ppm)	0.89 - 2.66	1.722	0.53	0.28	30.70
Available Boron (ppm)	0.31 - 0.78	0.577	0.14	0.02	23.71

Electrical Conductivity (EC)

The Electrical Conductivity ranged from 0.2 to 0.68 dS/m with a mean value of 0.417, standard deviation 0.20 and CV % 46.97 (Table 3). Most of the soil samples were normal in respect of total soluble salt concentration. The soil is found to be non-saline. This might be due to leaching of salts from the soil surface to lower depths due to irrigation and their accumulation in lower depths. Similar results were reported by Gehlot *et al.* (2019) Which showed that the EC of Ujjain Tehsil of Madhya Pradesh soils range between 0.10 to 0.79 dS/m.

Organic Carbon (OC)

The value of total Organic Carbon (%) varied from 0.69 to 0.96 %. with an average value of 0.829. Considering the soil test rating for organic carbon (0.96 as high in the status of organic carbon) the soils of Neemuch district fall under moderate to high rating class. The general statistics show that mean value of 0.829, standard deviation 0.10 and coefficient of variation (CV %) 11.55 for organic carbon content. The available S content (Table 3) of the soil samples ranged from 6.94 – 15.6 ppm with a mean value of 11.905 ppm. Considering the soil test rating for available S (< 10 mg kg^{-1} as low, medium is 10-20) the soils of Neemuch district fall under low to medium. Low and medium available Sulphur was recorded due to lack of Sulphur addition and continuous removal of S by crops Chouhan *et al.* (1985) Ujjain and Dewas district, Madhya Pradesh.

Table 4: Recommendations for Micro nutrients by Department of Kisan Kalyan Evam Krishi, Soil Testing Laboratory, Krashi Upaj Mandi, Neemuch (M.P.)

			RESEARCH FARM									
Para-meters	Recommendation		Jalodiya Khurd	Naval-pura	Nipaniya Abaad	Ranpur	Nalk-heda	Kelu-kheda	Jamuniya Khurd	Dhaneriya Kala	Peeth	Harna-wada
S	Sulphur	25 (kg ha^{-1})	--	--	--	Yes	--	Yes	--	--	--	Yes
Zn	Zinc Sulphate (21%)	25 (kg ha^{-1})	Yes	Yes	Yes	--	--	--	Yes	--	--	--
Fe	Ferrous Sulphate (19%)	50 (kg ha^{-1})	Yes	Yes	Yes	--	--	Yes	Yes	--	Yes	--
Mn	Manganese Sulphate (30.5%)	10 (kg ha^{-1})	--	--	--	--	--	--	--	--	--	--
Cu	Copper Sulphate(24%)	10 (kg ha^{-1})	--	--	--	--	--	--	--	--	--	--
B	Borax (10.5%)	10 (kg ha^{-1})	--	--	--	--	Yes	--	Yes	--	Yes	--

The value of available Zinc content in soil samples varied from 0.48 to 0.93 ppm with a mean of 0.66 ppm in surface soil (Table 3), indicating low to medium content of zinc. The low zinc content was also reported by Isa (2017) and Mustapha *et al.,* (2011). This indicates that some of the soils in the study area were medium in available zinc as reported by Esu (1991). The value of available Iron in soil varied from 2.61 to 6.04 ppm. The maximum Iron content found at

Ranpur farm. The value of total Manganese in Soil varied from 10.64 to 19.68 ppm. The minimum Manganese content found at Navalpura farm. The value of available Copper in Soil varied from 0.89 to 2.66 ppm. Kelukheda and Nalkheda farm has minimum and maximum Copper content respectively. The value of available Boron in soil varied from 0.31 to 0.78 ppm. Value of Boron content investigated maximum at Navalpura while least at Jamuniya Khurd of Neemuch research farm. Soil quality depends on the nutrient imbalance, excessive fertilization, soil pollution and soil erosion. Consequently, it cannot produce enough food to keep pace with its needs, therefore per capita food production is decreasing day by day. Amongst the several factor of crop production, better soil quality is one of the most important factors affecting sustainability. The farmers should use organic manure along with the chemical fertilizers, which will enhance soil fertility and crop yield (Dhalwani P. and Harit H. 2023; IJIRI).

CONCLUSION

A study of soil samples of different research farms under consideration is done and discussed, this study helps in determining the conditions of soil and also helpful for farmers to select fertilizers to get a good yield of crops and approach to improve soil fertility. It can be concluded from the above results that the soils of Neemuch District, Madhya Pradesh are low to medium in available N, P, Fe, B and Sulphur, high in available K, Medium in available Mn and Cu. These soils are characterized under neutral to alkaline in soil reaction (pH) and less than 1 dS/m soluble salt content (EC) which comes under safe limit for all soils. The prepared soil data base is very useful for fertilizer recommendations as shown in Table 4 for different crops to economize their production. The proper nutrient management and regular monitoring should be adopted to avoid any possible deficiency of the plant nutrients. In our investigations, we observed that due to the excessive use of fertilizer, the soil became slightly toxic and deficient in some nutrients. We conclude that farmers should use organic manure along with bio fertilizers, which will enhance soil fertility and crop yield.

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