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Assessment of Soil Fertility Status of Different Villages of Solan District of Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The current study has been conducted in Solan district of Himachal Pradesh to evaluate soil physico-chemical parameters and soil health. The soil samples have been collected from farmer's field of five villages of Solan district. From each village 10 farmers were randomly selected and making the sample size 50. The findings showed thatSoil pH ranged from 6.23 to 7.34 and electrical conductivity (EC) of the entire study area remained below 0.29 dSm^{-1}. It was discovered that there was a marked variation in chemical parameters of various samples *viz.* Soil Organic Carbon (SOC), available nutrients (NPK) and available micro nutrients. SOC ranged between 0.53 to 2.03 per cent, available nitrogen content varied from medium to high, phosphorus content remained at high range, but varied from 54.78 to 65.71 kg ha^{-1} and available potassium content varied from medium to high range. The findings also demonstrated a strong and positive relationship between organic carbon and available nitrogen. Farmers were given soil health cards after testing soil samples from various areas.

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1. INTRODUCTION

Soil is a vital and basic life support component of biosphere. Soil is a natural body made of mineral and organic ingredients with a specific genesis and nature [1]. Sustainable agriculture is entirely dependent on soil health, which is directly related to crop economic production. Plants, like all living things, require food for growth and development. Plant require 16 essential elements like carbon (C), hydrogen (H), oxygen (O), nitrogen (N),phosphorus (P), potassium (K), sulphur (S), magnesium (Mg), calcium (Ca), boron (B), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu) and chlorine (Cl). The deficiency of these nutrients is the major constraints to productivity, stability and sustainability of soils [2]. Soil fertility is determined by the concentration of organic and inorganic elements, soil minerals, and soil organic matter. Additionally, the availability of these nutrients in soil is affected by soil pH, organic matter, adsorptive surfaces, and other physical, chemical, and biological factors in the rhizosphere [3]. But due to imbalance and inadequate use of fertilizers, improper irrigation and various cultural practices leads to degrade the humic portion of soil, which gradually destroying the soil quality and soil fertility [4]. In the present scenario, soil testing is well recognized as a scientific tool to assess inherent power of soil to supply plant nutrients. Proper fertilizer application aids in increasing marketable yields, however excessive use may be damaging to the environment [5]. Therefore, evaluation of soil fertility status of farmer's field is of primary importance for a balanced application of fertilizers and manures as well as minimizes the wastage of these nutrients. Furthermore, excessive usage and exposure to pesticides and herbicides causes environmental contamination and significantly harms human health [6]. So the amount of nutrients to be supplied to soil for crop production is determined by the amount of nutrients already existing in the soil. As a result, soil test-based nutrient management has arisen as a critical issue in efforts to boost agricultural productivity and output, because appropriate fertilizer utilization based on soil analysis may enhance crop productivity. Since the information on the availability of nutrients in relation to the soil properties of the area is meager, therefore the present investigation was carried out with the objective to evaluate different physico-chemical properties of soil samples of different villages to assess soil fertility and to provide soil health cards which will give information both on macro and micro nutrients for different input recommendation to the farmers and this information will assist farmers in resolving issues concerning soil nutrients and the amount of fertilizer to be applied to make production profitable.

2. METHODOLOGY

2.1 Experimental Site

The study area was agricultural land of farmer's of different villages of Solan District, Himachal Pradesh, India. There were total five numbers of villages under investigation *viz.* Dehon, Mahi, Mansar, Jokhari and Adda The mean annual rainfall of the study area is 1100 to 1262 mm. The mean annual temperature lies between 10-30^{0}C. The agro climatic zone is sub temperate, sub humid, mid hills and vegetable, fruits, cereals and pluses based cropping systems are predominant in this zone. The main objective of the research to know about the fertility status of different farmers field and distribute soil health cards.

2.2 Soil Sampling and Analysis

The quality test survey of the soil was conducted in 2021. Soil samples were collected after the harvest of capsicum crop. Soil sampling is likely the most important phase in any analysis because just a small portion of the vast soil mass of the field is analyzed. It becomescritical to collect a properly representative soil sample from the field. Ten representative soil samples were collected from each village, thus making total number of 50 samples. The soil samples were collected to a depth of 0-15 cm before land preparation. The soil samples were air dried in shade for about 24 hrs and grinded with the help of pestle and mortar; passes the entire quantity of soil through 2mm stainless sieve. Thus, fertilizer recommendation based on Soil Test Recommendation (STR) for both macro and micro nutrients are determined and results were compared with standard values to find out low, medium or high nutrient's content (Table 2). Various Physico-chemical properties were determined in the laboratory by using standard methods in Table 1.

Table 1. Physico-chemical properties and methods

S.No.	Parameters	Methods	References
1.	Bulk Density	Pycnometer method	[7]
2.	Particle Density	Pycnometer method	[7]
3.	Soil pH (1:2)	Potentiometric	[7]
4.	Electrical conductivity (dSm^{-1})	Wheat stone bridge circuit method	[7]
5.	Available N (kg ha-1)	Alkaline potassium permanganate method	[8]
6.	Available P (kg ha-1)	Olsen's method	[9]
7.	Available K (kg ha -1) (1951)	Flame photometric method (1N NH4OAC extractable)	[10]
8.	Available micronutrients (mg kg-1) zinc, iron, manganese, copper	DTPA method	[11]

Table 2. Available nutrients and physico-chemical data of soil samples of selected villages

Soil parameters	Medium/Normal range	Dehon	Mahi	Mansar	Jokhari	Adda
Bulk density ($g\ cm^{-3}$)	1.0-1.4 $g\ cm^{-3}$	1.21	1.28	1.23	1.31	1.25
Particle density ($g\ cm^{-3}$)	2.55-2.70 $g\ cm^{-3}$	2.14	2.18	2.25	2.30	2.22
Porosity (%)	35-60%	43.46	41.28	45.33	43.04	43.69
pH (1:2)	6.5-7.5	6.87	7.34	6.97	6.84	7.23
EC ($dS\ m^{-1}$)	0-0.8 $dS\ m^{-1}$	0.19	0.23	0.32	0.20	0.30
Organic carbon (%)	0.40-0.75 %	1.21	0.53	2.03	1.34	1.37
Available nitrogen ($kg\ ha^{-1}$)	225-560 $kg\ ha^{-1}$	390.78	321.65	486.87	409.65	413.76
Available phosphorus ($kg\ ha^{-1}$)	11-25 $kg\ ha^{-1}$	65.71	63.89	54.78	58.55	59.77
Available potassium ($kg\ ha^{-1}$)	117-280 $kg\ ha^{-1}$	309.89	298.65	387.78	312.65	323.78
Available zinc ($mg\ kg^{-1}$)	0.6- 1.2 $mg\ kg^{-1}$	1.01	0.96	1.21	1.09	1.17
Available copper ($mg\ kg^{-1}$)	0.2 -0.4 $mg\ kg^{-1}$	0.20	0.21	0.43	0.29	0.39
Available iron ($mg\ kg^{-1}$)	4.0 -9.0 $mg\ kg^{-1}$	7.56	4.54	9.21	8.21	9.09
Available manganese ($mg\ kg^{-1}$)	2.5-3.5 $mg\ kg^{-1}$	3.78	3.03	4.56	4.02	4.21

3. RESULTS AND DISCUSSION

3.1 Bulk Density

The bulk density of soils of different villages ranged between 1.21-1.31 $g\ cm^{-3}$ with a highest value under Jokhari village (1.31 $g\ cm^{-3}$) and the lowest under Dehon (1.21 $g\ cm^{-3}$). The slightly higher values of bulk density of Jokhri village may be attributed to high sand, low clay content and highly erodible in nature.

3.2 Particle Density

Maximum particle density was found under Jokhari village (2.30 $g\ cm^{-3}$) and minimum 2.14 g cm-3 in Dehon Village.

3.3 Porosity

The porosity of soils of different villages variable and ranged between 41.28 – 45.33 per cent with a highest value in Mansar (45.33 %) and the lowest in Mahi village (41.28 %).

3.4 Soil pH (1:2)

Soil pH is an important parameter as it directly affects nutrients availability and also the micro-organisms. The soil reaction or pH is meant to express the acidity or alkalinity of the soil. The pH scale ranges from 0 to 14 with 7 as a neutral; < 7 indicates acidity while > 7 indicates alkalinity. Soil pH of the studied villages (Table 2) ranged from 6.87 at Dehon to 7.34 at Mahi village, hence the data indicate that soils were slightly acidic to neutral in nature which appeared to be influence of parent material, rainfall and topography. Similar nature of observation was also recorded by Kondvilkar et al. [12].

3.5 Electrical Conductivity

Electrical conductivity is an important characteristic of soil samples because it indicates soil salinity. In general, EC has a positive connection with particle size and texture in soil [13]. Electrical Conductivity (1:2) of surface soil samples of the entire study area was found to be less than 0.33 dS m^{-1} (Table 2). Hence, all the soils under the study area are within the permissible limit and are safe for all types of crop production. The probable reasons are topography of the area, relatively higher gradient and seasonal rainfall which is responsible to leach out alkali and alkaline bases from the soil. The normal values of EC (< 0.8 dS m-1) are recorded for upstream and topographically higher areas [14].

3.6 Organic Carbon

Organic carbon specifies the total carbon storage, fertility, and stability of a certain soil mass [15]. Soil organic carbon is the location of nitrogen in soil, and its determination is frequently used as an indicator of nitrogen availability. Organic carbon raised microbial biomass and their activities, which include elevated soil aggregate formation and stability, improved plant litter decomposition, increased nutrient cycling and transformations, slow-release storage of organic nutrients, and pathogen control [16]. Organic matter contents of soil samples of different villages varied from 0.53 per cent at Mahi to 2.03 per cent at Mansar (Table 2). The organic carbon status was discovered to be medium to high throughout the entire study region, allowing the soil to grow a variety of crops. The reason behind the high range of OC in selected villages due to natural farming and organic farming practices.

3.7 Available Nitrogen

It is the most critical major nutrient needed by plants for normal growth and development, and it is a vital component of all living cells, proteins, enzymes, and metabolic processes involved in energy synthesis and transmission [17]. Nitrogen has both positive and negative effects on soil. Soil acidification is the most serious issue that farmers confront as a result of the over use of inorganic nitrogen fertilizers in agriculture. Small variations in nitrogen content for some crops can have a big impact on plant growth and forage and fruit quality. As a result, it is critical that the nitrogen level be kept within the recommended boundaries of appropriate range by using nitrogen fertilizer properly. Available soil nitrogen content of surface soil samples of different villages (Table 2) were found to vary between 321.65 kg ha^{-1} at Mahi to 486.87 kg ha^{-1} at Mansar village, which indicates medium to high available nitrogen content.

3.8 Available Phosphorus

Phosphorus is found in every live cell of a plant. Phosphorus is most often limiting nutrients remains present in plant nuclei and act as energy storage and energy transfer [18]. Phosphorus promotes root development, flowering, seed and fruit development. Phosphorus deficiency can induce delayed maturity as well as impaired seed and fruit development. Available soil phosphorus content was found to lowest in Mansar (54.78 kg ha^{-1}) and highest in Dheon village (65.71 kg ha^{-1}). The lowest content at Mansar village is still above the normal range of 11-25 kg ha^{-1} (Table 2). This may be due to high organic matter and higher topographic positions of region. The available phosphorus content of the soil was greater in topographic position than in lower topographic position [17]. Soils having a high organic matter content provide greater supplies of organic phosphate for plant absorption than soils with a low organic matter content [19].

3.9 Available Potassium

Potassium is not an essential component of any major plant component, but it plays an important role in a wide range of physiological processes critical to plant growth, from protein synthesis to plant water balance management. Potassium involved in the photosynthesis of plants and also imparts disease resistance. Potassium deficiency resulted in slow and stunted growth; stems are weak and reduced production and quality also. Available soil potassium content of the studied area (Table 2) was found to vary from 298.65 kg ha^{-1} at Mahi to 387.78 kg ha^{-1} at Mansar, which indicates low to high available potassium content. There was variation in available potassium content, which might be due to parent material and potassium fixation. Potassium fixation happens when soil dries and potassium is bound between clay layers [20].

3.10 Micro Nutrients

The micronutrients are required by plants in minute quantities, although they are equally vital as major nutrients because of their role in plant development. These micronutrients are vital for gene expression, synthesis of proteins, nucleic acids, growth substances, chlorophyll, metabolism of carbohydrates and lipids.

Nutrients evaluated in the studies presented here include zinc, iron, manganese and copper. Furthermore, almost all micro nutrients Zn, Fe, Mn and Cu (Table 2) were found in sufficient amount in all the villages. The zinc concentrations range from 0.96 to 1.21 mg kg-1 indicating that in most of samples Zn is higher than the critical range. Copper is also an essential micronutrient for normal plant growth. In the soils under study, the concentrations of Cu are sufficient and varied from 0.20 to 0.43 mg kg^{-1}, Iron content ranges from 4.54 to 9.21 mg kg^{-1} in the soils from the study area indicating higher concentration of Fe. Iron is essential for chlorophyll and protein formation, photosynthesis, electron transfer oxidation and reduction of nitrates and sulphates and other enzyme activities. The manganese content in the soils from study area from 3.03 to 4.56 mg kg^{-1} indicating higher than normal range. The higher range may be due to availability of micronutrients under slightly acidic conditions and high organic matter. Soil pH is important parameter as it helps in ensuring availability of micro nutrients viz. Fe, Mn, Zn and Cu are more available in acidic than alkaline soils [14]. Organic carbon also plays essential role and is the main source of most of micro nutrients.

3.11 Correlation of Soil pH and SOC with Available Nutrients

The correlation coefficient values of physicochemical properties *viz;* soil pH and organic carbon with available nutrient elements were also worked out (Table 3). The soil pH showed non significant but positive correlation with nitrogen (r = 0.62), phosphorus (r = 0.15) and potassium (r = 0.89), as there is very less variation in soil pH the correlation is not significant. Soil pH correlated positively with Zn, Fe, Cu Mn and Cu. EC also showed non significant correlation with all nutrients. Data presented in the Table 3 revealed that soil organic carbon showed positive and significant correlation with available nitrogen (r = 0.99) and non significant positive correlation with all other available nutrients. The significant and positive correlation between organic carbon and available nitrogen could be because of release of mineralizable nitrogen from soil organic matter in proportionate amounts [21] and adsorption of NH4 –N by umus complexes in soil. The non significant but positive correlation between soil organic carbon and available micro nutrient might be due to formation of chelates by organic matter, acidulating action of soil organic carbon and decrease in soil pH thus increasing the solubility of micro nutrient complexes. The results are in accordance with the observations of Nazif et al. [22].

Table 3. Correlation of soil properties with available nutrients

Available nutrients	pH	EC	OC
N	0.62	-0.05	0.99
P	0.15	0.68	0.70
K	0.89	-0.05	0.41
Zn	0.34	0.22	0.55
Fe	0.45	-0.18	0.67
Mn	0.05	-0.28	0.67
Cu	0.09	-0.38	0.64

Significance level at 5%

3.12 Results

Results are in tune with farming practices followed by farmers of this region. The results revealed that available nutrients NPK and micro nutrients were found in medium to high range in all the selected village where mostly tomato-capsicum cropping system is followed and proper cultural practices followed and mostly uses recommended use of fertilizers. Whereas, available P was found to be vary in different villages which may be due to the phosphorus fixation. Furthermore, the SOC and available nutrient NPK and micronutrient content increased where vegetable – fruit cropping system is followed. They also use NPK fertilizers for, vegetables and fruits. At Mansar village their cultural practices are also different and use mostly Combined use of organic and inorganic fertilizers resulted in good soil health and sustainable crop production. Which further increase the SOC ultimately results in increase in available NPK. On the basis of these results farmers are issued soil health cards with suitable fertilizer recommendations and are also advised to use integrated nutrient management practice to maintain optimum concentration of all the essential nutrients for plants.[23, 24, 25].

4. CONCLUSION

Based on the presented results, it was concluded that the soil in the Solan District is suitable for agriculture because practically all of the criteria are within allowed limits. Soil testing aids in the diagnosis of soil health using a soil health card and the development of soil-specific and crop-specific treatments. The soil health card aids in the identification of problematic soils, as well as their nutritional status, texture, and structure. This research will also aid in identifying soil fertility-related crop production limits and recommending corrective methods for increased crop yield. The use of organic manures in addition to inorganic manures will not only help to enrich the soils with organic matter, but will also be important in maintaining soil health and quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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