

**ASSESSMENT OF SOIL FERTILITY STATUS OF DIFFERENT VILLAGES OF SOLAN
DISTRICT OF HIMACHAL PRADESH**

ABSTRACT:

The present study was carried out in five villages of Solan district of Himachal Pradesh to evaluate physico-chemical parameters of soil. 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 hr, grinded with the help of pestle and mortar and passed through 2mm stainless sieve. Results revealed that Soil pH ranged from 6.23 to 7.34 and electrical conductivity (EC) of the entire study area remained below 0.29 dS m^{-1} . It was found 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 results also revealed significant and positive correlation between organic carbon and available nitrogen. After analyzing the soil samples of different sites, soil health cards were issued to the farmers.

Key words: Available nutrients, EC, pH, soil organic carbon, soil health card

1 INTRODUCTION

Soil is a vital and basic life support component of biosphere. Soil is a natural body composed of mineral and organic constituents, having a definite genesis and a distinct nature of its own (Dokuchaiev, 1990). Sustainable agriculture is solely dependent on soil health which is directly linked with the economic productivity of the crops. Plants like all other living things need food for their 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 constraint to productivity, stability and sustainability of soil (Chaudhari et al. 2012). The fertility of the soil depends on the concentration of organic and inorganic materials, soil minerals and soil organic matter. Furthermore, the availability of these nutrients in soil depends upon soil pH, organic matter, adsorptive surfaces, other physical, chemical and biological conditions in the rhizosphere (Jiang et al. 2009). However, due to imbalance and inadequate use of fertilizers, improper irrigation and various cultural practices, there is degradation of humic portion of soil, which gradually destroying the soil quality and soil fertility (Bacchewar and Gajbhiye, 2011). In the present scenario, soil testing is well recognized as a scientific tool to assess inherent power of soil to supply plant nutrients. Proper application of fertilizers helps in maximizing marketable yields whereas, excessive use may be harmful to the environment (Ganorkar et al. 2017). 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 for minimizing the wastage of these nutrients. Moreover, excess use and exposure of pesticides and herbicides, leads to environmental pollution and harm human health a lot (Chitra et al. 2006). So, the amount of nutrients to be added to soil for crop production depends upon present status of the nutrients in that soil. Hence, soil test based nutrient management has emerged as a key factor to increase agricultural productivity and production since optimal use of nutrients, based on soil analysis can improve 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 about macro and micro nutrients for different input recommendation to the farmers. This information will help the farmers to solve the problems related to soil nutrients and let them know about the amount of different fertilizers to be used for making the production economic.

2 MATERIAL AND METHODS

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.* Dieun, Mahi, Mansar, Jokhri and Adda The mean annual rainfall of the study area is 1100 to 1262 mm whereas, mean annual temperature lies between 10-30°C. The agro climatic zone is sub

temperate, sub humid, mid hills and vegetable, fruits, cereals and pulse based cropping systems are predominant in this zone

Table 1 Geographical coordinates of the selected villages

Sr. No	Name of the village	Latitude	Longitude	Altitude
1.	Mahi	30°57' 27°N	77°06' 36°E	1,466m
2.	Mansar	30°56' 40°N	77°07' 48°E	1,375m
3.	Jokhri	30°56' 52°N	77°07' 38°E	1,403m
4.	Adda	30°57' 57°N	77°05' 35°E	1,415m
5.	Dieun	30°58' 22°N	77°06' 29°E	1,465m

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 perhaps the most vital step for any analysis since a very small fraction of the huge soil mass of field is used to analysis. It becomes extremely important to get a truly representative soil sample of 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. Various Physico-chemical properties were determined in the laboratory by using standard methods (Table 2). 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 3).

Table 2. Physico-chemical properties and methods

S.No.	Parameters	Methods	References
1.	Bulk Density	Pycnometer method	Jackson (1973)
2.	Particle Density	Pycnometer method	Jackson (1973)
3.	Soil pH (1:2)	Potentiometric	Jackson (1973)
4.	Electrical conductivity (dSm ⁻¹)	Wheat stone bridge circuit method	Jackson (1973)
5.	Available N (kg ha-1)	Alkaline potassium permanganate method	Subbiah and Asija (1956)

6.	Available P (kg ha-1)	Olsen's method	Olsen et al.(1954)
7.	Available K (kg ha -1) (1951)	Flame photometric method (1N NH4OAC extractable)	Merwin and Peech
8.	Available micronutrients (mg kg-1) zinc, iron, manganese, copper	DTPA method	Lindsay and Norvell (1978)

Table 3. 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

RESULTS AND DISCUSSION:

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 Jokhari village may be attributed to high sand, low clay content and highly erodible in nature.

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.

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 %).

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. 2017.

Electrical conductivity

Electrical conductivity is one of the important parameter of soil sample because it shows the salinity of soil. Generally EC has good relationship with soil particle size and texture (Grisso et al. 2009). 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 (Deshmukh 2012).

Organic carbon

Organic carbon defines the total carbon storage, fertility and stability of a particular soil mass (Brady and Weil 2005). Soil organic carbon is the seat of nitrogen in soil and its determination is often carried out as an index of nitrogen availability also. Organic carbon further increased microbial biomass and their activities includes; increased soil aggregate formation and stability,

enhanced plant litter decomposition, increased nutrient cycling and transformations, slow-release storage of organic nutrients, and pathogen control (Lagomarsino et al. 2009). 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). In the entire study area organic carbon status was found to be medium to high which enables the soil for growing a wide range of crops. The reason behind the high range of OC in selected villages due to natural farming and organic farming practices.

Available nitrogen

It is the most important major nutrient required by plant for proper growth and development and it is a necessary part of all living cells, proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy (Singh and Rathore 2013). Nitrogen plays a beneficial as well as harmful effect on soil. Soil acidification is the major problem faced by farmers due to the excessive use of inorganic nitrogen fertilizers in agriculture. Small changes in nitrogen content for some crops can result in large effects on plant growth and the quality of forage and fruit. So it is important that the nitrogen level be maintained within the prescribed limits of sufficient range by the proper use of nitrogen fertilizer. 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.

Available phosphorus

Phosphorus is a part of every living cell in plant. Phosphorus is most often limiting nutrients remains present in plant nuclei and act as energy storage and energy transfer (Jain et al. 2014). Phosphorus aids in root development, flower initiation, seed and fruit development. Lack of phosphorus can cause delayed maturity and poor 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 higher in topographic position as compared to soils occurring on lower topographic position (Singh and Rathore 2013). The soil with high organic matter content have better supplies of organic phosphate for plant uptake than have the soils with low organic content (Miller and Donahuer 2001).

Available potassium

Potassium is not an integral part of any major plant component but it plays a key role in a vast array of physiological process vital to plant growth from protein synthesis to maintenance of plant water balance. 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 occurs when soil dry and the potassium is bonded between layers of clay (Wagh et al. 2013).

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 (Deshmukh 2012). Organic carbon also plays essential role and is the main source of most of micro nutrients.

Table 4: 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%			

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 4). 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 4 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 (Vanilarasu and Balakrishnamurthy, 2014), and adsorption of $\text{NH}_4^- \text{N}$ 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. (2006).

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.

CONCLUSION

On basis of results obtained during the present studies, it can be concluded that the status of soil in selected villages of Solan District is suitable for cultivation of rabi season vegetable crops because all the parameters viz., Bulk density, Particle density, Porosity, Organic carbon, Available NPK and micronutrients were within the permissible limits. Soil pH ranged between 6.84-7.34 and organic carbon from 0.53 -2.03, which is suitable for the cultivation of all vegetable crops. This study has helped in finding out soil fertility related crop production constraints of farmer's fields and suggesting them remedial measures for higher crop production. Application of organic manures along with the inorganic will not only help in enriching the soils with organic matter but also will be a key for sustaining soil health and quality.

REFERENCES

- Bacchewar, G. K. and Gajbhiye, B. R. (2011). Correlation studies on secondary nutrients and soil properties in soils of Latur District of Maharashtra, *Research Journal of Agricultural Sciences*, 2(1), 91-94.
- Brady, N. C. and Weil, R. R. (2005). Nature and properties of soil, Pearson Publications, Singapore, Edition 2, 872- 873.
- Chaudhari, P.R., Ahire, D. V. and Ahire, V. D. (2012). Correlation between Physico-chemical properties and available nutrients in sandy loam soils of Haridwar. *Journal of Chemical Biological Physical Sciences*, 2(3), 1493-1500.

- Chitra, G. A., Muraleedharan, V. R., Swaminathan, T. and Veeraraghavan, D. (2006). Use of Pesticides and its impact on health of farmers in South India. *International Journal of Occupational and Environmental Health*.
- Deshmukh, K. K. (2012). Studies on Chemical Characteristics And Classification Of Soils From sangamner Area, Ahmadnagar District, Maharashtra, *Rasayan Journal of Chemistry*, 5(1), 74-85.
- Dokuchaiev, V. V. (1990). Dokuchaiev's ideas in the development of pedology and cognate sciences, Academy of Science USSR, Pedology 1, Leningrad.
- Ganorkar, R. P., Hole, H. A. and Pund, D. A. (2017). Assessment of soil nutrients and physicochemical parameters in the region of hiwarkhed village of Amravati district (maharashtra state), India, *Rasayan Journal of Chemistry*, 10(2), 429-433.
- Grisso, R., Alley, M., Holshouser, D. and Thomson, W. (2009). Precision farming tools: soil electrical conductivity, Report produced by Virginia Cooperative Extension, Publication 442-508.
- Jackson M C. (1973). Soil chemical analysis. Prentice Hall, India, Pvt. Ltd. New Delhi. pp.22-25
- Jain, S. A., Jagtap, M. S. and Patel, K. P. (2014). Physico- Chemical Characterization of farmland soil used in some villages of Lunawada Taluka, Dist : Mahisagar (Gujarat), India, *International Journal of Science and Research*, 4(3), 1-5.
- Jiang, Y., Zang, G., Zou, D., Qin, Y. and Liang, W. J. (2009). Profile distribution of micronutrients in an aquic brown soil as affected by land use, *Journal of Plant, Soil and Environment*, 155(11), 468-476.
- Kondvilkar, N. B., Thakare, R. S. and Annapurna, M. (2017). Level of significance of various chemical properties of soils in Sakri tehsil of Dhule District, *International Journal of chemical studies*, 5(5), 1960-1967.
- Lagomarsino, A., Moscatelli, M. C., Tizio, A. D., Mancinelli, R., Grego, S. and Marinari, S. (2009). Soil biological indicators as a tool to assess the short-term impact of agricultural management on changes in organic C in a Mediterranean environment, *Ecological Indicators* 9, 518-527.
- Lindsay, W. L. and Norvell, W. A. (1978). Development of DTPA soil test for Zn, Fe, Mn and Cu, *Soil Science Society of American Journal*, 42, 421 - 428.

- Merwin H W and Peech P M. (1951). Exchangeability of soil potassium in the sand by nature of complementary exchangeable cation. *Proceedings of Soil Science Society of America*.**15**: 125-128
- Miller, R. W. and Donahue, R. L. (2001). *Soils in our environment*, Seventh edition, Prentice Hall, Inc. Upper Saddle River, New Jersey.
- Nazif, W., Perveen, S. and Saleem, I. (2006). Status of micronutrients in soils of district Bhimber (Azad Jammu and Kashmir), *Journal of Agriculture and Biological Science*, 1(2), 35-40.
- Olsen S R, Cole C V, Watanabe F S and Dean L A.(1954). Estimation of available phosphorus by extraction with sodium bicarbonate, United States Department of Agriculture. *Citric*. 939p.
- Sakal, R., Singh, A. P., Singh, B. P., Sinha, R. B., Jha, S. N. and Singh, S. P. (1985). Distribution of available micronutrient cations in calcareous soils as related to certain soil properties, *Journal of Indian Society of Soil Science*, 33, 672-675.
- Singh, D. P. and Rathore, M. S. (2013). Available nutrient status and their relationship with soil properties of Aravalli mountain ranges and Malwa Plateau of Pratapgarh, Rajasthan, India, *African Journal of Agricultural Research*, 8(41), 5096-5103.
- Srivastava, S., Jha , P., Rashmi, L., Biswas, A. K., Dey, P., Neenu, S., Tapan, A., Patra, A. K., Rathi, A., Sreemannarayana, B., Maheshwari, M. and Rathi, S. (2017). Device and method for measurement of soil health parameters and fertilizer recommendation. International Application Published Under the Patent Cooperation Treaty (Pct), World Intellectual Property Organization International Bureau, International Publication Number WO 2017/029592.
- Subbiah B W and Asija G L. (1956). Rapid procedure for estimation of available nitrogen in soils. *Current Science*.**25**: 259-260.
- Takkar, P. N. and Mann, M. S. (1975). Evaluation of analytical methods for estimating available zinc in major soil series of Ludhiana, India, *Agrochemica*, 19: 420.
- Vanilarasu, K. and Balakrishnamurthy, G. (2014). Influences of organic manures and amendments in soil physiochemical properties and their impact on growth, yield and nutrient uptake of banana, *The Bioscan*, 9(2), 525-529.

Wagh, G. S., Chavhan, D. M. and Sayyed, M. R. G. (2013). Physicochemical analysis of soils from eastern part of Pune City, *Universal Journal of Environmental Research and Technology*, 3(1), 93-99.

UNDER PEER REVIEW