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Original Research Paper

Characterization of the Soils of Lower Himalayas of Himachal Pradesh, India

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ABSTRACT

Lower Shivalik hills are the part of Himalayas extending in the areas of lower Himachal Pradesh. These hills cover an area of about 55,673 sq. km with four districts of Himachal Pradesh. Forty soil samples were collected both from hilly and plain soils covering about 14,799 km. The chemical characteristics such as pH, organic matter, potassium and zinc, copper, iron and manganese were analysed. The soil in the hill regions shows greater pH changes than in plains. Micronutrients and organic carbon contents were higher in plains thus the soil was more appropriate for cash crops.

INTRODUCTION

Soil generally refers to the loose material composed of weathered rock and other minerals, and the partly decayed organic matter that covers large parts of earth (Wild 1996). Soil is a reservoir of nutrients in one form or other and differs from the parent materials in the morphological, physical and biological properties. The quantity of potassium is plentiful except in sandy soils. Calcium shows great variation, but it is generally present in lesser amount than potash. Phosphorus is needed not only as nutrients but also as a means of controlling soil acidity. Soil respiration is augmented by the respiration of living plants roots and is further abundance of carbonaceous materials in the soil (White 1987). Soil needs specific heat of soil, heat vaporization, and thus it is transferred through the process of conduction (Jaiswal & Wadhwani 1980). Further, calcium, magnesium, potassium and sodium reduce the acidity and increase alkalinity (Brady 1984).

Soil plays a pivotal role in supporting the growth of crops, and other vegetation maintaining the environment clean, and acts as source and sink for atmospheric gases. Man depends on soils and to a certain extent good soils are dependent upon the man and the use he makes of them. Soils are natural bodies on which plant grow.

Soils in India can be classified into the following three groups on the basis of cultivation (Jaiswal & Wadhwari 1980).

- Alluvial, black and red soils, which are fertile, arable and cultivable.
- Peat and Marsh, which are saline, alkaline and potentially arable.
- Laterite and forest and hill soils, which are not suitable for cultivation.

Alluvial type of soil is deposited by the action of moving water (usually rivers) and is usually highly fertile. This soil has texture with favourable physical characteristics and good permeability. Small showers are useful and there is utilization of the water held by soil due to low moisture content at wilting point. These include the deltaic alluvium, calcareous alluvial soil, coastal alluvium and sands. It is the largest share to the agriculture wealth. The soil contains varying amounts of calcium carbonate ($CaCO_3$) and soluble salts, and is neutral to alkaline. The lime content increases at lower depths. They are generally poor in phosphorus pentaoxide (P_2O_5), nitrogen and organic matter.

Black soil is highly argillaceous (clayey), fine grained and dark, and contains a high proportion of calcium and magnesium carbonates. The black soil is deeper, clay to clayey loam and characterized by low permeability and high water holding capacity, low infiltration rate, high plasticity and stickness, low organic matter, high CEC, calcareous nature and slightly old aline. It is specially suited for cotton cultivation. In the valleys of the rivers Tapti, Narmada, Godavari and Krishna, heavy black soil is often six metres deep.

Red soils are light textured, shallow to medium in depth and usually under layer by compact subsoil, fairly porous with low water holding capacity. They are generally poor in nitrogen, phosphorus and humus, and are present in many areas of Tamil Nadu, Karnataka, Goa, Daman and Diu, south-eastern Maharashtra, Madhya Pradesh, Orissa and Chhotanagpur plateau.

Laterite soil is formed by the decomposition of many kinds of rocks, and found especially in tropical rain forests. It is a vesicular rock composed essentially of mixture of hydrated oxides of aluminium and iron with small amount of manganese dioxide, titanium oxide, etc. It is common in the low hills of Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Orissa. The laterite may be broken off and carried to lower level by streams and when deposited may get into a compact may be the segregative action of the hydrated oxides.

Area under investigation: Himachal Pradesh lies in the western Himalayas between 30°22’40” to 33°12’40” north latitude and 75°47’55” to 79°04’20” east longitude (Fig. 1). Its geographical area is 55,673 sq. km, which is 1.69% of the India’s total area. The snowy mountains of Himachal are known for its natural and scenic beauty of Dhauladhar, Pir Panjal, Shivalik, great Himalayan and Zaskar ranges. It is one of the most complicated geological regions of Himalayas. The region falls in four broad stratigraphical zones: 1. Shivaliks; 2. Inner Himalayas; 3. Great Himalayas; 4. Trans Himalayas.

Inner Himalayas lie between the main boundary thrust and central Himalayan thrust. Main boundary thrust lies between middle Himalayas and lower Himalayas. The central Himalayan thrust lies between the greater Himalayas and middle Himalayas. The granite and crystalline rocks predominate in the zones, which are of unfossiliferous rudiments. The Karol belt stretches from the Shimla region towards the earth and repartees this region from the Shivalik

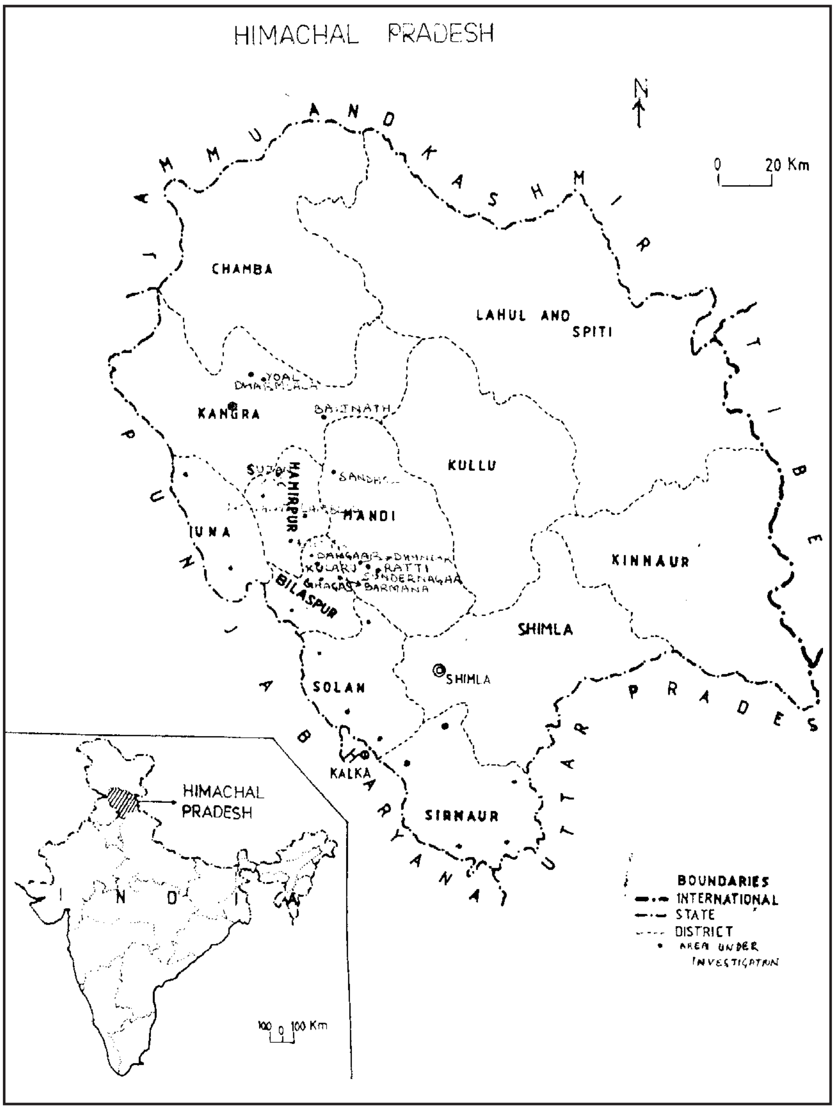

Fig. 1: Location map of the area.

system. The paleozoic region in the lower Himalayas is suddenly interrupted by the transgression of the permo-carboniferous with an outstanding different Gondwana rock sequence.

Outer or sub-Himalayas are also known as Manak Parbhat in the ancient time. The Shivalik hill tack runs along the southern border of the State from Kangra to Sirmour. There are the outermost ranges separating it from the Punjab plain. The altitude ranges from 600 metres to 120 metres. These ranges are youngest of Himalayan ranges and made up of tertiary sediments consisting of sand and clay. This range in Himachal is not a continuous range but forms several minor ranges. They are seen as eroded hill masses or residual detached hillocks. The crest line on some important Shivalik ranges are known by several local names like Dhog Dhar in Sirmaur, Ramgarh Dhar in Una, Chaumukhi range, Dharti Dhar, Sikandar Dhar and Naina Devi Dhar in Hamirpur and Bilaspur districts and Panchmunta hill in Solan district. The middle or lesser Himalayas are located to the north of Shivalik range. They form an intricate and rugged mountain system, about 60-80 km wide and 1000-4000 metres high, with several peak sites to nearly 5000 metres, and remains snow covered throughout year.

Inner Himalayas are not a continuous range but consist of a number of ranges like Dhauladhar, Pir Panjal, Churdhar and Shimla ranges. Dhauldhar or 'White Mountains' is the first prominent and outermost Inner Himalayas range that overlooks the Kangra valley. Dhauladhar runs parallel to the Pir Panjhal running across Kangra District. The three major rivers, Satluj near Rampur, Beas at Larji and Ravi near Chamba cut the Dhauladhar range forming deep gorges. The range is most prominent in Kangra valley where it records a 3600 metres vertical rise within a short distance of only 11 km. Bottom of the valley is situated at about 900 metres above sea level.

Pir-Panjal or the Pangi range is next range of inner Himalayas range. It enters Himachal Pradesh from Kashmir running through Chamba or a water divide between Chenab in the north and Ravi and Beas rivers in the south. The range is known for its great height and complex topography and has number of glaciers.

Nag-Tibba range is the outermost of the inner Himalayas range in eastern part of Himachal. Shivalik Duns intermittently located between the Shivalik and lesser Himalayas are the duns, which are flat-bottomed longitudinal structural valleys within own drainage systems. The Shivalik hills gently slope into flat bottomed strike. Valleys locally called 'duns' towards the north. Some important dun valleys of Himachal Pradesh are Paunta valley of Sirmaur, Kangra valley, Nalagarh dun in Solan and Jaswan dun in Kangra district. Soil samples from Kangra, Hamirpur, Mandi and Bilaspur districts were analysed.

Heavy metal contamination of soils is a worldwide problem of increasing importance and great environmental concern (Alloway 1990, Kabata Pendias & Pendias 1992). Soil contamination by heavy metals results in some changes in the counts of microorganisms and enzymatic activity which, according to Dick et al. (2000), Kucharski (1997) and Treasar Ceped et al. (2000) is an objective measure of the soil's microbiological status. The negative influence of most of the heavy metals on the activity of soil enzymes was reported by Leiros et al. (1990), Nowak & Smolik (2002), Nowak et al. (2003) and Wyszkowska & Kucharski (2003). Three metals often cited for their deleterious effects on both human and plant metabolism are cadmium (Cd), lead (Pb) and zinc (Zn). The excessive uptake of these elements by crop plants from the soil creates problem of crop yield reduction due to inhibition of metabolic processes in plants (Foy et al. 1978, Costa & Morel 1993, Aery & Jagetiya 1997). In addition, the crops so contaminated serve as a source of heavy metals in our food supply (Somers 1974, Singh et al. 1995, Sajwan et al. 1996). Therefore, the problems posed by increased amounts of these metals in the environment demand a thorough understanding of their phytotoxic effects in a soil plant system.

MATERIALS AND METHODS

The pH was measured by a pH meter and organic matter by Walkley and Black wet digestion method. The potassium determination was carried out by flame photometer. The micronutrients (zinc, copper, iron, manganese) were determined by diethylene triamine penta-acetic acid (DTPA) extraction method. The dissolved elements in the extract were then measured by Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The negative effect of heavy metals on the soil, which was observed in the present work has confirmed and verified in literature (Leiros et al. 1990). Furthermore, Welp (1999) claims that copper along with chromium III and VI belong to metal which has adverse effects on the activity of enzymes in soil. Leiros et al. (1990) found that copper needed to be applied at concentration as high as 800 mg/kg to produce an unfavourable effect on the activity of enzymes. As a consequence of these industrial activities in Barmana, large amounts of wastes have been generated. These wastes contain heavy metals such as copper, zinc, cadmium, lead, mercury and arsenic at level that exceeds the critical European ones (Garica et al. 2001b).

The physico-chemical characteristics of soil such as pH,

Table 1: pH values for different soil samples.

Sample	pH
Kangra	6.8
Lambloo	7.8
Sandhol	7.0
Ghagas	8.0
Dharamshala	7.1
Bhota	8.0
Ratti	7.2
Kularu	7.8
Yol	6.6
Nohangi	7.4
Dandor	7.4
Dangar	8.3
Chamunda	7.2
Sujanpur Tira	7.0
Sundernagar	8.1
Barmana	8.1

Table 2: Values of organic carbon for different soil samples.

Sample	X-Y (mg)	Percentage(%) of Organic Carbon	Rating
Kangra	6.8	0.0	L
Lambloo	7.9	1.1	H
Sandhol	3.8	1.0	M
Ghagas	2.5	0.6	M
Dharamshala	4.6	0.7	M
Bhota	4.2	0.6	M
Ratti	2.2	0.5	M
Kularu	5.2	1.3	H
Yol	9.0	1.3	H
Nohangi	10.8	1.6	H
Dandor	8.8	2.2	H
Dangar	5.2	1.3	H
Chamunda	5.4	0.8	M
Sujanpur Tira	5.6	1.4	H
Sundernagar	16.6	4.3	H
Barmana	2.4	0.6	M

Table 3: Values of available potassium for different soil samples.

Sample No.	kg/h	Rating
Kangra	649.6	H
Lambloo	672.4	H
Sandhol	358.4	H
Ghagas	268.8	H
Dharamshala	1366.4	M
Bhota	89.6	L
Ratti	89.5	L
Kularu	134.4	M
Yol	268.8	M
Nohangi	918.4	H
Dandor	201.6	M
Dangar	67.2	L
Chamunda	291.2	H
Sujanpur Tira	44.8	L
Sundernagar	33.6	H
Barmana	918.4	H

Table 4: Values of micronutrients for different soil samples.

Sample No.	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Kangra	3.48	2.13	4.05	1.72
Lambloo	2.33	1.20	7.11	0.78
Sandhol	2.47	0.66	4.49	0.9
Ghagas	0.6	0.78	8.08	9.56
Dharamshala	3.98	0.53	26.33	2.58
Bhota	0.80	0.3	5.8	0.92
Ratti	0.68	0.8	4.93	0.9
Kularu	1.3	1.0	4.0	13
Yol	0.69	1.63	3.5	0.4
Nohangi	0.62	1.0	5.72	0.4
Dandor	2.2	0.2	3.82	11.73
Dangar	1.3	0.1	6.25	1.88
Chamunda	3.77	1.25	21.42	1.21
Sujanpur Tira	0.7	0.7	4.2	0.85
Sundernagar	4.3	3.22	7.67	0.86
Barmana	0.4	0.70	7.6	23.0

organic matter, potassium and micronutrients like zinc, copper, iron and manganese are given in Tables 1, 2, 3 and 4, and Figs 2-29.

The heavy soil contamination by copper, manganese and organic matter was reported in Sundernagar Barmana belt that is 3.22 ppm, 23 ppm and 4.3% respectively, which is responsible for pollution of the soil in the area. These metals have negative effect on the activity of soil enzymes like dehydrogenase, urease acid phosphatase and alkaline phosphatase, etc. There is, thus, inhabitation of soil enzyme activity as reported by Nowaki (2002). Furthermore, Welp (1999) claims that copper along with chromium VI and III belongs to metals which has strong adverse effect on activity of enzyme. The enzymes are contaminated by copper and other heavy metals which in turn affect different sorptive properties of soil, as reported by the Leiros et al. (1990) that excessive copper can affect the activity of enzymes in soil. Therefore, it was suggested that the copper is lesser toxic than the zinc. But, since both of them are reported equally in all the soil samples, it is necessary to avoid the concentration of copper as well as zinc. The iron, manganese and potassium have concentrations of 26.33 ppm, 23.0 ppm and 1366.4 kg/ha was reported in Dharamshala and Barmana. This high concentration may be attributed to the solid waste and mining activities in the area. Thus, therefore, it becomes pertinent that the soil may be saved from such activities. The highest pH was reported at Dangar towards more basic due to excessive limestone mining in the area for the use of cement and other industries. Therefore, it is suggested that if this excessive mining is not checked, the day is not far off

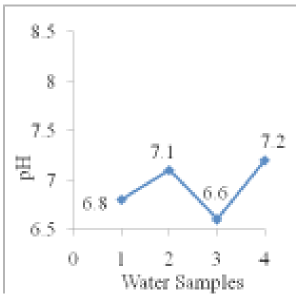

Fig. 2: Variation in the value of pH at different sites in Kangra district.

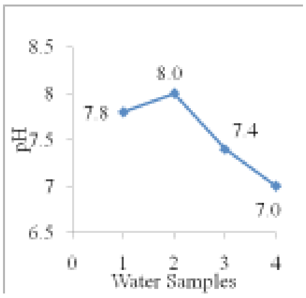

Fig. 3: Variation in the value of pH at different sites in Hamirpur district.

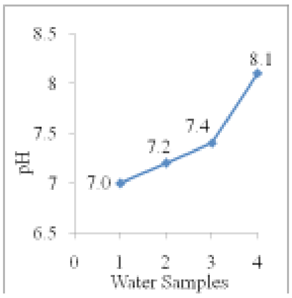

Fig.4: Variation in the value of pH at different sites in Mandi district.

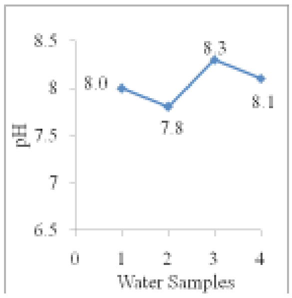

Fig. 5: Variation in the value of pH at different sites in Bilaspur district.

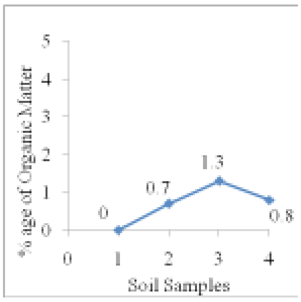

Fig. 6: Variation in the value of organic matter at different sites in Kangra district.

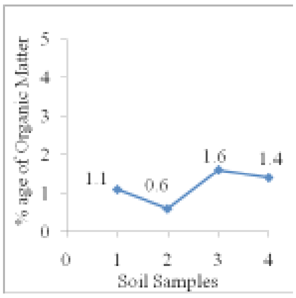

Fig. 7: Variation in the value of organic matter at different sites in Hamirpur district.

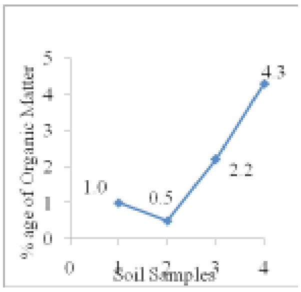

Fig. 8: Variation in the value of organic matter at different sites in Mandi district.

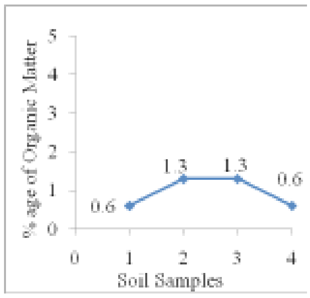

Fig. 9: Variation in the value of organic matter at different sites in Bilaspur district.

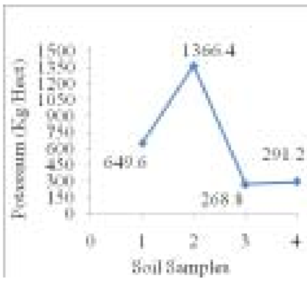

Fig. 10: Variation in the value of potassium at different sites in Kangra district.

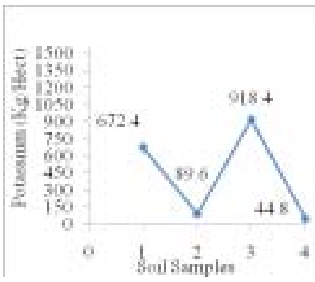

Fig. 11: Variation in the value of potassium at different sites in Hamirpur district.

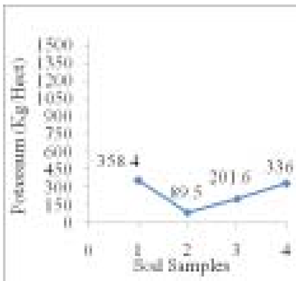

Fig. 12: Variation in the value of potassium at different sites in Mandi district.

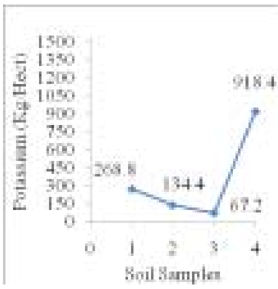

Fig. 13: Variation in the value of potassium at different sites in Bilaspur district.

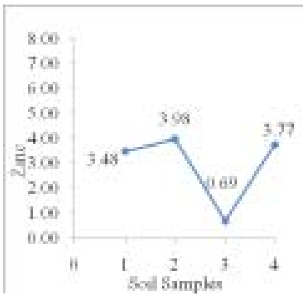

Fig.14: Variation in values of micronutrient zinc at different sites in Kangra district.

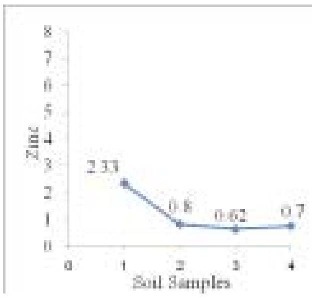

Fig.15: Variation in values of micronutrient zinc at different sites in Hamirpur district.

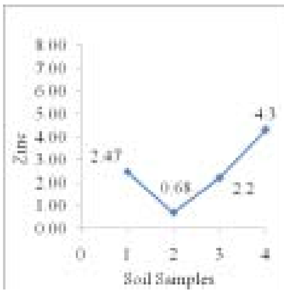

Fig.16: Variation in values of micronutrient zinc at different sites in Mandi district.

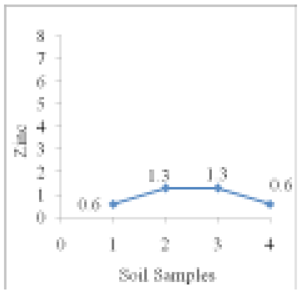

Fig.17: Variation in values of micronutrient zinc at different sites in Bilaspur district.

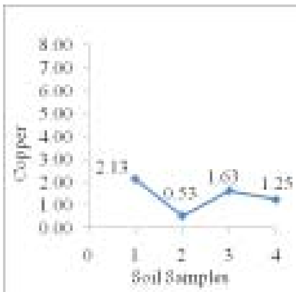

Fig. 18: Variation in values of micronutrient copper at different sites in Kangra district.

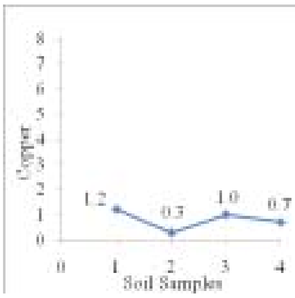

Fig. 19: Variation in values of micronutrient copper at different sites in Hamirpur district.

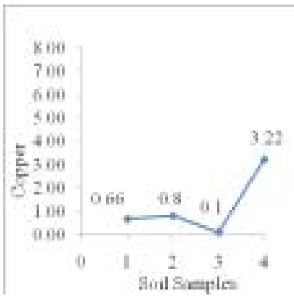

Fig. 20: Varition in values of micronutrient copper at different sites in Mandi district.

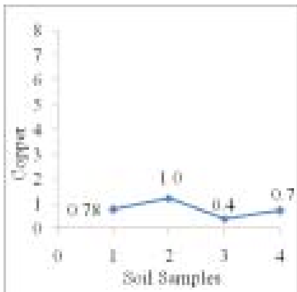

Fig. 21: Variation in values of micronutrient copper at different sites in Bilaspur district.

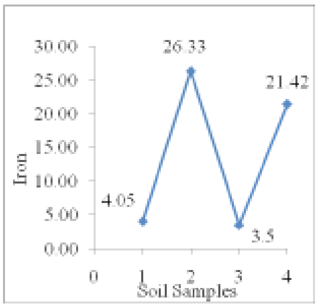

Fig. 22: Variation in values of micronutrient iron at different sites in Kangra district.

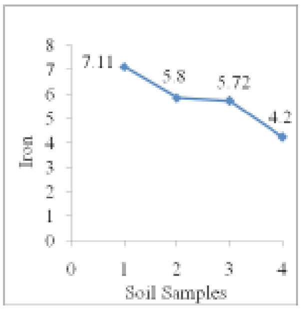

Fig. 23: Variation in values of micronutrient iron at different sites in Hamirpur district.

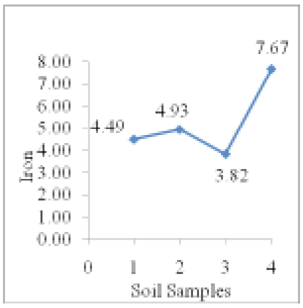

Fig. 24: Variation in values of micronutrient iron at different sites in Mandi district.

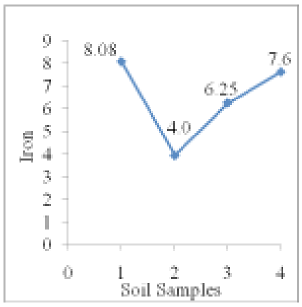

Fig. 25: Variation in values of micronutrient iron at different sites in Bilaspur district.

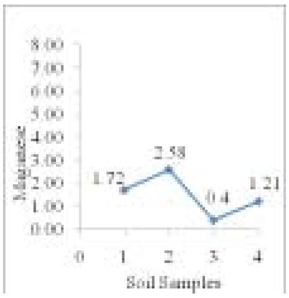

Fig. 26: Variation in values of micronutrient manganese at different sites in Kangra district.

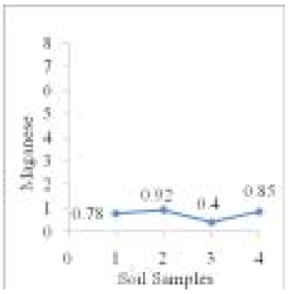

Fig. 27: Variation in values of micronutrient manganese at different sites in Hamirpur district.

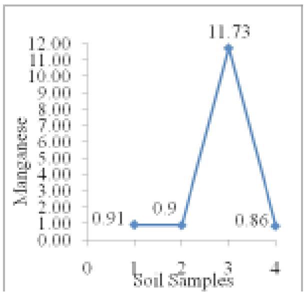

Fig. 28: Variation in values of micronutrient manganese at different sites in Mandi district.

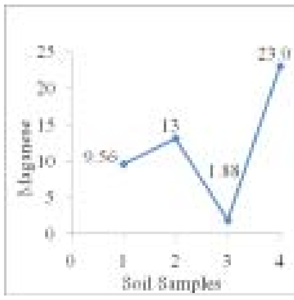

Fig. 29: Variation in values of micronutrient manganese at different sites in Bilaspur district.

when soil will have excessive basic nature which can greatly affect fertility of soil and water quality.

Both, water and soil play a significant role in ecosystems and plant growth but, when their quality is not good, they inhibit plant growth. Water is necessary for all living beings for their sustenance. The polluted water disturbs the growth of animals and plants.

Organic carbon plays an important role in soil biology by releasing nutrients to plants, providing buffering to soil, and stabilising the soil structure. In fact, these properties along with organic carbon, nitrogen and phosphorus are considered critical indicator for the health and quality of soil. The organic carbon was found to be maximum in Sundernagar (4.3%) district of Mandi, and minimum in Kangra (0.0%). The high content of 4.3 % was attributed to the smoke released by cement plant located in the area. Loss of organic carbon lead to the reduction in soil fertility, land degradation and even desertification due to the CO_2, SO_2, CO and unburnt carbon. The unburnt carbon generally increases the pH of soil and, thus, affect the fertility. Also the ash with unburnt carbon decreases the absorption capacity of the soil. Excessive amount of organic carbon can be problematic.

Potassium is one of the important nutrients found in soil. Potassium is high in most of the soils, except in those containing sand. Potassium is important in plant photosynthetic process and in helping plants to metabolize their food to get more energy. Potassium control water and chemicals inside plants and helps plants to function well. The potassium in soil varied from 67.2 kg/ha (Dangar of District Bilaspur) to 1366.4 kg/ha (Dharamshala of District Kangra). The permissible limit of potassium is 118 kg/ha to 280 kg/ha. Therefore, it was established that some places have potassium content lower than the permissible limit, i.e., Sujanpur Tira (44.8 kg/ha), Dangar (67.2 kg/ha), Bhota (89.6 kg/ha) and higher than the permissible limit like Chamunda (291.2 kg/ha), Sundernagar (336 kg/ha), Sandhol (358.4 kg/ha), Lambloo (672.4 kg/ha), Kangra (49.6 kg/ha), Nohangi (918.4 kg/ha), Barmana (918.4 kg/ha) and Dharamshala (1366.4 kg/ha). Plants lacking in potassium do not have enough energy to properly grow, their roots are not well developed and they have weak stems. Potassium deficient plants can not regulate and use water efficiently.

Excess potassium in plants can reduce the potential production of the crop inducing deficiencies of other nutrients like calcium and magnesium.

Zinc is an essential component of various enzyme systems for energy production, protein synthesis and growth regulation. Its values in the study area varied from 4.3 ppm in Sundernagar of Kangra district to 0.4 ppm in Barmana of Bilaspur district. The critical level for zinc in soils is 0.6 ppm. But Barmana of District Bilaspur has lower value of zinc (0.4 ppm) than the permissible limit, while some places reported zinc content higher than the permissible limit like Nohangi (0.62 ppm), Ratti (0.68 ppm), Yol (0.69 ppm), Sujanpur Tira (0.7 ppm), Bhota (0.80 ppm), Kularu and Dangar (1.3 ppm), Dangar (2.2 ppm), Lambloo (2.33 ppm), Sandhol (2.47 ppm), Kangra (3.48 ppm) and Sundernagar (4.3 ppm). Zinc deficient plants exhibit delayed maturity. The most visible zinc deficiency symptoms are short internodes and decrease in leaf size. Zinc deficiency is mainly found in sandy soils. Excessive uptake of zinc by plants causes stunting of short, curling and rolling of young leaves, death of leaf tops, and chlorosis.

Copper is necessary for carbohydrates and nitrogen metabolism. It is also required for lignin synthesis, which is needed for cell wall strength and prevention of wilting. Similarly copper was found from 3.22 ppm to 0.1 ppm in Sundernagar and Dangar respectively. The critical level of copper in soil is 0.2 ppm. Some places reported copper content lower than the permissible limit, that is Dangar (0.1 ppm), and higher than the permissible limit, that is Bhota (0.3 ppm), Dharamshala (0.53 ppm), Sandhol (0.66 ppm), Sujanpur Tira and Barmana (0.7 ppm), Ghagas (0.78 ppm), Ratti (0.8 ppm), Kularu (1.0 ppm), Nohangi (1.0 ppm), Lambloo (1.20 ppm), Chamunda (1.25 ppm), Yol (1.63 ppm), Kangra (2.13 ppm) and Barmana (3.22 ppm). Deficiency of copper results in stunning of plants. Concentration above 20 µM prevents root growth and result in death of the transplanted cuttings. Copper toxicity in many nontolerant plants is associated with the disturbance of mitosis, inhibition of root elongation and damage to root cell membrane. Copper also inhibits several enzymes, which play important role in photosynthesis. Excess copper may cause iron deficiency. The effect of copper toxicity is largely on root growth and morphology.

Iron is involved in the production of chlorophyll. It is also a component of many enzymes associated with energy transfer, nitrogen reduction and fixation and lignin formation. It was established that the iron varies from 26.33 ppm in Dharamshala to 3.5 ppm in Yol, whereas critical level of iron in soil is 4.5 ppm. Some places reported iron content lower than the permissible limit, that is Yol (3.5 ppm), Dandor (3.82 ppm), Kularu (4.00 ppm), Kangra (4.05 ppm), Sujanpur Tira (4.2 ppm), and higher than the permissible limit, that is Ratti (4.93 ppm), Nouhangi (5.72 ppm), Bhota (5.8 ppm), Dangar (6.25 ppm), Lambloo (7.11 ppm), Barmana (7.6 ppm), Sundernagar (7.67 ppm), Ghagar (8.08 ppm), Chamunda (21.42 ppm) and Dharamshala (26.33 ppm). Iron deficiencies are mainly manifested in leaves due to low level of chlorophyll. Severe iron deficiencies cause leaves to turn completely yellow or almost white and then brown as they die. Too much iron can affect the chlorophyll itself, causing it to change and inhibiting the plant's ability to properly absorb energy form sunlight and as a result it become difficult for plants to perform necessary biochemical reactions and prepare food.

Manganese is necessary in photosynthesis, nitrogen metabolism and to form other compounds required for plants metabolism. It was found that it varies from 0.4 ppm at Yol of Kangra district and Nohangi to 23.0 ppm at Barmana of District Bilaspur. The critical level of manganese in soil is 1.0 ppm. Some places reported manganese content lower than the permissible limit, that is Yol (0.4 ppm), Nohangi (0.4 ppm), Lambloo (0.78 ppm), Sujanpur Tira (0.85 ppm), Sundernagar (0.86 ppm), Sandhol and Ratti (0.9 ppm), Bhota (0.92 ppm), and higher, that is Chamunda (1.21 ppm), Kangra (1.72 ppm), Dharamshala (2.58 ppm), Ghagas (9.56 ppm), Dandor (11.73 ppm), Kularu (13 ppm) and Barmana (23.0 ppm).

Interveinal chlorosis is a characteristic of manganese deficiency symptom. In very severe manganese deficiency brown necrotic spots appear on leaves, resulting in premature leave drop or delayed maturity. Manganese toxicity symptoms include yellowing of leaves, which later darkens into small brown spots. Manganese toxicity becomes problem in soil with manganese containing minerals.

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