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Status of secondary nutrients *vis-à-vis* soil site-characteristics of vegetable growing soils of Varanasi

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Abstract : A study was conducted to assess the status of available secondary nutrients (Ca, Mg and S) along with physico-chemical properties of soils under continuous vegetable based cropping systems at the Central Research Farm of Indian Institute of Vegetable Research, Varanasi situated at 82.52°E longitude and 25.10°N latitude in the alluvial belt of Indo-Gangetic Plains (IGP) of Eastern Uttar Pradesh. The soils at this farm have been under continuous vegetable cultivation with the exception of intermittent cultivation of paddy in some blocks for the last 15 years. The experimental farm has a total area of 45 ha spread over 16 blocks. The analysis of soil samples collected from different blocks for various physico-chemical properties and status of secondary nutrients revealed that the soils of the research farm were neutral to slightly alkaline in reaction having pH in the range of 6.61 to 7.82 with a mean value of 7.29. Electrical conductivity was found within the normal limits (ranged from 0.09 to 0.76 dSm^{-1} with a mean value of 0.28 dSm^{-1}). Twenty two per cent soil samples of the research farm were found low, 73 per cent medium and rest 5 per cent high in organic carbon content. Water retention at field capacity and permanent wilting points was 25.6 and 6.3 per cent, respectively, and available water content was estimated to be 19.4 per cent. The soils of the entire farm were found to be silt loam in texture. Among the secondary nutrients, available Ca ranged from 1206 to 2302 ppm, whereas, available Mg ranged from 164 to 723 ppm, which indicated that these soils are sufficient in calcium and magnesium. With regard to the status of available sulfur, 3 per cent soils were found to be in low, 13 per cent in medium and 84 per cent in high range.

Keywords: Soil physio-chemical properties, secondary nutrients, vegetable cultivation

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Introduction

ICAR Vision 2030 emphasizes that the problem of land-and-water degradation is becoming a key constraint in augmenting agricultural production. The Soils of Indo-Gangatic Plains are known for their low to medium content of organic matter, nitrogen, phosphorus and high level of available potassium. It is reported that alluvial soils of IGP having 15-20 per cent clay and larger portion of silt are the most productive, as these soils contain enough of clay to provide an adequate surface for interaction with water and nutrients (Pal 2003). Their sandy loam to silt loam texture and friable structure are beneficial for proper tillage and root growth making them suitable for vegetable cultivation. Being high value cash crop, indiscriminate use of N, P, K fertilizers, insecticides and pesticides is a common practice in vegetables, whereas, use of secondary nutrients (Ca, Mg and S) is very rare. It has been reported that vegetable crops remove huge amounts of major, as well as, secondary nutrients from the soil. However, there is hardly any study on the long term effect of vegetable cultivation on soil properties and the status of secondary nutrients, especially under Indian conditions. Keeping this in view, the present study was carried out to investigate the effects of long term (>15 years) cultivation of vegetable crops on soil physic-chemical properties and the content of secondary nutrients.

Materials and Methods

A study was carried out to determine the status of available secondary nutrients (Ca, Mg and S) along with physico-chemical properties of the soils under continuous vegetable based cropping systems at the Central Research Farm of Indian Institute of Vegetable Research (IIVR), Varanasi situated at 82.52°E longitude and 25.10°N latitude in the alluvial belt of Indo-Gangetic Plains (IGP) of Eastern Uttar Pradesh. The study area consists of alluvium deposited by Ganga River dominated by silt fraction. The experimental farm has a total area of 45 ha spread over 16 blocks (A1- A7; B1- B7 and C1-C2). The soils at this farm have been under continuous vegetable cultivation over the last 15 years with the exception of intermittent cultivation of paddy in some blocks. For soil sampling purpose, each block was divided into four hypothetical sub divisions. A total of 360 soil samples (0-15 cm depth) were collected from all the blocks. These samples were composited in 60 samples following standard procedure. The samples were air dried in shade, crushed with a wooden pestle and passed through 2 mm sieve and stored in well labeled plastic jars for further laboratory analysis to determine various physico-chemical properties and content of secondary nutrient.

The particle size distribution was determined by the international pipette method after the removal of organic matter, $CaCO_3$ and free Fe_2O_3. Sand (2000–50 µm), silt (50–2 µm) and clay (< 2 µm) fractions were recorded. Soil pH and electrical conductivity were measured by standard methods (Richards, 1954). Cation exchange capacity (CEC) and exchangeable sodium and potassium were determined following the method of Richards (1954). Organic carbon was determined by Walkley and Black's wet digestion method as described by Jackson (1973). Exchangeable calcium and magnesium were extracted by 1 N NaCl solution as per the method of Piper (1966) and were determined by EDTA titration method. The values of exchangeable Ca and Mg were then converted to available Ca and Mg in parts per million using the respective equivalent weights. Available sulfur was extracted using 500 ppm P and 0.15 % $CaCl_2$ solutions as described by Chesnin and Yien (1950) and the concentration in the extract was measured using turbidimetric method on Spectro-photometer.

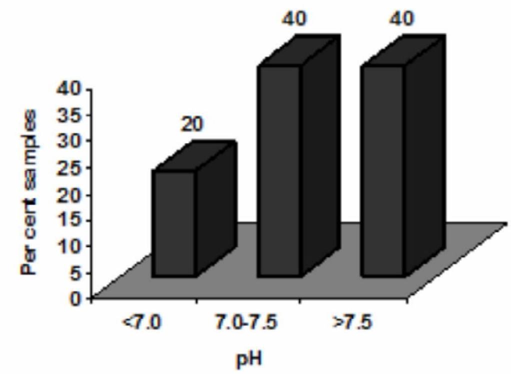
Results and Discussion

Soil Reaction

Soil pH is a measure of the soil acidity or soil alkalinity. An acid solution has a pH value less than 7.0 while a basic solution always has a pH larger than 7.0. In soils of IIVR research farm, the pH ranged from 6.61 to 7.82 with a mean of 7.34. Twenty per cent soils of the farm have pH below 7.0, 40 per cent soils are in the range of 7.0 to 7.5 and rest 40 per cent soils have pH more than 7.5 (fig.1).

Soil pH is one of the major factors responsible for nutrients availability to the plants. The pH values at this farm indicate that the soils are ideal for the production of most of the vegetable crops. Most of the vegetable crops prefer slightly acidic to neutral soil environment for their best performance. Brinjal, onion, cabbage and cauliflower favor pH between 5.5 and 6.5, whereas potato, pumkin and pea can be produced in neutral to mildly alkaline (pH 7.0 to 7.5) soil environment (Sharma et al., 2011). As about 40 per cent soils of the farm are mildly alkaline in reaction so application of agricultural grade gypsum before onset of monsoon during alternate years will be helpful in maintaining the pH within desirable limits for vegetable production.

Fig. 1 Soil reaction (pH) of IIVR soils

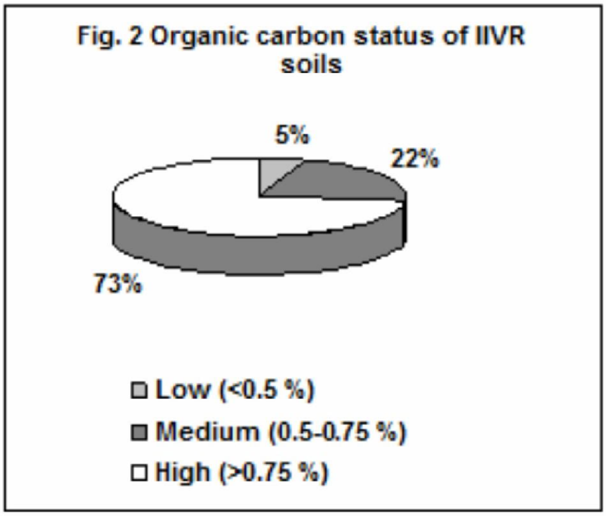


Electrical Conductivity (EC)

Electrical conductivity (EC) is an estimate of amount of total dissolved salts (TDS), or the total amount of dissolved ions in the soil. Higher EC values indicate the presence of more soluble salts in the soil system. EC of the soils at the farm ranged from 0.09 to 0.76 dSm^{-1} with a mean value of 0.28 dSm^{-1}. The electrical conductivity of the soils of A, B and C blocks ranged from 0.14 to 0.45, 0.17 to 0.76 and 0.09 to 0.42 with mean value of 0.26, 0.32 and 0.25 dSm^{-1}. Soils of C1 sub-block were found to be lowest and B7 sub-block highest in soluble salt content. However, the values in these blocks were within the permissible limits. The soils of the research farm are normal in soluble salt content and do not pose any negative impact on vegetable production.

Organic Carbon (OC)

Estimates of organic carbon are used to assess the amount of organic matter in soils. Soil organic matter (SOM) content can be used as an index of N availability (potential of a soil to supply N to plants) because the N content in SOM is relatively constant. Soil organic carbon was recorded in the range of 0.39 to 0.84 with an average of 0.57 per cent. 22 per cent soils of the research farm were found in the range of low, 22 per cent in medium, while rest of samples were high in available carbon status (Fig.2).



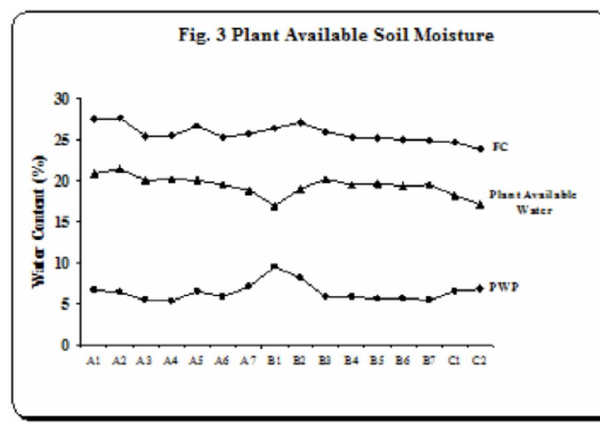
Particle size distribution

Soil texture a measure of the relative distribution of sand, silt and day particles is the primary soil property. It regulates water holding, AWC, aeration, nutrient retention, ion exchange phenomenon and other physico-chemical properties in soil system. Sand, silt and clay content ranged from 7.2 to 17.4, 64.7 to 71.2 and 17.6 to 21.3 per cent, respectively in soils of IIVR farm and the soil texture was classified as silt loam as per USDA triangle.

Sand content in A, B and C blocks was ranged from 7.50 to 17.80, 8.10 to 18.60 and 13.90 to 16.10 with a mean of 13.15, 14.24 and 15.05 per cent, respectively. There is a general trend of decreasing sand content from A1 and B1 sub block towards the direction of A7 and B7 sub-blocks. A further increase of sand was observed in C1 and C2 sub-blocks. Silt content in A, B and C blocks was ranged from 63.10 to 71.21, 63.20 to 71.10 and 68.20 to 72.30 with a mean of 67.84, 67.41 and 70.09 per cent, respectively. There is a general trend of increasing silt content from A1 and B1 sub block towards the direction of A7 and B7 sub-blocks. Further a similar trend as in sub-blocks A7 and B7 of silt was observed in C1 and C2 sub-blocks. Clay content in A, B and C blocks was ranged from 14.95 to 22.61, 15.50 to 22.48 and 13.10 to 16.20 with a mean of 19.00, 18.35 and 14.86 per cent, respectively. There is a general trend of increasing clay content from A1 & B1 sub block towards the direction of A7 and B7 sub-blocks. A further decrease of clay was observed in C1 and C2 sub-blocks.

Soil moisture characteristics

Soils of the farm were studied for water retention at field capacity and permanent wilting points. It is used to estimate the soil, water availability to the plants. Moisture retention in soils of different blocks at field capacity (33 kPa) and permanent wilting point (1500 kPa) ranged from 22.85 to 25.83 and 5.52 to 8.41 per cent with a mean value of 24.25 and 6.66 per cent, respectively. Plant available water content ranged from 16.1 to 20.3 per cent with a mean content of 17.6 per cent (Fig-3). A significant positive correlation was found between organic carbon status and soil moisture retention at 33 kPa (r=0.4269*) and 1500 kPa (r=0.3662*). Soil moisture retention at both the suctions were negatively correlated with bulk density (r= -0.5200**at 33 kPa and r=-0.2277* at 1500 kPa). Organic carbon in soil helps to reduce compaction and retains moisture at both the pressures due to its higher surface area. Water relations are among the most important physical phenomena that affect the use of soils for agricultural purposes. Moisture retentions are sensitive to the changes in bulk densities and disturbances of soil structures and organic carbon status.



Exchangeable Bases and Cation Exchange Capacity

Fraction of exchangeable cations that are base (Ca, Mg, K and Na) plays a very important role in vegetable production. Exchangeable calcium ranged from 6.03 to 11.51 with average value of 8.82 cmol/kg whereas exchangeable magnesium ranged from 1.37 to 6.03 with average of 4.14 cmol/kg. Exchangeable potassium raged from 0.40 to 0.97 with an average of 0.72 cmol/kg, whereas exchangeable sodium was found negligible. Under long term vegetable cultivation systems continuous use of various fertilizer nutrient sources especially potash bearing, influences the exchangeable bases ratios. Cation exchange capacity of soils ranged from 14.2 to 19.6 with an average value of 15.8 cmol/kg. Soils of the research farm are as slightly low to normal range with slightly low nutrient holding capacity indicating a more loamy mineral soil. Leaching may be a problem and therefore foliar applications of nutrients should be considered.

Base Saturation

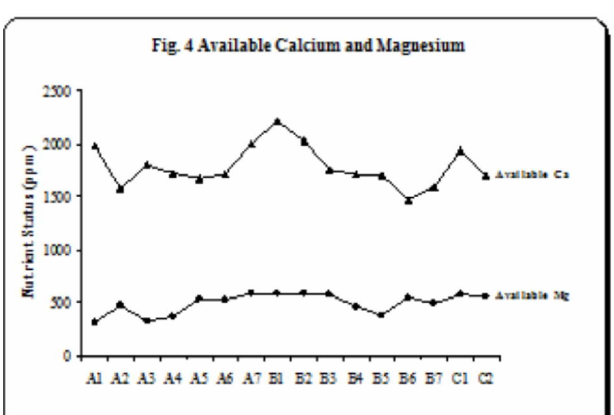
Base saturation of the soils ranged from 86.9 to 93.8 with an average of 91.5 per cent. Closely related to cation exchange capacity is the base saturation (Turner & Clark, 1966). Base saturation percentage was contributed by potassium from 2.8 to 4.2 (mean 3.6), magnesium from 26.7 to 37.3 (mean 32.5) and calcium from 58.0 to 68.8 (mean 62.7) per cent. It was also observed that contribution of sodium was found negligible in base saturation. If the CEC of soils range from 16-20 cmol/kg then the optimal contribution of exchangeable bases should be 2-4 % K, 50-70 % Ca and 8-20 % Mg. Considering the above limits the soils of the research farm are highly suitable for vegetable production with good nutrient supplying capacity except some extremes in exchangeable Mg.

Status of Secondary Nutrients

Most of soils of the Indo-Gangatic alluvial plains, red and lateritic and hill soils are prone to S deficiency while coastal soils are reported to be adequate in it (Singh 2010).

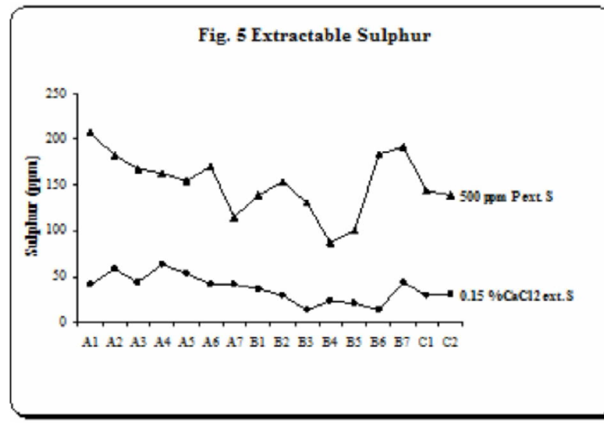
Calcium and Magnesium

Available calcium ranged from 1206 to 2302 with average of 1764 ppm, whereas available magnesium ranged from 164 to 723 with average of 496 ppm (Fig-4)). Soil test results of less than 300 ppm for calcium and 100 ppm for magnesium were considered low for vegetables crops (Sharma et al. 2011). Therefore, all soils of the research farm in this are sufficient in available Ca and Mg status.



Sulphur

Available S in 500 ppm P extract ranged from 18 to 310 ppm with average of 150 ppm. Available S in 0.15 % $CaCl_2$ extract ranged from traces to 84 ppm with average of 37 ppm. Considering the critical limits of 0.15 % $CaCl_2$ extractable sulfur 0-6 ppm for low, 7-12 ppm for medium and > 12 ppm for high (Sharma et al. 2011), it was observed that 3 per cent soils were low, 13 per cent soils were medium, while 84 per cent soils were high in available sulphur status.



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