Soil Fertility Appraisal for Pea Growing Regions of Himachal Pradesh using GPS and GIS Techniques

Nishant Thakur, Rakesh Sharma, Anil Kumar, Kunal Sood

ABSTRACT

Background: Overexploitation of productive lands creates serious problem of lowering the fertility status of soil and it leads to deterioration of soil. The deficiency of nutrients directly affects on the growth of crops and crop response become poor. Pea crop, like other plants, need different nutrients in varying quantities to achieve optimum growth and productivity. Soil fertility and its productivity are mainly affected by soil properties and nutrient status. Hence, it is necessary to assess the fertility status of soil with the consideration of available nutrients in soils and to recommend the specific nutrients for the proper management of soil.

Methods: In this field-laboratory investigation during 2017-2019, about 135 geo-referenced soil samples were collected from 49 pea growing locations/ villages of Gohar and Sundernagar blocks of Mandi district. The collected (0-15 cm) soil samples were analyzed for different soil properties such as pH, electrical conductivity, soil organic carbon and available N, P, K, Ca, Mg, Fe, Mn, Cu and Zn content. Different thematic maps were prepared using Arc-GIS software version 10.2.1.

Result: The investigations revealed that the soils were acidic to neutral in soil reaction and are in safe limits of electrical conductivity as the values were less than 0.8 dS m\(^{-1}\). Soil organic carbon status was found to be medium to high in surface layer. About 94.8 and 22.2\% soil samples were recorded deficient in available N and Zn, whereas K, Cu and Zn were moderate in 53.3, 28.1 and 55.6\% samples, respectively. On the basis of coefficient of variation, the soil pH and exchangeable Ca are least variable, whereas, available nutrients like N, Ca, Mg, Fe and Mn are moderately variable. However, electrical conductivity, OC, available P, K, S, Cu and Zn are highly variable in the samples under investigation. This information will also help to adopt effective strategy on fertilizer use and cropping pattern.

Key words: Pea (\textit{Pisum sativum} L.), Soil properties and nutrients, Thematic maps.

INTRODUCTION

Pea (\textit{Pisum sativum} L.) is one of the most important commercial vegetable crop which belongs to family leguminosae and is grown in temperate to tropical regions. Pea cultivation is believed to have originated in Central Asia, the Near East, Abyssinia and the Mediterranean from where it seems to have spread all over the World. It is basically a temperate vegetable crop, but has acclimatized to sub-tropical and tropical agro climatic conditions prevailing in the Indian sub continent. It is the second most widely cultivated legume crop of the world (Pawar \textit{et al.}, 2017). In India it is cultivated on an area of 554 thousand ha with an annual production of 5524 thousand metric tons (Anonymous, 2019). The main pea producing states are Uttar Pradesh, Madhya Pradesh, Punjab, Assam, Himachal Pradesh and West Bengal in the country. Himachal Pradesh is an important hill state in Western Himalayas and is endowed with varied agro-climatic conditions. In Himachal Pradesh pea is cultivated on an area of 23.65 thousand ha producing 277.20 thousand metric tons (Anonymous, 2017) and the area under pea is on an increase due to its premium returns fetches by the farmers under present agro-climatic conditions.

Overexploitation of productive lands with increasing population pressure creates serious problem of lowering the fertility status of soil and it leads to deterioration of soil. The deficiency of nutrients directly affects on the growth of crops and crop response become poor. Pea crop, like other plants, need different nutrients in varying quantities to achieve optimum growth and productivity. Ordinarily, the elements which need constant replenishment are mainly nitrogen (N), phosphorus (P) and potassium (K), as these are used up in considerable quantities by crops. Soil fertility and its productivity are mainly affected by soil properties and nutrient status. Hence it is necessary to assess the fertility status of soil with the consideration of available nutrients in

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Soil and to recommend the specific nutrients for the proper management of soil. This information will also help to adopt effective strategy on fertilizer use and cropping pattern. The information on fertility status of pea growing soils of Himachal Pradesh is virtually lacking and hence present study was carried out to assess the soil fertility status and prepare thematic maps using GPS and GIS techniques for pea growing areas of Mandi district.

MATERIALS AND METHODS

One hundred thirty five representative soil samples from surface (0-15 cm) were collected randomly using GPS from forty nine major pea growing locations of Gohar and Sundernagar blocks of the district during the month of September-October, 2018. Invariably, two-three soil samples were collected mostly from each of the location/village and the samples were collected using stainless steel augur.

The collected soil samples were air-dried, processed and analyzed for pH, electrical conductivity (EC) and soil organic carbon (OC) by standard methods (Jackson, 1973). Available nitrogen was determined by alkaline potassium permanganate method of Subbiah and Asija (1956). Available phosphorus was extracted by using 0.5 M NaHCO$_3$ extractant at pH 8.5 (Olsen et al., 1954) and determined by SnCl$_2$ reduced ammonium molybdate blue color method (Jackson, 1973). Available potassium was extracted by neutral normal ammonium acetate (Merwin and Peach, 1951) and determined by flame photometer. Exchangeable calcium and magnesium in the ammonium acetate extract were determined by atomic absorption spectrophotometer (Sarma et al., 1987). Available sulphur was extracted by morgan’s reagent and determined by turbidity method (0.15% CaCl$_2$) of Chesnin and Yien (1950). The analytical results of each soil sample were categorized as low, medium and high categories for OC and macronutrients (N, P and K) and micronutrients, deficient and sufficient for Ca, Mg and S based on the critical limits as followed in Himachal Pradesh. About 52.6 and 42.2% soil samples were under medium and high category for OC and macronutrients (N, P and K) and micronutrients, deficient and sufficient for Ca, Mg and S based on the critical limits as followed in Himachal Pradesh.

The pH of the soils of selected pea growing areas of Mandi district of Himachal Pradesh ranged from 4.4 to 7.7 (extremely acidic to slightly alkaline) with a mean value of 6.15 (Table 1). About 74.8 and 19.3 % of the samples were found to be acidic and neutral, respectively (Fig 1). The variation in soil pH could be attributed to leaching of bases, rainfall, continuous decaying of organic matter etc. (Chander et al., 2014). Kumar and Paliyal (2018) while investigating the soils under different crops in Mandi district also reported about acidic nature of the soil and attributed because of their location at relatively higher altitude and also higher amount of organic carbon in the surface horizon.

Electrical conductivity of surface soils ranged from 0.013 to 0.185 dS m$^{-1}$ (Table 1) with a mean value of 0.07 dS m$^{-1}$. In light of the suggested EC value < 0.8 dS m$^{-1}$ is considered as normal and suitable for all crops, the pea growing soils of the district were in safe limits (Fig 2). The results are in agreement with those obtained by Verma and Tripathi (2007) who found that the soils of Himachal Pradesh are very low in soluble salt concentration with EC value ranging from 0.01 to 0.15 dS m$^{-1}$.

The soil organic carbon content varied from 2.6 to 26.9 g kg$^{-1}$ (Table 1) with a mean value of 13.8 g kg$^{-1}$ in surface soils. About 52.6 and 42.2% soil samples were under medium and high in organic carbon status mainly due to higher addition of FYM, low temperature, high rainfall and continuous mineralization of organic matter (Fig 3) (Sharma and Kanwar, 2012). Tripathi et al. (1992) reported that organic carbon content in the soils of Mandi district ranges from 0.20 to 2.6 per cent.

The available N content ranged from 94.1 to 345.0 kg ha$^{-1}$ (Table 1) with a mean value of 168.0 kg ha$^{-1}$ in surface soils and 94.8 and 5.2% samples were under low and medium category with an overall low fertility rating (Fig 4). The low fertility rating of available N in the region may be primarily due to reduced rate of organic matter decomposition at low temperature in the region thus, temporarily withholding the mineralization of nitrogen and along with continuous cultivation of peas and other vegetables which needed high nutrients for growth and

Soil nutrient index value (SNIV) and fertility rating was calculated from the proportion of soils under low, medium and high available nutrient categories, as represented by

\[
\text{SNIV} = \frac{(NL \times 1) + (NM \times 2) + (NH \times 3)}{NT}
\]

Where, SNIV = soil nutrient index value; NL, NM, NH and NT are number of samples falling in the category low, medium, high nutrient status and total no. of samples analyzed and given weightage of one, two and three respectively (Ramamoorthy and Bajaj, 1969). The index values <1.67, 1.67-2.33 and > 2.33 indicate low, medium and high nutrient status of soils, respectively.

Database on soil properties and available nutrient was generated in Microsoft Excel and the thematic maps of soil variables were prepared at Centre for Geo-informatics Research and Training, CSK Himachal Pradesh Agriculture University, Palampur (HP) using Arc-GIS software version 10.2.1. The thematic maps on soil variables were categorized into different classes for pH, EC, OC, available N, P, K, Ca, Mg, S, Fe, Mn, Cu and Zn based on the critical limits.

RESULTS AND DISCUSSION

The available N content ranged from 94.1 to 345.0 kg ha$^{-1}$ (Table 1) with a mean value of 168.0 kg ha$^{-1}$ in surface soils and 94.8 and 5.2% samples were under low and medium category with an overall low fertility rating (Fig 4). The low fertility rating of available N in the region may be primarily due to reduced rate of organic matter decomposition at low temperature in the region thus, temporarily withholding the mineralization of nitrogen and along with continuous cultivation of peas and other vegetables which needed high nutrients for growth and










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Table 1: Soil properties of pea growing areas of Mandi district.

| Properties/Nutrients | Range      | Mean   | CV (%) | Acidic/ Non-saline/Low/ Deficient | Neutral/Slightly Saline/Medium/ Moderate | Alkaline/Saline/High/Sufficient | SNIV | Fertility rating |
|----------------------|------------|--------|--------|-----------------------------------|------------------------------------------|--------------------------------|------|------------------|
| pH                   | 4.4-7.7    | 6.15   | 11.17  | 74.8                              | 19.3                                     | 5.9                           |      |                  |
| EC (dS m⁻¹)          | 0.013-0.185| 0.07   | 48.88  | 100                                | -                                        | -                             |      |                  |
| OC (g kg⁻¹)          | 2.6-26.9   | 13.8   | 41.1   | 5.2                               | 52.6                                     | 42.2                          |      |                  |
| N (kg ha⁻¹)          | 94.1-345.0 | 168    | 31.3   | 94.8                              | 5.2                                      | -                             | 1.05 | Low              |
| P (kg ha⁻¹)          | 15.4-173.8 | 93.4   | 49.4   | 3.0                               | 97.0                                     | 2.97                          |      |                  |
| K (kg ha⁻¹)          | 118.5-830.9| 335.9  | 54.5   | -                                 | 53.3                                     | 46.7                          | 2.47 | High             |
| Ca [cmol(p⁺) kg⁻¹]   | 2.99-5.91  | 4.85   | 13.76  | -                                 | -                                        | 100                           | 3.00 | High             |
| Mg [cmol(p⁺) kg⁻¹]   | 1.92-3.89  | 2.76   | 15.97  | -                                 | -                                        | 100                           | 3.00 | High             |
| S (mg kg⁻¹)          | 8.3-57.5   | 41.3   | 37.15  | 3.0                               | -                                        | 97.0                          | 2.94 | High             |
| Fe (mg kg⁻¹)         | 13.3-119.9 | 76.6   | 34.0   | -                                 | -                                        | 100                           | 3.00 | High             |
| Mn (mg kg⁻¹)         | 2.8-41.2   | 32.3   | 28.4   | -                                 | 0.70                                     | 99.3                          | 2.99 | High             |
| Cu (mg kg⁻¹)         | 0.06-4.85  | 1.42   | 64.36  | 3.0                               | 28.1                                     | 68.9                          | 2.66 | High             |
| Zn (mg kg⁻¹)         | 0.04-7.05  | 2.13   | 60.07  | 22.2                              | 55.6                                     | 22.2                          | 2.00 | Medium           |

Acidic, neutral and alkaline for pH; Non-saline, slightly saline and saline for EC; Low, medium and high for OC, available N, P, K; Deficient and sufficient for Ca, Mg and S; Low, medium and high for micronutrients.
development. The results are in conformity with the findings of Raina (1988) who reported that the soils of Ponta valley of Himachal Pradesh were also low in available N.

The available P content of the soils ranged from 15.4 to 173.8 kg ha\(^{-1}\) (Table 1) with a mean value of 93.4 kg ha\(^{-1}\) in surface soils. About 97.0 per cent soil samples were rated as high in status with an overall rating of high which might be due to high organic matter content and continuous application of single super phosphate (Sharma and Kanwar, 2012) in pea growing soils of Himachal Pradesh (Fig 5).

The available potassium ranged from 118.5 to 830.9 kg ha\(^{-1}\) (Table 1) with a mean of 335.9 kg ha\(^{-1}\). About 53.3 and 46.7 per cent samples were under medium and high status with an overall fertility rating of high owing to the nature of parent material, management practices along with the addition of manures and fertilizers in the pea fields (Fig 6) (Mahajan et al., 2007).

The exchangeable Ca and Mg contents ranged from 2.99 to 5.91 and 1.92 to 3.89 [cmol (p\(^{+}\)) kg\(^{-1}\)] (Table 1) with a mean of 4.85 and 2.76 [cmol (p\(^{+}\)) kg\(^{-1}\)] in surface soils, respectively (Fig 7 and 8). Sufficient status of Ca and Mg was observed in samples with an overall fertility rating of high as these soils are least leached. Mahajan et al. (2007) reported that sufficient exchangeable Ca and Mg contents in soils of vegetable growing areas of Balh valley of Himachal Pradesh.

The available sulphur ranged from 8.3 to 57.5 mg kg\(^{-1}\) (Table 1) with a mean of 41.3 mg kg\(^{-1}\) in surface soil (Fig 9). About 97.0 % samples were under sufficient category with an overall fertility rating of high due to high organic matter content and use of fertilizers like SSP (Tripathi and Singh, 1992) in the soils of Himachal Pradesh.

The available Fe and Mn status ranged from 13.3 to 119.9 and 2.8 to 41.2 mg kg\(^{-1}\) (Table 1) with a mean of 76.6 and 32.3 mg kg\(^{-1}\) in surface soils, respectively (Fig 10 and 11). All samples were high in status with an overall
fertility rating of high which might be due to high organic matter and acidic to near neutral soil reaction beside presence of gypsiferrous and ferruginous parent materials containing hematite and limonite minerals (Wadia, 1966). Lahiri and Chakravarti (1989) also inferred that a high altitude soil has high availability of iron, manganese and organic matter content than the low altitude soils.

The available Cu status ranged from 0.06 to 4.85 mg kg\(^{-1}\) (Table 1) with a mean of 1.42 mg kg\(^{-1}\) in surface soils. About 28.1 and 68.9 % samples were under medium and high status with an overall fertility rating of high may be due to high organic matter and regular addition of manures and fertilizers to surface soils (Fig 12) of Himachal Pradesh (Mahajan et al., 2007).

The Zn status varied from 0.04 to 7.05 mg kg\(^{-1}\) (Table 1) with a mean of 2.13 mg kg\(^{-1}\) in surface soils. Low, medium and high status was noticed in 22.2, 55.6 and 22.2 per cent of the samples, respectively with a mean fertility rating of medium based on soil nutrient index values (Fig 13). The variation in amount of zinc might be due to difference in organic carbon, soil pH and other management practices etc. (Kakar et al., 2018).

**CONCLUSION**

On the basis of field and laboratory investigations, it may concluded that based on thematic maps, the soils of pea growing locations were extremely acidic to slightly alkaline in reaction and non-saline with medium to high organic carbon status. Plant available N is low in overall fertility rating. However, available P, K and S were high with an overall high fertility rating. The exchangeable Ca and Mg were sufficient in the area under study. Micronutrients such as Fe, Mn and Cu were high in fertility rating except Zn which is medium in rating. On the basis of coefficient of variation, the soil properties such as the pH and exchangeable Ca are least variable. Whereas, available nutrients like N, Ca, Mg, Fe and Mn are moderately variable. However, electrical conductivity, OC, available P, K, S, Cu and Zn are highly variable. For moderately and highly variable soil parameters, site specific nutrient management strategies should be developed and popularized for enhancing the productivity and profitability of pea crop in the region.

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