Soil properties assessment in surface and subsurface using spectroradiometer for Raver Tehsil of Jalgaon district

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Abstract:

Soil nutrient identification is most significant in soil fertility management system. Fertilizers play an important role for enhancing soil fertility in agriculture field since last decades, but accurately use of fertilizers based on the required amount for a certain site or type of crop and soil has always remained a challenge. Moreover, regular laboratory evaluates are very time wasting and expensive. In this work, we use spectroscopy technique using remote sensing. Spectral signature obtaining the diffused reflectance from spectroradiometer. Based on this reflectance data obtained from the spectroradiometer system, unique soil spectral signatures were obtained and analysed statistically for surface and subsurface soil samples collected from different fertilizers treatment were applied for dissimilar banana and cotton main crops in raver tehsil. The spectral data is used for fast non-destructive estimation of chemical properties nitrogen, phosphorous, potash, carbon, soil organic matter (SOM) as well as physical properties sand, silt, clay, pH, moisture based on diffuse reflectance spectroscopy using Visible, NIR, SWIR (350-700, 700-1100, 1100-2500) spectral range respectively. The availability of physical and chemical properties are analysed in surface and subsurface soil. Correlation-coefficient were analysed for surface and subsurface soil based on the statistical parameters R2. The R2 values obtained almost near to 1 it means the positive correlation is detected in two different surface and subsurface soil.

Keywords: *Soil, Fertilizers, physical properties, chemical properties, Spectroradiometer*

Introduction:

Soil nutrients are the major source of soil fertility that helps for plant growth as well as production. In the agriculture field farmers used the organic, inorganic or mixed fertilizers for fulfilment of nutrients. Fertilizers play an important role for enhancing soil fertility in agriculture field since last decades, but accurately use of fertilizers based on the required amount for a certain site or type of crop and soil has always remained a challenge. But farmers are not aware with the content availability, nutrient management, requirement of specific nutrient. Farmers are not aware with the

soil testing or need of soil testing in Indian agriculture. Some of are aware with soil testing but due to the time consuming techniques and large amount of charges they avoid soil analysis. This aim is fulfilled by developing and implementing a spectral soil analysis using spectral data obtained by a field Spec4 spectrometer. Soil properties were measured on the basis of derived soil spectral signature from surface and subsurface soil samples. The spectral curve plotted reflectance with respect to wavelength. Reflectance spectroscopy provides a large range of soil properties. Spectral information gives a better understanding of the influence of fertilizers on soil spectral reflectance. Chemical fertilizers influence detection can be difficult due to the different elements on the surface. The surface features creating spectral confusion with different elements of reflectance properties [7]. The appropriate methods selection is very important task for analysis of soil properties. Several statistical procedures, consisting of a series of operations were used. The spectral analysis procedure involves the preparation of soil samples, spectral acquisition, of spectral data, and the selection of an appropriate statistical method.

Physical and Chemical Properties:

Physical Properties: . In the physical properties sand, silt, clay, pH, moisture were calculated.

Moisture: soil moisture is the water that is held in the spaces between soil particles. Surface soil moisture is the water that is in the upper 10 cm of soil, whereas root zone soil moisture is the water that is available to plants, which is generally considered to be in the upper 200 cm of soil [15].

pH: In some mineral soils aluminium can be dissolved at pH levels below 5.0 becoming toxic to plant growth. Soil pH may also affect the availability of plant nutrients. Nutrients are most available to plants in the optimum 5.5 to 7.0 range. pH can also affect the structure of the soil, especially in clay soils. The best pH for most plants is between 6.0 and 7.0 [10].

Chemical Properties: The following chemical properties are analysed in this study

Nitrogen: Nitrogen is important for formation of amino acids and the building blocks of protein. It is essential for plant cell division and vital for plant growth.

Phosphorus: Phosphorus involved in photosynthesis, respiration, cell division and enlargement of cell. It promotes early root formation and growth of plant. Phosphorous is important for improve the quality of fruits, vegetables and grains.

Potash: Potassium is useful for increase photosynthesis as well as it increases water-use efficiency. It is important in fruit formation [14].

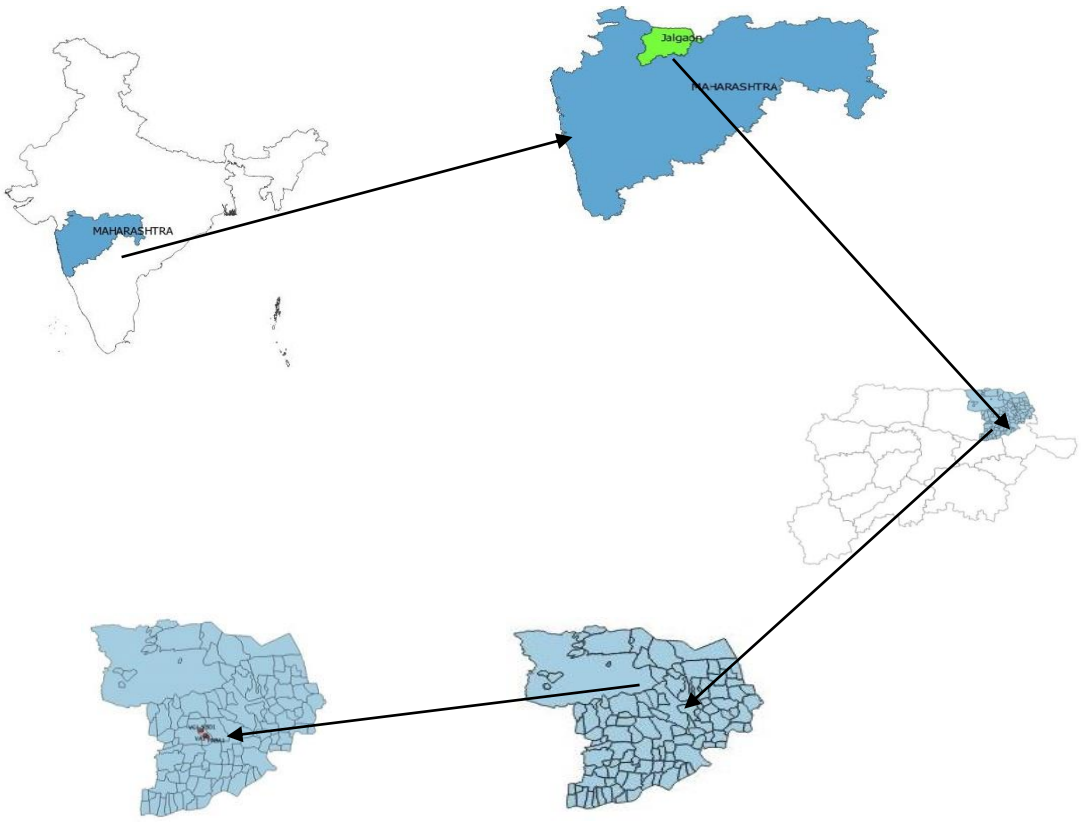
Carbon: Increasing soil organic carbon has two benefits – as well as helping to mitigate climate change, it improves soil health and fertility. The use of organic fertilisers/amendments to supplement inorganic fertilisers has the greatest potential to enhance soil carbon levels [4].

SOM: Soil organic matter is a crucial indicator of soil fertility status and soil health. The presence of organic matter in soil significantly affects the soil colour. Generally soil becomes darker as the percentage of organic matter increases and vice-versa. When increase in soil moisture and organic matter tends to decrease the reflectance value [16].

The spectral reflectance data can be alternative to the traditional methods for determining soil properties. This techniques gives the fast results in minimum cost and it is helpful to reduce the fertilizers cost.

2. Study area

The study was conducted at Jalgaon District, Raver tahsil, Wadgaon Shivar which is located between Lat: 21°12’30’’N, Lon:75°56’36’’E and Lat: 21°11’42’’N, Lon:75°58’08’’ E in, Maharastra, India with GPS information. Raver tahshil is famous for agricultural activities where different crops Jowar, banana, cotton, yellow gram and, soybean, wheat, corn taking farmers. Mostly Banana is the main cash crop in the study area. Banana from this area is very famous in the national and international market. Banana and cotton crops are associated with the formation of soils, nature of surface, availability of groundwater. Fig. 1 shows the study area map.



Raver Tahshil Study area

Figure 1 Study area location map

3. Methods

3.1 Spectral Data Acquisition:

Spectroradiometer giving minimal sample preparation, fast analysis, cost-effective to analyse a single or batch of samples, several constituents can be determined simultaneously, no destruction of samples, no hazardous chemical used, and results can be accurate and fast [8-10]. Spectral data acquire using FieldSpec4 spectroradiometer having spectral range (350- 2500 nm) analytical spectral device (ASD) [11]. The fieldSpec4 Spectroradiometer was used to collect the surface and subsurface soil sample reflection of each samples in the form of spectral signature it sown in figure 1 and figure 2. After data collection, approximate ten spectral signatures are acquired for every sample. Then calculate the mean of every ten spectral signature using View Spec Pro version 6.2 software. Generate the statistic data of each mean sample and process data using View Spec Pro 6.2 software [12-14].

3.2. Data Processing:

Calculating the mean of ten spectral signatures which are collected for each sample then calculate the average of five samples which are collected from each category field. All soil samples divide in different five category organic cotton, organic banana, mixed cotton, inorganic banana, mixed banana. The various content are analysed using physical and chemical properties. After processing the spectral data extract the numerical data in MS-excel and arranged in tabular format. The graphical representation of statistical data in figure 1 for all category.

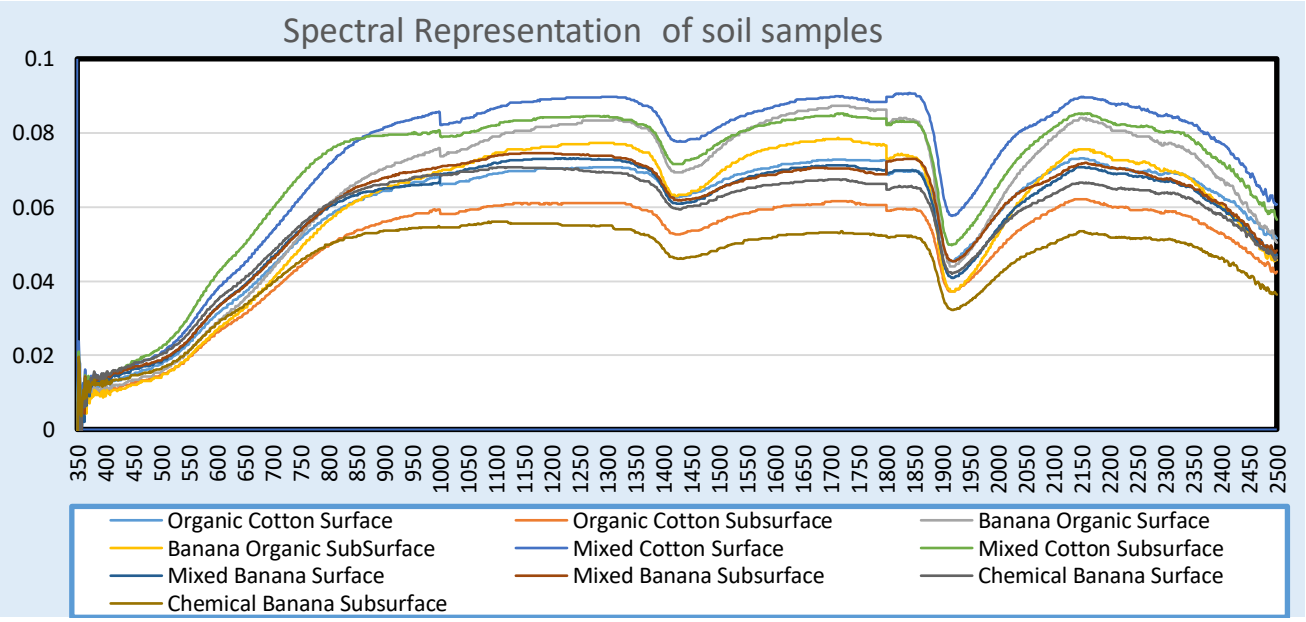


Figure 1: Spectral Signature of each category and each class

The cotton soil having less reflection than banana soil in organic and mixed fertilizers category. Cotton and banana crop surface soil having less reflection than subsurface soil. Mixed subsurface having a high reflection in banana crop soil. An organic surface having less reflection on cotton crop soil. Subsurface soil sample having more reflection than surface soil sample in all category.

4. Results

Soil physical as well as chemical parameters are calculated from statistical data which is collected from spectral signature. Statistical data is released in Microsoft Excel. Spectral data is represented in the numeric format in the range of 350-2500 total 2150 values. Different chemical soil parameters are analyse on different spectral absorption range like Soil organic matter SOM (2052, 2200, 2215, 2265, 2285, 2295, 2315, 2495, 1109, 1232, 1414, 1522, 1420, 1900-1950, 2040-2260, 2440-2460), carbon (2040, 2260), nitrogen (1702, 1870, 2022), phosphorus (2021-2025, 2081-2084, 2240-2400), Potash (537, 1542, 1862, 1947, 2187, 2290). Physical soil parameters are analyse on different spectral absorption range like pH (517, 657, 747, 1477, 1492, 1932, 2062, 2227), Moisture (1400, 1900, 2200), Sand (1832, 1870, 1872, 2067, 2159, 2249, 2362), Silt (1019, 1608, 1852, 1904, 1937, 2076, 2238, 2377), Clay (2200, 2232, 2278, 2329) Then calculate the average of ranges values for every soil parameter for different fertilizers treatment used soil sample from the surface and subsurface. The result is shown in table 1.

4.1 Statistical analysis of physical properties:

Table No.1. Statistical analysis of surface soil sample for physical properties

Surface Soil Sample for analysis of Physical Properties					
	Sand	**Silt**	**Clay**	**pH**	**Moisture**
Organic Cotton	0.061	0.061	0.063	0.061	0.062
Organic Banana	0.068	0.068	0.070	0.066	0.069
Mixed Cotton	0.076	0.076	0.079	0.075	0.079
Inorganic Banana	0.052	0.052	0.054	0.052	0.053
Mixed Banana	0.059	0.059	0.061	0.058	0.060

Figure 2: Representation of Statistical analysis of surface soil sample for physical properties

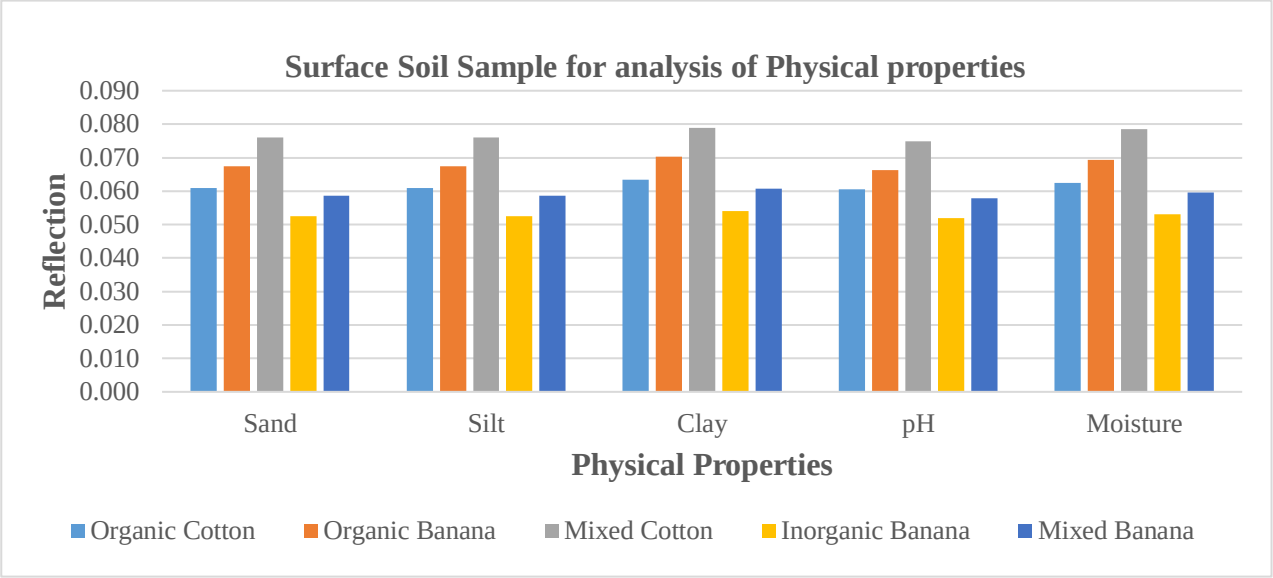
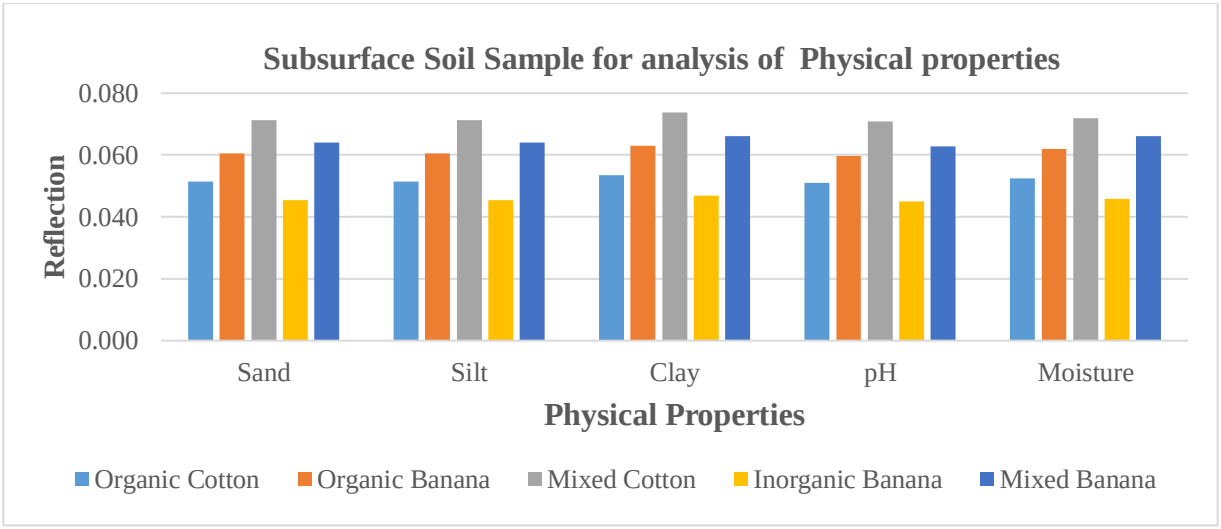


Table No.2. Statistical analysis of subsurface soil sample for physical properties

Subsurface Soil Sample analysis for Physical Properties					
	Sand	**Silt**	**Clay**	**pH**	**Moisture**
Organic Cotton	0.051	0.051	0.053	0.051	0.052
Organic Banana	0.061	0.061	0.063	0.060	0.062
Mixed Cotton	0.071	0.071	0.074	0.071	0.072
Inorganic Banana	0.046	0.046	0.047	0.045	0.046
Mixed Banana	0.064	0.064	0.066	0.063	0.066

Figure 3. Statistical analysis of subsurface soil sample for physical properties



4.2 Statistical analysis of Chemical Properties: chemical properties SOM (Soil Organic Matter), Carbon, Nitrogen, Phosphorus and Potash are calculated and the results shown in table 3 for surface soil sample and the table 4 shown the subsurface soil sample with chemical properties.

Table 3: Statistical analysis of surface soil sample for chemical properties

Surface Soil Sample analysis for Chemical Properties					
	SOM	**Carbon**	**Nitrogen**	**Phosphorus**	**Potash**
Organic Cotton	0.038	0.067	0.067	0.066	0.065
Organic Banana	0.039	0.074	0.077	0.072	0.074
Mixed Cotton	0.047	0.083	0.085	0.082	0.082
Inorganic Banana	0.038	0.056	0.057	0.055	0.055
Mixed Banana	0.039	0.064	0.064	0.063	0.063

Figure 4. Statistical analysis of surface soil sample for chemical properties

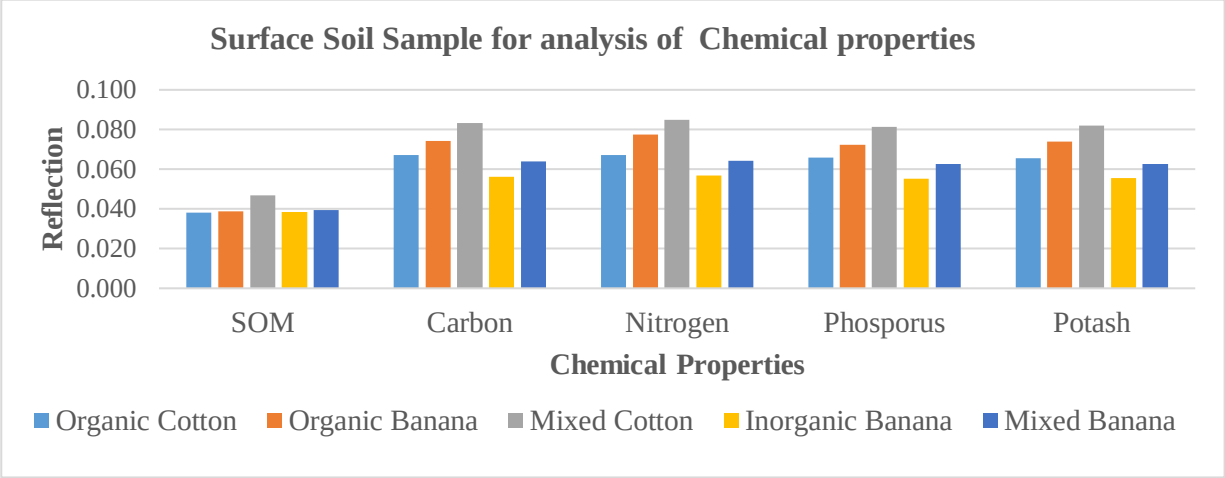
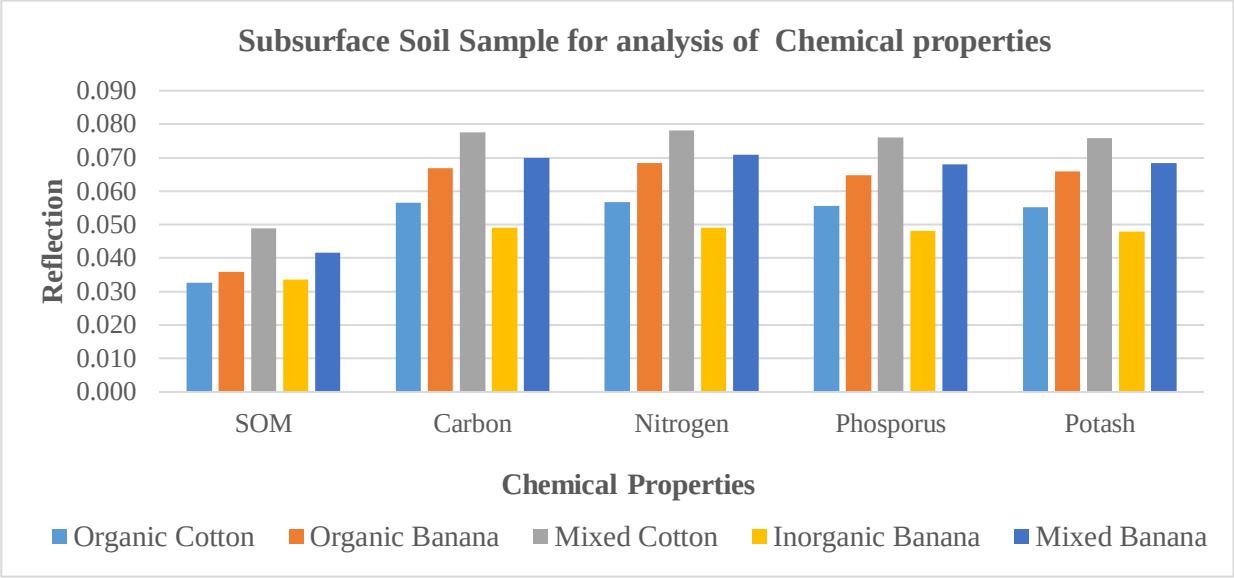


Table 4: Statistical analysis of subsurface soil sample for chemical properties

Subsurface Soil Sample analysis for Chemical Properties					
	SOM	**Carbon**	**Nitrogen**	**Phosphorus**	**Potash**
Organic Cotton	0.033	0.057	0.057	0.056	0.055
Organic Banana	0.036	0.067	0.068	0.065	0.066
Mixed Cotton	0.049	0.078	0.078	0.076	0.076
Inorganic Banana	0.034	0.049	0.049	0.048	0.048
Mixed Banana	0.042	0.070	0.071	0.068	0.068

Figure 5. Statistical analysis of subsurface soil sample for chemical properties



In figure 4 shows the graphical representation of surface soil parameters whereas figure 5 shows graphical representation of subsurface soil parameters. According to figure 4 and 5 the surface soil chemical parameters having more content in mixed cotton.

4.3 Calculation of correlation coefficient:

Correlation coefficient shows the relation between two values in the form of R^2. Range of R^2 is between 0 to 1. When R^2 is near to 1 then it is showing the positive relation between two values or it is highly correlated to each other. Otherwise it is negatively correlate with each other. Surface soil parameters and subsurface soil parameters are calculated for correlation and result shown in table 5 for all physical and chemical properties of soil. The table 5 shows the highly correlation between surface soil parameter and subsurface soil parameters.

Table 5 Correlation coefficient between Surface & Subsurface soil parameter

Correlation Coefficient									
Sand	**Silt**	**Clay**	**SOM**	**pH**	**Moisture**	**Carbon**	**Nitrogen**	**Phosphorus**	**Potash**
0.83	0.83	0.83	0.91	0.84	0.80	0.83	0.82	0.83	0.83

5. Conclusion:

The spectral reflectance data can be alternative to the traditional methods for determining soil properties. Different physical and chemical properties are analysed in the acquired spectral data where different fertilizers treatment were used for banana and cotton crops, in surface and subsurface soil samples. In the surface soil samples physical and chemical properties availability are higher than

subsurface soil sample where organic and inorganic fertilizers are used. But where mixed fertilizers were used for banana and cotton crops the physical as well as chemical properties are higher than surface soil sample. Physical properties analysis for soil texture the sand, silt, clay are calculated it shows clay soil is present in the study area. In the fertilizer treatment and crop wise analysis content are higher in mixed fertilizer than organic fertilizer and organic fertilizers content is higher than chemical fertilizers.

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