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# Relationship between soil Physico-chemical properties, available macro and micronutrients and yield in cotton growing soils of Nanded district of Maharashtra

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**Abstract**
Available nutrient status and their correlation with the physico-chemical properties is an important indicator of soil health and plant nutrition. The research was conducted to understand the nutrient status in relation to soil properties in cotton growing region of Nanded district of Maharashtra. Seven representative soil profiles from different physiographic unit were selected, studied and determined the relationship between physico-chemical properties, available nutrients status of soil and yield of cotton. Results indicated that the soil depth, clay and PAWC showed positive correlation with all the macro and micronutrients but significantly with available N and Ca and Mg and negatively significant with Mn. pH of soils showed no significant negative correlation with N, P, K, Ca, Mg and B and significantly negative correlated with Fe. The soil organic carbon showed positive relationship with N, K, Ca, Mg, S, Fe, Zn, Cu and significantly with B but negatively relationship with available P and Mn. $CaCO_3$ showed negative relationship with P, K, S, Fe and Zn and significantly negative correlated with N, Ca and Mg. On the other hand, calcium carbonate showed positive and significant relationship with Mn. CEC showed positive relationship with available P, S, Fe, Zn, Cu and B and significantly positive correlated with N, K, Ca and Mg and significantly negative correlated with Mn. Among physico-chemical soil properties, yield of cotton showed positive relationship with organic carbon while positive and significant relationship with soil depth, clay and PAWC and CEC and negative relationship with silt, pH and EC but negative and significant relationship with sand and $CaCO_3$.

**Keywords:** Correlation, nutrients, physico-chemical properties, yield, cotton

## Introduction

Nanded district of Maharashtra states which belongs to sub-tropical region with an average annual rainfall 890 mm. The soils of Nanded are formed from Deccan basalt rock which is rich in Ca, Mg and carbonates but poor in N, P and K. The rainfed cotton is frequently grown mostly in shrink-swells of central India, southern states and Gujarat. These soils are generally productive but hard to manage. In Maharashtra, cotton is grown primarily as a rainfed crop in Vertisols (black or regur) and associated soils. Soil associated limitations such as nutritional imbalance affecting the crop productivity extremely which can be determined by evaluating the soil fertility status. Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is made (Vineet Kumar, 2018) [28].

The soil pH, organic matter, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere are responsible for availability of nutrients in soil (Jiang *et al.*, 2009) [10]. The physical, chemical and biological properties of soil and their interaction controlled the soil quality (Papendick and Parr, 1992) [19]. The deficiency of nutrients is the major constraints to productivity, stability and sustainability of soils (Chaudhari *et al*. 2012) [2]. Soil organic matter, cation exchange capacity, soil pH and soil texture are the main indicators of soil fertility. For the better growth of plants, amongst many other factors, seventeen essential elements are required to be present in soil in proper proportion and available form. Amongst these elements, N, P, K, Ca, Mg and S are categorized as macronutrients are required in larger quantity than Fe, Mn, Zn, Cu and B categorized as micronutrients. Macro and micronutrients are important for maintaining soil health and also increasing productivity of crops. Agriculture activities change the soil chemical, physical and biological properties (Mukesh Kumar, 2017) [17].

For the sustainable agricultural production the information on soil characterization in relation to fertility status of the soils of the region will be useful.

Therefore, the present investigation was undertaken to study the physico-chemical properties and available nutrient status of cotton growing soils Nanded district of Maharashtra.

## Materials and Methods

Geographically, Nanded district of Maharashtra state is located between $18^0$ 15'to $19^0$ 55' North Latitude and $77^0$ 07'to $78^0$ 15' East Longitude with the total geographic area is about 10,528 sq. Kms. Nanded district is located exactly in between $18^0$ 01' 35" to $18^0$ 25' 49" North latitude and $75^0$ 55' 36" to $76^0$ 19' 10" East longitude at an altitude of 640 to 660 m above MSL. This area received mean annual rainfall of 873 mm and mean maximum and mean minimum temperature are $36.6^0$C and $21.53^0$C, respectively. The area has Ustic soil moisture regime, Hyperthermic temperature regime and length of growing period is 149 days. Seven representative pedons were selected from different physiographic unit of the study area. EC, pH, organic carbon and $CaCO_3$ were determined by standard procedure (Jackson, 1973) [9]. Available N in the samples was estimated by alkaline permanganate method. Available phosphorus was determined by Olsen's method, reading was recorded using spectrophotometer (Jackson, 1967) [7]. The available K was determined in neutral normal ammonium acetate [1 N $CH_3$CooNa] extract of soil using flame photometer. Available sulphur was determined by using spectrophotometer outlined by William and Steinberg (1969) [29]. The available Fe, Mn, Cu and Zn in soil samples were extracted with DTPA [0.005 M DTPA+0.01 M $CaCl_2$+0.1 M triethanolamine, pH 7.3 ] as per method described by Lindsay and Norvell (1978) [14] concentration of Fe, Mn, Cu and Zn in the DTPA extracts was determined using atomic absorption spectrophotometer. Available boron was determined as per the standard procedure by Berger and Trang (1939). The particle size distribution analysis was carried out as per the international pipette method (Jackson, 1979) [8]. Plant available water capacity (PAWC) were determined using the expression suggested by Gardner *et al*. (1984) [5] and latter modified by Coughlam *et al*. (1986) [3].

Cation exchange capacity was estimated by soil screened through 2 mm sieve was saturated with 1N sodium acetate (pH 8.2). After removal of excess sodium acetate by washing with alcohol, the adsorbed sodium was extracted by washing with 1N ammonium acetate (pH 7.0) and the leachate was made up to known volume. Na+ present in the leachate were determined with a flame emission spectrophotometer (Richards, 1954) [25]. Exchangeable calcium and magnesium were determined on less than 2 mm samples by leaching with 1N NaCl solution (Piper, 1966) [22] and titrating the leachate with standard EDTA solution as per the method of Richards (1954) [25]. Exchangeable sodium and potassium were determined on less than 2 mm soil by leaching with 1N ammonium acetate (pH 7.0) solution. Na and K from the leachates were estimated by flame emission spectrophotometer (Jackson, 1958) [6].

## Results and Discussion

The correlation coefficient values of physico-chemical properties viz; soil pH, organic carbon, calcium carbonate, cation exchange capacity, sand, silt and clay with available nutrient elements were worked out for weighted mean of soil profile and are presented in Table 1 and 2. The correlation between physico-chemical properties, available nutrients and yield of cotton presented in table 3. The results of correlations studies are detailed and discussed as under;

Table 3 revealed that the soil depth, clay and PAWC showed positive correlation with all the macro and micronutrients but significantly with available nitrogen (r=0.87**, r=0.87** and r=0.88**, respectively) and exchangeable calcium (r=0.93**, r=0.81** and r=0.93**, respectively) and magnesium (r=0.94**, r=0.93** and r=0.94**, respectively) and negatively significant with manganese (r=-0.92**, r=-0.98** and r=-0.95**, respectively). A positive and significant correlation of clay with available calcium and magnesium content was also observed by Ahmad (2003) [1]. Available K in soils had highly significantly positive correlation with CEC (r= 0.82*) and non significant and positive correlation with clay (r= 0.64) of soil and organic carbon (r= 0.31) while, non significant and negative correlation with silt (r= -0.12). This might be due to creation of favourable soil environment with presence of organic matter. The soil of arid and semi-arid regions were rich in available K, generalized that K content of soil series under Vertisols was higher than that of Alfisols and related soils. A positive and significant correlation of clay with available calcium and magnesium content was also observed by Dar.

All the macro and micronutrients showed negative relationship but significantly negative relationship of available nitrogen (r=-0.72*), exch. magnesium (r=-0.75*) and copper (r=-0.75*) and positive and significant relation of manganese (r=0.87**) with sand. Silt showed nonsignificant and negative relationship with all the macro and micronutrients but available sulphur (r=0.65) and copper (r=0.46) showed nonsignificant positive relationship. pH of soils showed nonsignificant negative correlation with nitrogen (r =-0.34) and phosphorus (r = -0.21), potassium (r=-0.35), exchangeable calcium (r=-0.57) and magnesium (r=-0.19) and boron (r=-0.49) and significantly negative correlated with available iron (r=-0.97**). The negative relation of available Fe with soil pH may possibly because of higher pH favor the existence of Fe as hydroxide (Rawat and Mathpal, 1981) [24]. On the other hand, soil pH exhibited significant and positive correlation with available manganese (r = 0.15), zinc (r = 27) and copper (r = 0.59). The negative correlation between soil pH and available nitrogen indicated that increase in soil pH decreased available nitrogen, which might be due to volatilization loss of nitrogen with rise pH of soil. Khokar *et al.* (2012) and Patil *et al.* (2015) [21] have also found significant and negative correlations between soil pH and available nitrogen. The negative relationship between soil pH and available phosphorus may be due to conversion of soluble phosphorus to insoluble calcium and magnesium phosphate thus reducing its availability with the rise in soil pH. Similar results were reported Patil *et al.* (2015) [21]. The increase in availability of calcium with rise in soil pH is obvious, because of basic nature of calcium cation. The results are in line with those of Medhe *et al*. (2012) [15]. Electrical conductivity showed nonsignificant and positive relationship with available phosphorus (r=0.06), potassium (r=0.24), sulphur (r=0.35), zinc (r=0.26), copper (r=0.06) and exchangeable magnesium (r=0.17) and nonsignificant and negative relationship with available nitrogen (r=-0.19), manganese (r=-0.12), boron (r=-0.48) and exchangeable calcium (r=-0.25). On the other hand, electrical conductivity showed nonsignificant and negative relationship with iron (r=-0.72*).

Soil organic carbon showed positive relationship with available nitrogen (r=00.35), potassium (r=0.31), exchangeable calcium (r=0.46) and magnesium (r=0.40), sulphur (r=0.06), iron (r=0.48), zinc (r=0.06), copper (r=0.20) and significantly with boron (r=0.71*) but negatively relationship with available phosphorus (r=-0.40) and manganese (r=-0.26). The 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) [27] and adsorption of $NH_4$-N by humus complexes in soil. The results are in conformity with those of Kumar *et al.* (2014) [12]. Secondly, most of the soil nitrogen is found in organic form; therefore, this relationship was observed to continuous addition of farm residues and FYM which being still under the state of decomposition and the higher rate of mineralization of organic matter due to soil condition being optimum. The increase in availability of sulphur by organic carbon may be attributed to release of sulphur from organic complexes as well as acidulating action of soil organic carbon thus enhancing the weathering of minerals containing sulphur. The available sulphur has positive correlation with organic carbon; this might be due to increase in pH and calcareousness of soil which decreases the availability of boron, while organic carbon helps in increasing the availability of boron. The results are confirmatory with the results obtained by Siddequi *et al.* (1994) [26]. Similar results were reported by Pareek (2007) [20]. The positive correlation between soil organic carbon and available iron content might be due to formation of iron chelates by organic matter, release of iron from organic complexes, acidulating action of soil organic carbon and decrease in soil pH thus increasing the solubility of iron complexes. The results are in accordance with the observations of Nazif *et al.* (2006) [18]. Organic carbon was positive correlated (r = 0.97**) with available content of zinc, Rajeshwar *et al.* (2009) [23] confirmed similar result observed by Kumar *et al.* (2009) [13] in Dumka series of Santhal Paraganas region of Jharkhand.

Calcium carbonate showed negative relationship with available phosphorus (r=-0.24), potassium (r=-0.68), sulphur (r=-0.49), iron (r=-0.26) and zinc (r=-0.56) and significantly negative correlated with available nitrogen (r=-0.84**) and exchangeable calcium (r=-0.75*) and magnesium (r=-0.89**). On the other hand, calcium carbonate showed positive and significant relationship with available manganese (r=0.92**). The significant and negative correlation of calcium carbonate with available phosphorus might be due to formation of insoluble calcium phosphates thus reducing its availability. The results are supported by the findings of Minhas and Bora (1982) [16].

Cation exchange capacity showed positive relationship with available phosphorus (r=0.41), sulphur (r=0.07), iron (r=0.57), zinc (r=0.43), copper (r=0.38) and boron (r=0.63) and significantly positive correlated with available nitrogen (r=0.86**), potassium (r=0.82*), exchangeable calcium (r=0.94**) and magnesium (r=0.95**) and significantly negative correlated with available manganese (r=-0.92**). Among physico-chemical soil properties, yield of cotton showed positive relationship with organic carbon while positive and significant relationship with soil depth, clay and plant available water capacity and cation exchange capacity. On the other hand, negative relationship with silt, pH and electrical conductivity but negative and significant relationship with sand and calcium carbonate.

**Table 1:** Physical and chemical characteristics of typifying pedons and yield of cotton (weighted means).

| Pedon | Depth (cm) | Sand (%) | Silt (%) | Clay (%) | PAWC (mm) | pH | EC ($dSm^{-1}$) | OC (%) | $CaCO_3$ (%) | CEC (cmol($P^+$)$kg^{-1}$) | Yield ($qha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_1$ | 80 | 19.83 | 39.27 | 46.50 | 176.4 | 8.1 | 0.3 | 0.2 | 20.6 | 46.61 | 13.6 |
| $P_2$ | 65 | 16.67 | 38.48 | 44.97 | 138.4 | 8.0 | 0.3 | 0.5 | 19.4 | 47.46 | 15.3 |
| $P_3$ | 115 | 9.8 | 29.57 | 61.74 | 340.4 | 8.1 | 0.3 | 0.7 | 08.3 | 58.98 | 22.5 |
| $P_4$ | 70 | 33.42 | 25.64 | 40.89 | 123.5 | 7.6 | 0.3 | 0.7 | 19.1 | 51.69 | 14.9 |
| $P_5$ | 120 | 16.54 | 28.96 | 54.89 | 366.2 | 7.0 | 0.2 | 0.5 | 16.2 | 61.12 | 21.7 |
| $P_6$ | 70 | 37.77 | 26.57 | 35.66 | 101.3 | 8.1 | 0.3 | 0.3 | 28.5 | 40.69 | 9.4 |
| $P_7$ | 115 | 7.31 | 31.79 | 60.87 | 345.2 | 8.1 | 0.4 | 0.4 | 11.5 | 61.06 | 20.9 |

**Table 2:** Available nutrients in typifying pedons under cotton growing soils of Nanded district (weighted means).

| Pedon | N ($kgha^{-1}$) | P ($kgha^{-1}$) | K ($kgha^{-1}$) | S ($mgkg^{-1}$) | Exch.Ca [cmol($P^+$)$kg^{-1}$] | Exch.Mg [cmol($P^+$)$kg^{-1}$] | Fe ($mgkg^{-1}$) | Mn ($mgkg^{-1}$) | Zn ($mgkg^{-1}$) | Cu ($mgkg^{-1}$) | B ($mgkg^{-1}$) | Yield ($qha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 144.7 | 16.0 | 357.2 | 30.4 | 25.26 | 13.33 | 12.0 | 13.1 | 0.8 | 3.4 | 0.4 | 13.6 |
| P2 | 117.9 | 07.4 | 286.0 | 26.7 | 25.35 | 13.34 | 12.4 | 17.1 | 0.3 | 3.9 | 0.8 | 15.3 |
| P3 | 170.2 | 11.1 | 366.1 | 31.4 | 35.65 | 19.13 | 14.0 | 06.1 | 1.0 | 4.9 | 0.9 | 22.5 |
| P4 | 131.8 | 11.7 | 453.5 | 19.8 | 28.92 | 14.55 | 17.2 | 16.5 | 0.6 | 2.4 | 0.6 | 14.9 |
| P5 | 164.7 | 14.5 | 440.4 | 14.8 | 39.32 | 17.97 | 21.9 | 08.6 | 0.6 | 1.3 | 0.9 | 21.7 |
| P6 | 103.7 | 10.4 | 197.3 | 14.8 | 24.62 | 12.65 | 10.7 | 21.6 | 0.6 | 1.2 | 0.3 | 9.4 |
| P7 | 148.5 | 15.1 | 535.3 | 23.1 | 34.28 | 19.81 | 12.1 | 06.1 | 0.8 | 4.8 | 0.5 | 20.9 |

**Table 3:** Correlation between physico-chemical properties and available macro and micro nutrients in cotton growing soils in Nanded district

| | N ($kgha^{-1}$) | P ($kgha^{-1}$) | K ($kgha^{-1}$) | Exch.Ca [cmol($P^+$)$kg^{-1}$] | Exch.Mg [cmol($P^+$)$kg^{-1}$] | S ($mgkg^{-1}$) | Fe ($mgkg^{-1}$) | Mn ($mgkg^{-1}$) | Zn ($mgkg^{-1}$) | Cu ($mgkg^{-1}$) | B $mgkg^{-1}$) | Yield ($qha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | 0.87** | 0.53 | 0.61 | 0.93** | 0.94** | 0.03 | 0.43 | -0.92** | 0.61 | 0.27 | 0.47 | 0.89** |
| Sand (%) | -0.72* | -0.27 | -0.52 | -0.59 | -0.75* | -0.55 | -0.05 | 0.87** | -0.38 | -0.75* | -0.53 | -0.83** |
| Silt (%) | -0.01 | 0.05 | -0.12 | -0.36 | -0.24 | 0.65 | -0.39 | -0.06 | -0.17 | 0.46 | -0.01 | -0.06 |
| Clay (%) | 0.87** | 0.39 | 0.64 | 0.81* | 0.93** | 0.39 | 0.22 | -0.98** | 0.60 | 0.64 | 0.55 | 0.94** |
| PAWC (mm) | 0.88** | 0.49 | 0.63 | 0.93** | 0.94** | 0.10 | 0.43 | -0.95** | 0.55 | 0.35 | 0.55 | 0.93** |
| pH | -0.34 | -0.21 | -0.35 | -0.57 | -0.19 | 0.59 | -0.97** | 0.15 | 0.27 | 0.59 | -0.49 | -0.33 |
| EC ($dSm^{-1}$) | -0.19 | 0.06 | 0.24 | -0.25 | 0.17 | 0.35 | -0.72* | -0.12 | 0.26 | 0.66 | -0.48 | -0.05 |
| OC (%) | 0.35 | -0.40 | 0.31 | 0.46 | 0.40 | 0.06 | 0.48 | -0.26 | 0.06 | 0.20 | 0.71* | 0.51 |
| $CaCO_3$ (%) | -0.84** | -0.24 | -0.68 | -0.75* | -0.89** | -0.49 | -0.26 | 0.92** | -0.56 | -0.73* | -0.64 | -0.94** |
| CEC [cmol($P^+$)$kg^{-1}$] | 0.86** | 0.41 | 0.82* | 0.94** | 0.95** | 0.07 | 0.57 | -0.92** | 0.43 | 0.38 | 0.63 | 0.97** |
| Yield ($qha^{-1}$) | 0.89** | 0.29 | 0.69 | 0.92** | 0.93** | 0.23 | 0.50 | -0.94** | 0.44 | 0.48 | 0.74* | 1 |

Significant at 1%-**(r=0.83), Significant at 5%-*(r=0.71)

**Conclusion**

Soil health and fertility are key parameters for sustainable agriculture. Soil testing for available nutrient status and assessment of soil physico-chemical factors affecting their availability is an important tool for managing the nutrient balance and productivity levels in cotton growing soils. It can be concluded that physico-chemical properties of pH, OC, $CaCO_3$, clay and CEC have a profound effect on the availability of soil available nutrients. Proper management of these properties can help in restoring the fertility levels in the soil and their relation can prove beneficial for nutrient recommendation system of cotton growing soils.

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