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# Distribution of nutrients in different soil types in Konkan region of Maharashtra

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**Abstract**
The fertility status of soil is one of the most important influencing factor for getting the yield and quality of crop. The soil samples were collected from areas representing Lateritic soil, Medium black soil and Coastal saline soils from the Agricultural Research centers of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and which were collected from different tahsils of Konkan namely Dapoli, Karjat and Panvel. The result showed that the Lateritic soil are acidic in reaction due to leaching of bases due to high rainfall, whereas the neutral to alkaline pH was observed in Medium black soil and Coastal saline soil. The electrical conductivity was observed < 1dS $m^{-1}$ except coastal saline soils which varies from 3.0 to 4.2 dS $m^{-1}$. The CEC showed higher in coastal saline soil followed by medium black soil. The infiltration rate was minimum (0.90 $cmhr^{-1}$) in Panvel (Coastal saline) soil profile due to salinity and heavy texture, whereas it was observed maximum in Lateritic soil (2.1cm $hr^{-1}$) due to light textured soil. The available nitrogen content in the konkan region of different surface soils was in order as Coastal saline soil > Lateritic > Medium black soils. The available phosphorous was observed low in lateritic soils may be due to fixation capacity of soil. the available potassium was observed highest in coastal saline which was might be associated with salinity. The DTPA extractable micronutrient content was observed sufficient in all soils.

**Keywords:** soil profile, cation exchange capacity, lateritic soil, medium soil and coastal saline soil

## 1. Introduction

Intensively cultivated soils are being depleted with available nutrients especially micronutrients. Therefore, assessment of nutrient constraints of soils being intensively cultivated with high yielding crops need to be carried out (Patil *et al.*, 2016) [20]. Though the high yielding varieties and hybrids have contributed significantly towards improving production, these varieties and hybrids are more demanding in terms of water requirement, insecticides and fertilizers. NPK are major nutrients required by all the crops for their growth. The fertilizers are required for the nutrient support to the plant growth. When fertilizers was applied to crop as water soluble sources do not remain in the soil for longer period and quickly starts getting converted into sparingly soluble or insoluble compounds due to different soil characteristics. It has been documented very well that dry land soils are not only thirsty but hungry too (Wani, 2008) [29] meaning that besides soil and water conservation if nutrient management constraints are addressed, the productivity of watershed will further enhanced.

The soil type has a great important influence on nutrient leaching losses as the movement of these nutrients in water is affected by the soil characteristics which define their retention. The factors known to influence the fate and behavior of fertilizers in soil systems. The total amount of rainfall or irrigation water received, the intensity (water flux) and frequency of received water, all appear to effect movement of these chemicals in soils.

The spread of Konkan is 30846 sq. km. comprising Greater Bombay, Thane, Raigad, Ratnagiri and Sindhudurg districts. The region has warm and humid climate with an average rainfall of 2515 to 3625 mm. Arabian Sea coastline of 720 km on the west with a background of coastal strip of land bounded by Sahyadri hills on the east state the geographical characteristics of Konkan. Konkan region is broadly divided into three agroclimatic zones viz. very high rainfall zone with Lateritic soil, very high rainfall zone with non-lateritic soil and ghat zone. All these three zones are important zone for rice production. Some studies on soil fertility status at representative research station level have been carried out at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

The propose study was planned with the objective of identifying available nutrients constraints in soils of the area.

## 2. Material and Methods

The research was conducted during *Kharif*, 2012. The soil samples were collected from Agricultural Research Centers of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli representing these three distinct zones of Konkan i.e, Lateritic, Medium black and Coastal saline. The samples were collected from rice growing soil at 0-30cm, 30-60cm and 60-90cm soil depth by following standard procedure. Infiltration rate was determined by using Double ring infiltrometer method (Jaiswal, 2004) [11] and the porosity was calculated by using the relationship as described by Black (1965) [2]. The pH and EC of soil was determined using 1:2.5 soil: water suspension ratio (Jackson, 1973) [10]. The Soil Organic carbon was determined by Walkley and Black wet oxidation method (Black, 1965) [2]. Available nitrogen was determined by alkaline permanganate (0.32% $KMnO_4$) method (Subbiah and Asija, 1956) [26]. Available phosphorus was determined by extracting the soil P with 0.5 M $NaHCO_3$ from alkaline soil at pH 8.5. (Olsen *et al*., 1954) [18] and from acidic soil by using $NH_4F$ as an extracting solution (Brays-I, 1945) [3]. Available potassium was estimated by using neutral-normal-ammonium acetate ($NH_4OAc$, pH 7.0) (Jackson 1973) [10]. DTPA extractable micronutrients was analysed by using 0.005 M DTPA extracting solution (Lindsay and Norwell, 1978) [15]. The cation exchange capacity of soil was determined by leaching the soil with 1N ammonium acetate and excess of ammonium acetate was removed from the soil with absolute ethanol. The exchanged ammonium ions corresponding to CEC of soil was then extracted with 1N KCL solution and determined by kjeldahl distillation Jackson (1973) [10]. The data were statistically analyzed by using the standard procedure given by Panse and Sukhatme (1967) [19].

## 3. Results and Discussion

### 3.1 Physical properties of soil

The mechanical composition of Lateritic soil reveals that, the percent sand content, 59.32, 37.00 and 32.52 percent at 0-30, 30-60 and 60-90 cms depths, respectively. Similarly, the values of silt are 14.72, 28.0 and 36.0 percent and that for clay were 25.76, 35.0 and 31.48 percent at 0-30, 30-60 and 60-90 cms depths, respectively. The soils under study showed a wide variation in soil texture may be due to differences in parent material, physiography, *in situ* weathering and translocation of clay (Basava Raju *et al.*, 2005) [1] and (Thangasamy *et al.*, 2005) [27]. The sub-surface horizons of Lateritic soil exhibit higher clay content as compared to surface horizons due to the illuviation process occurring during soil development caused by high rainfall and high leaching rate. Sandy clay loam texture in Lateritic soils were developed over granite/gneeis contains more sand and less clay as compared to soil derived from basalt. (Kadrekar *et al.*, 1981) [14]. The Medium black soil profile exhibited a uniform clay loam texture. Finer texture characteristics of this soil in all depth of profile might be because, these soils were developed over argillaceous basalt, and Deccan trap and hence produced higher amount of clay (Patil and Prasad 2004) [21]. The coastal saline soils exhibited a (heavy) clay, clay loam, and loam texture respectively.

These Coastal saline soil showed more fine and heavy texture at surface layer as compared to Medium black soil may be because of these (Coastal saline) soil near Arabian sea coast which remain submerged condition under continues tidal action which results into more weathering of soil and intrusion of finer texture particles in soil with tidal waves was studied by Joshi (1985) [12].

### 3.2 Porosity

The Porosity was minimum (20.60) in Panvel (Coastal saline) soil profile and maximum in Dapoli (Lateritic soil) soil profile (38.10%). Porosity of soil is generally closely related to texture of soil. Among the two fine textured soil (Coastal saline and Medium black soil) the porosity was lowest in Coastal saline soil might be due to more heavy texture as well as more salts at the surface soil as compared to Medium black soil.

### 3.3 Infiltration rate

The infiltration rate was minimum (0.90 $cmhr^{-1}$) in Coastal saline soil profile and maximum in Lateritic soil profile (2.1$cmhr^{-1}$). Infiltration rate of soil is generally closely related to texture of soil. Among the two fine textured soils (Coastal saline and Medium black soil) the infiltration rate is lowest in Coastal saline soil it might be due to more heavy texture as well as more salts at the surface soil as compared to Medium black soil (Joshi and Kadrekar, 1987) [13]. As the heavy texture as well as salts of Coastal saline soil pose the problem for infiltration of water. Higher infiltration rate value in Lateritic soil might be due to the coarse textured and low clay content of soil.

### 3.4 pH of soils

The pH of soil at different depths (0-30, 30-60 and 60-90 cm) varied from 5.80 to 6.40, 6.9 to 7.2 and 7.3 to 8.4 for Lateritic, Medium black and Coastal saline soil, respectively. The acidic pH of lateritic surface soil 0-30 cm might be due to acidic nature of parent material (granitic-gneiss) from which this soil derived. Similar results of soil reaction of Lateritic soil profile have also been reported by Mohaptra and Kibe, 1973 [16]. The neutral nature of pH of this Medium black soil which attributed to content of high calcium/magnesium carbonates and other bases present in the soil (Joshi and Kadrekar 1987) [13]. The increase in this soil reaction (slightly alkaline) at subsurface layer 30-60cm could be due to leaching of bases from higher topography and getting accumulated at lower elevations and also high concentration of $CaCO_3$ in the lower areas (Meena *et al.*, 2006) [17]. In case of Coastal saline soil, pH was found neutral to alkaline in nature. The neutral to alkaline pH of this soil is due to these soil contains high exchangeable Na percent, preponderance of calcium, magnesium, chlorides and sulphates of sodium at surface soil and low permeability of soil for these bases makes the subsurface soil more alkaline than surface soil.

### 3.5 Electrical conductivity of soils

The electrical conductivity at different depth of soil profile ranged from 0.06 to 0.09, 0.11 to 0.14 and 3.0 to 4.2 $dSm^{-1}$ in Lateritic, Medium black and Coastal saline soil, respectively. The electrical conductivity of soil was observed to be high in Coastal saline soil as compared with other two soil types. However, there was no regular trend observed as regards electrical conductivity and depths. On the other hand, the electrical conductivity of Lateritic soil and Medium black soil showed non saline nature of soil. Whereas the high electrical conductivity in Coastal saline soils were due to salinity developed due to ingress of sea water as well as poor drainage. The increasing trend of electrical conductivity was found with increasing depth of soil might be due to the accumulation of larger amount of $Na^+$, $Mg^{++}$ and $Ca^{++}$ in the surface as well as in the lower depths soils coastal zone near sea coast (Joshi, 1985; Joshi and Kadrekar 1987) [12, 13]. The electrical conductivity of all the surface soils ranged from 0.08 to 3.8 $dSm^{-1}$, in which two soil (Lateritic and Medium black soil) are within the acceptable limit (non saline nature) and in Coastal saline soil have salinity hazards.

### 3.6 Organic carbon and organic matter content of soils

The percent organic carbon varied from 0.51 to 1.80 in Lateritic soil, 0.46 to 1.29 in Medium black soil and 0.20 to 0.78 in Coastal saline soils. Whereas the percent organic matter varied from 0.879 to 3.10 in Lateritic soil, 0.79 to 2.22 in Medium black soil and 0.34 to 1.34 in Coastal saline soils. The highest percent organic carbon and organic matter was found in Lateritic soil followed by Medium black and was lowest in Coastal saline soil. There was a regular trend of decreasing in the percent organic carbon and organic matter as the depth increased in all the three soil profile under study. The organic carbon and organic matter content in the surface soil was relatively higher under both the zone which might be due to deposition of marine and vegetative residues into soil during the formation of these soils Joshi and Kadrekar *et al.*, (1987) [13].

### 3.7 Cation exchange capacity of soils

The cation exchange capacity of soils at different depths ranged from 28.40 to 31.69, 34.40 to 40.86, 41.4 to 49.4 c mole($P^+$) $kg^{-1}$ in Lateritic, Medium black and Coastal saline soil, respectively. The cation exchange capacity was found to be maximum (46.6 c mole (P+) $kg^{-1}$) in Coastal saline soil followed by Medium black soil (40.86 c mole ($P^+$) $kg^{-1}$) and was lowest (28.4 c mole ($P^+$) $kg^{-1}$) in Lateritic soil. The minimum cation exchange capacity was exhibited by Lateritic soil. It showed increasing trend in cation exchange capacity with increasing depth up to 0-30cm and 30-60 cm of profile in both soil (Lateritic and Coastal saline soil) and thereafter at (60-90 cm depth) it showed a declining trend. In Medium black soil profile showed decreasing trend of cation exchange capacity with increasing depth of soil (0-30 to 30-60cm) and further increase in depth (60-90cm) showed a decline in cation exchange capacity. Similar results were quoted by (Gabhane *et al.*, 2006) [8]. The cation exchange capacity of surface soil of all profile varied from 28.40 to 49.4 c mol ($P^+$) $kg^{-1}$. The results proved that, the cation exchange property is closely related to clay content in soil, as clay percent of soil increases it also increases (Gupta *et al.* 1999) [9]. Low values of cation exchange capacity may be ascribed to the predominance of low CEC minerals, especially Illite and Kaolinite in lateritic soil (Sanjeev *et al.*, 2005) [24]. Cation exchange capacity of the soils with smectitic type of clay mineralogy (Coastal saline soil and medium black soil) was higher as compared to the soils with mixed mineralogy Patil and Prasad, (2004) [21].

### 3.8 Available nitrogen in soils

The available nitrogen at different depth of soil profile ranged from 273.5 to 311.0, 247.8 to 259.4, 302.3 to 312.4 kg $ha^{-1}$ in Lateritic, Medium black and Coastal saline soils, respectively. Overall in general the available nitrogen content of Lateritic and Medium black soil were low as compared to Coastal saline soil. The available nitrogen content in the konkan region of different surface soils was in order as Coastal saline soil > Lateritic > Medium black soils.

**Table 1:** Physical properties of different types of soil profiles studied.

| Soil depth cm | Mechanical Composition (%) | | | Textural class | Porosity % | IR cm $hr^{-1}$ |
|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | |
| Lateritic soil - Location Dapoli | | | | | | |
| 0-30 | 59.52 | 14.72 | 25.76 | Sandy clay loam | 38.10 | 2.1 |
| 30-60 | 37.00 | 28.00 | 35.00 | Clay loam | 35.40 | |
| 60-90 | 32.52 | 36.00 | 31.48 | Clay loam | 35.30 | |
| Medium black soil - Location Karjat | | | | | | |
| 0-30 | 39.88 | 24.36 | 35.76 | Clay loam | 28.65 | 1.4 |
| 30-60 | 38.96 | 22.00 | 39.04 | Clay loam | 22.62 | |
| 60-90 | 42.96 | 24.00 | 33.04 | Clay loam | 25.62 | |
| Coastal saline soil - Location Panvel | | | | | | |
| 0-30 | 33.04 | 20.48 | 46.48 | Clay | 20.60 | 0.9 |
| 30-60 | 40.96 | 28.00 | 31.04 | Clay loam | 22.35 | |
| 60-90 | 44.96 | 30.00 | 25.04 | Loam | 25.60 | |

**Table 2:** Chemical properties of different types of soil profiles studied.

| Soil depth (cm) | pH | EC dS $m^{-1}$ | Organic carbon % | Organic matter % | CEC Cmole ($P^+$)$kg^{-1}$ | Av. Nitrogen $kgha^{-1}$ | Av. $P_2O_5$ $kgha^{-1}$ | Av. $K_2O$ $kgha^{-1}$ | DTPA extractable micronutrient (mg $kg^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Zn | Cu | Mn | Fe |
| Lateritic soil – Dapoli | | | | | | | | | | | | |
| 0-30 | 5.80 | 0.08 | 1.8 | 3.10 | 28.40 | 298.8 | 9.1 | 229.8 | 3.21 | 4.46 | 47.9 | 48.3 |
| 30-60 | 6.10 | 0.09 | 0.57 | 0.982 | 31.69 | 311.4 | 9.0 | 249.3 | 3.60 | 3.25 | 41.4 | 49.4 |
| 60-90 | 6.40 | 0.06 | 0.51 | 0.879 | 30.45 | 273.5 | 9.8 | 232.6 | 2.90 | 3.20 | 32.6 | 48.3 |
| Medium Black soil - Karjat | | | | | | | | | | | | |
| 0-30 | 7.0 | 0.14 | 1.29 | 2.22 | 40.86 | 258.3 | 18.4 | 270 | 3.00 | 3.56 | 31.6 | 25.8 |
| 30-60 | 7.2 | 0.11 | 0.68 | 1.17 | 34.40 | 259.4 | 17.4 | 282.5 | 3.51 | 3.10 | 25.6 | 21.4 |
| 60-90 | 6.9 | 0.13 | 0.46 | 0.79 | 37.59 | 247.8 | 15.6 | 260.4 | 2.40 | 2.91 | 25.1 | 21.5 |
| Coastal saline soil – Panvel | | | | | | | | | | | | |
| 0-30 | 7.3 | 3.8 | 0.78 | 1.34 | 46.6 | 312.4 | 23.4 | 972.8 | 3.25 | 5.87 | 22.6 | 23.8 |
| 30-60 | 8.4 | 4.2 | 0.50 | 0.862 | 49.4 | 302.3 | 20.5 | 972.0 | 3.10 | 4.20 | 28.9 | 28.4 |
| 60-90 | 8.4 | 3.0 | 0.20 | 0.34 | 41.4 | 308.4 | 16.5 | 982.6 | 3.10 | 3.80 | 29.1 | 29.2 |

### 3.9 Available phosphorus in soils

The available phosphorus at different depth of soil profile ranged from 9.0 to 9.8, 15.6 to 18.4, and 16.5 to 23.4 $kgha^{-1}$ in Lateritic, Medium black and Coastal saline soils, respectively. It is evident that in general available $P_2O_5$ content in surface layer was found more in all the profile as compared to lower layers. Thangaswamy *et al.,* 2005 [27] stated that the higher content of phosphorous in Lateritic soil was due to confinement of crop cultivation to surface layer and supplementation of the depleted $P_2O_5$ through fertilizers. Sharma and Bali (2000) [25] observed that the declining trend of phosphorous was due to higher fixation of it with depth. The available phosphorus of Lateritic soil was low and it ranged from 9.0 to 9.8 kg $ha^{-1}$ as compared to the available phosphorus of Coastal saline soil and Medium black soil which ranged from 16.5 to 23.4 and 15.6 to 18.4 $kgha^{-1}$, respectively. Prasunarani *et al.*, (1992) [23] the low content of available $P_2O_5$ in Lateritic soils might be due to low native phosphorous content and fixation of released phosphorous by clay minerals and oxides of Fe and Al. Joshi and Kadrekar (1987) [13] reported that the saline soils are usually medium to high in phosphorus similarly they observed that saline soils, in general, were moderate in available phosphate due to use of the fertilizers in soils.

### 3.10 Available potassium in soils

The available $K_2O$ at different depth of soil profile ranged from 229.8 to 249.3, 260.4 to 282.0 and 972.0 to 982.0 $kgha^{-1}$ in Lateritic, Medium black and Coastal saline soils, respectively. It showed decreasing trend in available potassium with increasing depth from 0-30 to 30-60 cm of profile in Coastal saline soil and thereafter it increase at 60-90 cm. In case of Lateritic and Medium black soils, the available $K_2O$ trend found increased up to 30-60 cm depth, and thereafter a declined in both the soils at 60-90 cm depth. The available potassium of coastal saline soil was found highest as compared to Lateritic soil and Medium black soil. The higher available potassium value in Coastal saline soil associated with high salinity, indicating that potassium from the sea water might be one of the major source contributing to the higher soil potash (Joshi and Kadrekar, 1987) [13].

### 3.11 DTPA extractable micronutrient

The DTPA extractable Zn content ranged from 2.90 to 3.60 mg $kg^{-1}$. In Medium black soil, Zn content varied from 2.40 to 3.51 mg $kg^{-1}$ and the depth variation was observed in Coastal saline soil 3.25 to 3.10 mg $kg^{-1}$. The DTPA extractable Cu content was in the range of 3.20 to 4.46 mg kg-1 in Lateritic soil, 2.91 to 3.56 mg $kg^{-1}$ in Medium black soil and 3.80 to 5.87 mg kg-1 in Coastal saline soils. The Mn content was maximum in Lateritic soil and ranged from (32.60 to 47.97 mg $kg^{-1}$) followed by Medium black soil (25.10 to 31.60 mg $kg^{-1}$) and was minimum in Coastal saline soil (22.60 to 29.10 mg $kg^{-1}$). The DTPA extractable Fe content of Lateritic soil ranged in between 48.30 to 49.40 mg $kg^{-1}$, Medium black soil from 21.40 to 25.80 mg $kg^{-1}$ and that of Coastal saline soil from 23.80 to 29.20 mg $kg^{-1}$. DTPA extractable Mn content in the soil was in the order of Lateritic soils followed by Medium black and Coastal saline soils. Similar trend in DTPA extractable Mn in these soils types was also reported by Vaidya (1988) [28]. The higher DTPA extractable Fe in Lateritic soil than Medium black and Coastal saline soil might be due to acidic pH of Lateritic soil and also observed that the decrease in DTPA extractable Fe contains as alkalinity increases in soil (Yadav, 1988) [30]. The DTPA extractable Zn was found highest in Coastal saline soil followed by Lateritic and Medium black soil. Similar trend in DTPA extractable Zn in these soil types of konkan region was mentioned by Dabke (1987) [4]. The DTPA extractable Cu was found highest in Coastal saline soil followed by Lateritic soil and Medium black soil.

### 4. References


1. Basava Raju D, Naidu MVS, Ramavatharam N, Venkaiah K, Rama Rao G, Reddy KS. Characterization, classification and evaluation of soils in Chandragiri mandal of Chittoor district, Andhra Pradesh. *Agropedology*, 2005; 15:55-62.
2. Black CA. Method of soil analysis Part-II. *Am. Agron. Inc. Madison Wisconsin, U. S.* A. 1965; 1040-41:1374-75.
3. Bray RH, Kurtz LH. Determination of Total, organic and available forms of phosphorus in soils. Illinois Agricultural Experiment station database. 1945; 59(1):39-46.
4. Dabke DJ. Studies on the physico-chemical properties and available micronutrient status of the rice soils from Agricultural Research Station, Phondaghat (Sindhudurg). *M.Sc. (Agri.) Thesis submitted to* Dr. Balasaheb. Sawant. Konkan Krishi Vidyapeeth., Dapoli, Ratnagiri, Maharasthra, 1987.
5. Das AC, Mukherjee D. Insecticidal effects on soil microorganisms and their biochemical processes related to soil fertility. World Journal Microbiology Biotechnology. 1998a; 14:903-909.
6. Das DK. Nutrient transformation and yield of rice (*Oryza sativa*) as affected by soil application of insecticides in its flooded ecosystem. Indian Journal of Agricultural sciences, 1995; 67(8):302-304.
7. FAI. Fertility index of Indian soil, fertilizers statistics, 2001, 2000-2001.
8. Gabhane VV, Jadhao VO, Nagdeve MB. Land evaluation for land use planning of a Macro-watershed in Vidarbha region of Maharashtra. Journal of the Indian Society of Soil Science. 2006; 54(3):307-315.
9. Gupta GP, Tembhare BB, Mishra SR. Characterization and classification of soils of granitic terrain in Jabalpur district of Madhya Pradesh. *Agropedology*, 1999; 9:77-81.
10. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. 1973; 134-182.
11. Jaiswal PC. Soil, Water and Plant analysis Text book Reprinted. *Kalyani Publication.* 2004, 39-42.
12. Joshi RG. Characterization of the coastal salt affected soils of Maharashtra. *Ph.D. (Agri.) Thesis submitted to* Dr. Balasaheb. Sawant. Konkan Krishi Vidyapeeth., Dapoli, Ratnagiri, Maharasthra. (Unpublished) 1985.
13. Joshi RG, Kadrekar SB. Fertility status of coastal salt affected soils of Maharashtra. Journal of Indian Society of Coastal agriculture Research. 1987; 5(1):111-116.
14. Kadrekar SB, Chavan AS, Chavan KN, Sahu RK, Ingale BV, Joshi RG. Summary of Research on Coastal Saline Soils of Maharashtra. A brochure (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth., Dapoli, Ratnagiri, Maharasthra) 1981.
15. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. Proceedings of Soil Science Society of America, 1978; 42:421-428.
16. Mahopatra AR, Kibe MM. Effect of rainfall on the physico-chemical properties of basaltic soils of

Maharashtra State. Madras Agriculture Journal. 1973; 60(3):164-169.
17. Meena HB, Sharma RS, Rawat RS. Status of Macro and Micronutrients in some soils of Tonk district of Rajasthan. Journal of the Indian Society of Soil Science. 2006; 54(4):508-512.
18. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate *Circ. U. S. Dept. Agric*. 1954, 939.
19. Panse VG, Sukhatme PV. Statistical methods for agricultural workers, ICAR, New Delhi, 1967.
20. Patil PL, Kuligod VB, Gundlur SS, Katti Jahnavi, Nagral IN, Shikra Shett P *et al*. Soil fertility mapping in Dindur subwatershed of Karnataka for site specific recommendations. Journal of Indian Society of Soil Science. 2016; 64(4):381-390.
21. Patil RB, Jagdish Prasad. Characteristics and classification of some *Sal* (*Shorea robusta*) supporting soils in Dindori district of Madhya Pradesh. Journal of the Indian Society of Soil Science. 2004; 52:119-124.
22. Pillai MY, Natarajan A. Characterization and classification of dominant soils of parts of Garakahalli watershed using remote sensing technique. Mysore Journal of Agricultural Sciences. 2004; 38:193-200.
23. Prasunarani P, Pillai RN, Bhanuprasad V, Subbaiah GV. Nutrient status of some red and associated soils of Nellore district under Somasila project in Andhra Pradesh. The Andhra Agriculture Journal. 1992; 39:1-5.
24. Sanjeev KC, Karan Singh, Tripathi D, Bandari AR, Morphology, genesis and classification of soils from two important land uses in outer Himalayas. Journal of the Indian Society of Soil Science. 2005; 53:394-398.
25. Sharma MP, Bali SV. Long term effect of different cropping system on physico-chemical properties and soil fertility. Journal of the Indian Society of Soil Science. 2000; 48(1):183.
26. Subbiah BV, Asija GL. A rapid procedure for the estimation of available Nitrogen in soil. Current Science. 1956; 25(8):259-260.
27. Thangaswamy A, Naidu MVS, Ramavatharam N, Raghava Reddy C. Characterization, classification and evaluation of soil resources in Sivagiri micro-watershed of Chittoor district in Andhra Pradesh for sustainable land use planning. Journal of the Indian Society of Soil Science. 2005; 53:11-21.
28. Vaidya KP. Forms of manganese and their distribution in rice soil profiles in Konkan. *M.Sc. (Agri.) Thesis submitted to* Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth., Dapoli, Ratnagiri, Maharashtra, 1988.
29. Wani SP. Taking soil science to farmers door steps through community watershed managentmnt. Journal of the Indian Society of Soil Science. 2008; 56:367-377.
30. Yadav AN. Characterisation of soils from sapota garden at Dahanu (Thane). *M.Sc. (Agri.) Thesis submitted to* Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharasthra. (Unpublished) 1988.