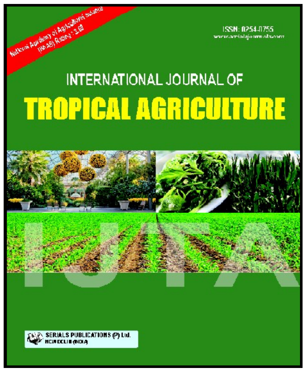

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Evaluation of Different Fractions of N and S in Soils of Tuljapurtahsil of Osmanabad District

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Abstract: The present investigation was carried out to studyestablishment of correlation between N fractions with soil properties in soils of Tuljapurtahsil of Osmanabad district. For this purpose 180 representative soil samples were collected from 30 villages of Tuljapurtahsil. The collected soil samples were grouped into three orders *viz.*Vertisols, Inceptisols and Entisols. Out of the total surveyed soil samples, 34 per cent samples were grouped under Vertisols while, 47 per cent and 19 per cent samples were grouped under Inceptisols and Entisols, respectively and orderwiseanaysis was carried out. In chemical analysis, the soils under study area were alkaline in reaction, safe in limit of electrical conductivity and moderately calcareous to calcareous in nature. The organic carbon content in soils was found low to medium. The soils were found to be low in all the fractions of N *viz.* total N, available N, total hydrolysable N, amino acid N, acid insoluble N, ammonical N and nitrate N and S *viz.* total S, available S, organic S, water soluble S and non-sulphate S.

Key words: N fractions, S fractions, soil properties, Vertisols, Inceptisols and Entisols.

INTRODUCTION

Osmanabad district is located between 18° 28′ to19° 28′ North altitude and 76° 25′ to 77° 25′ East latitude. The geographical area of the district is 7512.40 sq. km. Osmanabad district is the South western part of Marathwada region of Maharashtra state with annual rainfall 769 mm. Maximum and minimum temperature of this district is 43.3°C and 11.9°C, respectively. The elevation is 725-750 m from mean sea level and which comes under Central Maharashtra Plateau Agro-climatic Zone and Semi- arid region. Osmanabad district comprises 8 tahsils, out of theseTuljapurtahsil is considered for the study. The chemical characteristics like, pH, EC, organic carbon and calcium carbonate are important as these affect on availability of nutrients in soil and thereby on crop growth and production. The soil must supply the nutrients that are essential for plant growth and necessary component of human and animal food for sustainable agriculture. The total nitrogen in soil generally varies from 0.02 to 0.44 percent and its percent of clayey soil of Maharashtra is 0.045. The total nitrogen content of the soil depends on several factors like soil type, texture, soil pH, soil Ec, climate, topography, vegetation, and fertilizer management. Nitrogen in soil exists in two major forms i.e. organic and inorganic nitrogen. 98 percent total nitrogen is present in the organic form and only about 2 percent in inorganic form. The inorganic form is liable to be lost through different types of losses like run off, ammonia volatization, leaching, denitrification and fixation by clay minerals. The organic form of nitrogen, mainly the hydrolysable form is slowly mineralized and is transformed to minerals nitrogen through ammonization, ammonificatin and nitrification processes and made available to crops.

Nitrogen is necessary for life however, it is ironic that more than 99 percent of the N exists as N_2 in the atmosphere and is not available to > 99 percent of living organisms. Nitrogen is the most important mineral nutrient for crop production and its adequate supply in the soil in different forms, which roots can take up is essential for high yields. Until recent times, specialized abilities of certain types of microbes living in the soil and lightning strikes are the only ways to convert N_2 molecules to reactive N forms (the process is called fixation) which made their way from the environment into living organisms. Plants turn this fixed N into organic nitrogen – the form combined with carbon (C) in a wide variety of molecules essential both to plants and animals that will eat them. The N cycle gets completed through the process of denitrification, in which organisms use reactive forms of N such as nitrate as their energy source and return N_2 molecules to the atmosphere (Singh and Singh, 2009). Organic N forms can be fractionated into amino acid, amino sugars, hydrolysable NH_4-N, unidentified and non hydrolysable-N. Out of these, amino acid and amino sugars are of microbial origin and influenced by changes in microbial activity. Trees may differentially influence organic fractions of N in soil and also losses from applied urea. Crops are reported to display preference for specific N fraction to meet their N requirement *e.g.* pearl millet for amino acid and hydrolysable NH_4, while rice and wheat for amino acid and amino sugars. Therefore, it is hypothesized that in desirable agroforestry systems companion tree species shall enrich N fraction preferred by companion crops, and reduce delay period of nitrification. (Burman *et al.,* 2002)

In the mineral soils of arid and semi-arid regions, textural classification, pH and calcium carbonate have been reported to influence the sulphur supplying capacity of the soils.

Sulphur present in the soil, added through fertilizers undergoes chemical to transformation and ultimately changes into sulphate before it can ranges from less than 20 to several thousand ppm but in most cases within 50-500 ppm. Sulphur in soils is mostly present in organic form combines with carbon, sulphur and nitrogen of the soil. Sulphur is an essential element, becoming deficient due to continuous use of sulphur free fertilizers, high yielding crops, varieties, intensive cropping with high sulphur requiring crops. Several soil factors influence the availability of sulphur and hence the status of different forms of sulphur in soil varies widely with soil type. A knowledge of different forms of sulphur and C: N: S ratios throughout the zone of root penetration is essential in improving sulphur nutrition of crops. (Rai *et al.,*2010).

Distribution of different sulphur forms at various soil depths decides the sulphursupplying power of soil by influencing its release and dynamics in soil particularly where sulphur is added as a carrier. Knowledge of the relative distribution of sulphur at different soil depths may be helpful in formulating a sound fertilizer programme in realizing higher economic productivity under long-term fertilizer use in a cropping system (Setia and Sharma 2005).

The present study is undertaken on "Study of Different fractions of N and Sin Soils of Tuljapurtahsil of Osmanabad District" with following objective: To estimate different nitrogen and sulphur fractions from soils.

MATERIALS AND METHODS

Geography and climate of Osmanabad district, Soils of Osmanabad district, Selection of site or location, Collection of soil samples, Preparation of soil samples

Chemical Properties of Soil

Soil pH, EC, Organic carbon, Calcium carbonate.

Nitrogen Fractions in Soils

Available nitrogen, Total nitrogen, Total hydrolysable nitrogen, Amino acid nitrogen, Acid insoluble nitrogen, Ammonical nitrogen, Nitrate nitrogen

Materials: Geography and Climate of Osmanabad District

Osmanabad district is located between 18° 28′ to19° 28′ North altitude and 76° 25′ to 77° 25′ East latitude. The geographical area of the district is 7512.40 sq. km. Osmanabad district is the South western part of Marathwada region of Maharashtra state. Annual rainfall is 769 mm. Maximum and minimum temperature of this district is 43.3°C and 11.9°C, respectively. The elevation is 725-750 m from mean sea level and which comes under Central Maharashtra Plateau Agro-climatic Zone and Semi- arid Region.

Soils of Osmanabad District

Soils of Osmanabad district mostly belongs to order Vertisols, Inceptisols and Entisols. The soils were varied in colour due to presence of different types of minerals like plagioclase, augite, calcite, dolomite, magnetite *etc*. The soils in the area vary widely in both texture and depth. The soils of the area are rough and rocky largely consisting of basalt. Thin deposits of fertile black soil are found in the northern part and in the South at the western region. Most of the land of the district is full of rock and thin layers of soil except Kumbhari, Kilaj, Masala, Hangarga and Kathi where the land consists of rich fertile black cotton soil.

Selection of Site or Location

Tuljapurtahsil consist of 109 villages, out of these 30 villages were selected for this study. The villages were selected randomly in such way that it should cover whole area of the tahsil. The selected villages from Tuljapurtahsil of Osmanabad district were Kakramba, Khandala, Wadgaodev, Kilaj, Horti, Jalkot, Hangarga, Sindhagao, Lohgao,Sindhafal, Masala, Kati, Jalkotwadi, Wadgao, Suratgao, Pinpala, Devkurali, Dhotri, Eatkal, Nilegao, Gujnur, Khumbhari, Nanduri, Vasantvadi, Chivari, Andur Tirthbuduruk, Aapsinga, Kamtha, Mardi for collection of soil samples.

Collection of Soil Samples

In order to study the fertility status of soils from Tuljapurtahsil of Osmanabad district, six soil samples were collected from each village. One hundred and eighty representative surface (0-20 cm) soil samples were collected. The soils were grouped into different orders according to USDA classification.

Preparation of Soil Samples

Soil samples collected from different villages of Tuljapurtahsil were brought to the laboratory, thoroughly mixed, air dried in shade, ground with wooden mortar and pestle and passed through 2 mm sieve. The sieved soil samples were stored in cloth bags/polythene bags with proper labeling for subsequent analysis. All the precautions outlined by

Jackson (1973) were scrupulously followed in order to avoid contamination.

Methodology

The standard methods were followed for determination of physico- chemical properties andforms of N in soils which are given below.

Soil pH

It was determined in soil: water suspension (1:2.5) using glass electrode pH meter (Jackson, 1973).

Electrical conductivity

It was estimated from supernant solution of soil water suspension (1:2.5) by using conductivity bridge (Jackson, 1973).

Organic carbon

Modified method of Walkley and Black (1934) was used for determination of organic carbon.

Calcium carbonate

Free calcium carbonate was determined with rapid titration method as outlined by Piper (1966).

Nitrogen Fractions

Available nitrogen

It was analysed by alkaline potassium permagnate method as suggested by Subbiah and Asija (1956).

Total nitrogen

Total nitrogen from soil samples was estimated by micro kjeldhal method as described by Page *et al.* (1989).

Total hydrolysable nitrogen

It was estimated by steam distillation method as suggested by Bremner (1965).

Amino acid nitrogen

It was estimated by steam distillation method as described by Bremner (1965).

Acid insoluble nitrogen

Itwasanalysed by steam distillation method as described by Bremner (1965).

Ammonical nitrogen

It was evaluated by steam distillation method as suggested by Bremner (1965).

Nitrate nitrogen

It was evaluated by steam distillation method as suggested by Bremner (1965).

Sulphur Fractions

Total sulphur

Total sulphur from soil was estimated in diacid digestion mixture (Chapman and Pratt, 1961). From the diacid extract of soil, the total sulphur was determined by turbidimetric method as described by Chesnin and Yein (1951).

Available sulphur

It was extracted with 0.15 percent $CaCl_2$ and the soluble sulphate sulphur was estimated turbidimetrically on a colorimeter using blue filte on spectrometer at 440 nm. (Wiliam and Steinberg, 1959).

Organic sulphur

Organic suphur was estimated by the procedure described by Evans and Rost (1945).

Non sulphatesulphur

Non sulphatesulphur was determined by substraction of organic sulphur and sulphatesulphur from total sulphur as given by Chesnin and Yein (1951).

Water soluble sulphatesulphur

Water soluble sulphatesulphur was estimated as per the method described by Jackson (1973).

RESULTS AND DISCUSSION

In order to determine the nitrogen and sulphur fractions of the soils from Tuljapurtahsil of Osmanabad district, one hundred and eighty representative surface soil samples were collected from different villages.

The collected soil samples were grouped into three orders. 34 per cent soil samples were grouped under the order Vertisol while, 47 per cent and 19 per cent soil samples were grouped under the order Inceptisol and Entisol, respectively. Soil samples from Tuljapurtahsil of Osmanabad district were analyzed for its chemical properties,nitrogen and sulphur fractions.The results obtained after analysis are presented and discussed under following head.

Chemical Properties in Soils of Tuljapurtahsil

Out of 180 soil samples, 62 samples were grouped under Vertisols, while, 84 and 34 soil samples were placed in Inceptisols and Entisols, respectively. The data on chemical properties of soils from Tuljapurtahsilare presented orderwise categorization of soils (Table 1).

Vertisols

Out of 62 soil samples of Vertisols, 5 samples (8%) were normal and 57 samples (92%) were alkaline in pH. All samples (100%) in Vertisols showed normal range hence these soils were safe for crops.Out of

Table 1

Order wise categorization of soils from Tuljapurtahsil on the basis of chemical properties

Parameter		*Soil orders*								
		Vertisols			*Inceptisols*			*Entisols*		
pH		Acidic (< 6.5)	Neutral (6.5-7.5)	Alkaline (> 7.5)	Acidic (< 6.5)	Neutral (6.5-7.5)	Alkaline (> 7.5)	Acidic (< 6.5)	Neutral (6.5-7.5)	Alkaline (> 7.5)
	%	0	8	92	0	10	90	0	15	85
	No. samples	0	5	57	0	8	76	0	5	29
EC(dSm^{-1})		Safe (< 0.8)	M. safe (0.8-2.5)	Unsafe (> 2.5)	Safe (< 0.8)	M.safe (0.8-2.5)	Unsafe (> 2.5)	Safe (< 0.8)	M.safe (0.8-2.5)	Unsafe (> 2.5)
	%	100	0	0	100	0	0	100	0	0
	No. Samples	62	0	0	84	0	0	34	0	0
Organic carbon (g kg^{-1})		Low (< 5)	Medium (5- 10)	High (> 10)	Low (< 5)	Medium (5- 10)	High (> 10)	Low (< 5)	Medium (5-10)	High (> 10)
	%	32	45	23	32	39	29	44	29	27
	No. samples	20	28	14	27	33	24	15	10	9
$CaCO_3$(g kg^{-1})		N.ca (< 50)	Ca. (50-100)	H.ca (> 100)	N.ca (< 50)	Ca. (50-100)	H.ca (>100)	N.ca (<50)	Ca. (50-100)	H.ca (>100)
	%	45	55	0	37	32	31	68	32	0
	No. samples	27	35	0	31	27	26	23	11	0

N.ca-Non calcareous, Ca.-Calcareous, H.ca-Highly calcareous, M.safe-Marginal safe.

62 samples, 20 samples (32%) were low, 28 samples (45%) were medium and 14 samples (23%) were high in organic carbon. $CaCO_3$content in the soils ranged from 5.0 to 81.0 g kg^{-1} with an average 48.7 g kg^{-1}. Out of 62 samples, 27 samples (45%) were non-calcareous and 35 samples (55%) were calcareous in nature.

Inceptisols

The soil pH varied from 7.0 to 8.9 with an average value of 8.2. It is revealed from the data 10 per cent soils were found neutral in reaction and 90 per cent soils were alkaline in reaction. Data revealed that all the soil samples from inceptisols were safe in EC. Out of 84 samples from Inceptisols, 27 samples were (32%) low, 33 samples (39%) were medium and 24 samples (29%) were high in organic carbon content. Out of 84 soil samples, 31samples were (37%) noncalcareous in nature, 27 samples (32%) were calcareous and remaining 26 samples (31%) were highly calcareous.

Entisols

These soils were varied in pH from 6.1 to 8.9 with a mean value of 8.0. Out of 34 soil samples, 5 samples (15%) were neutral and 29 samples (85%) were alkaline in reaction.All the soil samples in Entisols order were safe, as far EC categorization. Most of soils in Entisols were low to medium in organic carbon content. Out of 34 soil samples, 23 samples (68%) were non- calcareous and remaining 11 samples were (32%) calcareous in nature. Thus, the majority soil samples in Entisols showed non-calcareous in nature.

The data revealed that 92, 90 and 85 per cent soil samples in Vertisols, Inseptisols and Entisols, respectively were alkaline in reaction. These values of pH indicated that most of the soils under study were alkaline in reaction. The alkaline reaction of soil is probably due to the presence of sufficient free lime content and basaltic alluvium parent material rich in alluminosilicates and alkaline earth from which these are derived. Similar findings were also reported by Mali and Raut (2001) that most of the soils of Latur district were alkaline in nature under Vertisols, Inceptisols and Entisols. With regards to soil EC, 100 per cent soil samples showed safe EC for growing crops. The values of EC obtained in the investigation were found within desirable range as proposed by Richard and Cambell (1948). When EC exceeds 4 dSm^{-1}, the present salts become harmful to the crop growth. However, EC values below 1.0 dSm^{-1} was considered as normal. Normal range of EC of soil of Chakur and Shirur- anantpaltahsil were ranged from 0.13 to 0.79 and 0.12 to 0.75 dSm^{-1}, respectively reported by Jagtap (2007).

It was observed that in Vertisol 32, 45 and 23 per cent soil sampleswere low, medium and high in organic carbon content, respectively while, in case of Inceptisols32, 39 and 29 per cent soil samples were low, medium andhigh respectively. With regards to Entisol 44, 29 and 27 soil samples were low, medium and high in organic carbon content, respectively. From the values of organic carbon, it was clearly depicted that the majority of soil samples were low to medium in range. The agro climate and agro ecological unit is very important from standpoint of soil fertility and plant growth. The content of organic carbon in soils depends on the range of precipitation within experimental area, considerable variation in precipitation is observed. The differences in the level of organic carbon in these soils are largely attributed to the pattern of rainfall in the area. In addition, hot and dry climate is directly related with the temperature variation in the region/ecological unit. Organic carbon is also attributed to the variation in decomposition rate. Similar results are also reported by Malewar*et al.* (2004). Majority soils from Vertisols and Inceptisols were calcareous in nature and contribute 56 and 37 per cent while, 68 per cent soils from Entisols were non calcareous. Relative more accumulation of $CaCO_3$ in Vertisols and associated black soils may be partly associated with their recent origin with rich in alkali earth and partly due to calcification process prevalent in this region (Joshi, 2000). Dhage *et al.* (2000) reported that the $CaCO_3$ content in Shevgaontahsil (A.nagar district) was ranged from 11.4 to 161.3 g kg^{-1}. Similar range of $CaCO_3$ (13.0 to 156 g kg^{-1}) was recorded in swell- shrink soils of Vidarbha region (Padole and Mahajan, 2003). Similarly,Waghmare *et al.* (2007) reported that the $CaCO_3$ content in Ausatahsil of Latur district was ranged from 8.80 to 125 g kg^{-1}.

Status of Nitrogen Fractions in Soils of Tuljapurtahsil

The data on total N, available N, total hydrolysable N, amino acid N, acid insoluble N, ammonical N and nitrate N are presented under Vertisols, Inceptisols and Entisols, respectively.

It is seen from the data (Table 2) total N content in Vertisols varied widely from 0.039 to 0.100 per cent with a mean value of 0.069 per cent. In Inceptisols, total N content ranged from 0.025 to 0.089 per cent with an average of 0.058 per cent. However, the total N content in Entisols varied from 0.021 to 0.081 with a mean value of 0.059. Relatively higher total nitrogen content in Vertisols is due to high clay content and lower values of total nitrogen in Inceptisols and Entisols may be associated with different parent material and it's rate of disintegration (Sharma and Mishra 1988) similar results also reported by Kumar *etal.*, (1995) that the total N contents in the soils varied from 0.07 to 0.11 and 0.06 to 0.15 per cent in the surface and subsurface soils, respectively.

From the results, it was observed that the available nitrogen content ranged from 106.60 to 404.50 kg ha^{-1} with an average of 189.01 kg ha^{-1} in Vertisols. In Inceptisols, available N varied from 90.90 to 373.20 kg ha^{-1} with a mean value 192.11 kg ha^{-1}. However, the available N content in Entisols varied from 100.40 to 276.00 kg ha^{-1} with an average value 184.57 kg ha^{-1}. The lower content of available nitrogen in this area was associated with hot and dry climate. Low content of organic matter and low total nitrogen reserve and in term C:N ratio of immobilized forms of nitrogen was reported by Malewar (1995). Similar results also reported by Waghmare and Takankhar (2007) that in soil of Ausa and Nilanga Tahsil of Latur district available N content ranged from 102.2 to 385.7 kg ha^{-1} and 100.3 to 366.9 kg ha^{-1}, respectively.

The mean values for total hydrolysable, amino acid, acid insoluble, ammonical and nitrate nitrogen in all the surface soil samples of Vertisols were recorded 531.18, 244.61, 167.65, 25.16 and 10.48 mg kg^{-1}, respectively. In Inceptisols, the mean values of total hydrolysable, amino acid, acid insoluble, ammonical and nitrate nitrogen recorded were 441.56, 203.09, 141.64, 20.87 and 8.69 mg kg^{-1}, respectively. However, in Entisols the mean values

Table 2
Range and average value of nitrogen fractions in soil

Soil order	*Total N (%)*	*Available N (kg ha^{-1})*	*Total hydrolysable N (mg kg^{-1})*	*Amino acid N (mg kg^{-1})*	*Acid N insoluble (mg kg^{-1})*	*Ammonical N (mg kg^{-1})*	*Nitrate N (mgkg^{1})*
Vertisols	0.039-0.100 (0.069)	106.60-404.50 (189.01)	292.00-750.00 (531.18)	136.50-350.00 (244.61)	90.00-250.00 (167.65)	14.04-36.00 (25.16)	5.85-15.00 (10.48)
Inceptisols	0.025-0.089 (0.058)	90.90-373.20 (192.11)	190.00-672.00 (441.56)	87.50-311.50 (203.09)	60.00-228.50 (141.640	9.00-32.04 (20.87)	3.75-13.35 (8.69)
Entisols	0.021-0.081 (0.059)	100.40-276.00 (184.57)	157.50-633.36 (454.10)	73.50-284.20 (207.57)	52.50-199.50 (140.48)	7.56-29.16 (21.28)	3.15-12.15 (8.86)

fortotal hydrolysable, amino acid, acid insoluble, ammonical and nitrate nitrogen recorded were 454.10, 207.57, 140.48, 21.28 and 8.86 mg kg^{-1}. Vertisols showed higher mean values for total hydrolysable, amino acid, acid insoluble, ammonical and nitrate nitrogen as compared to Inceptisols and Entisols which is partly attributed to higher content of total nitrogen in these soils as compared to other soil groups. Further, higher values of various fractions of nitrogen in Vertisols and Inceptisols may be associated with finer texture of soil and high organic carbon content. These findings are in accordance with the results of Singh and Singh (2007) and Soniya*et al.* (2011).

Status of Sulphur Fractions in Soils of Tuljapurtahsil

The results on various forms of sulphur in these soils such as total, available, organic, water soluble and non-sulphatesulphur showed that total S content in Vertisols varied widely from 300.00 to 2500.00 mg kg^{-1} with a mean value of 1654.38 mg kg^{-1}. In Inceptisols, it was ranged from 370.00 to 1875.00 mg kg^{-1} with an average of 1251.02 mg kg^{-1}. However, in Entisols it was varied from 162.50 to 1585.00 mg kg^{-1} with a mean value of 561.27 mg kg^{-1}. Wide variation in the total S content in these soil orders may be due to greater heterogeneity in content of organic matter and parent material. Comparatively lower amounts of total S in the Entisols might be due to lower content of clay and organic carbon. Dharaknath *et al.* (1995) reported that the total S content in the Vertisols of the Mahrashtra varied from 1125 to 2525 mg kg^{-1} with an average of 1788 mg kg^{-1}. Similar findings were reported by Venkatesh and Satyanarayana (1999) that total S content in the soils of Vertisols of North Karnataka varied from 1120 to 4620 ppm with an average of 2794 ppm. Available sulphur content in Vertisols ranged from 2.00 to 57.75 mg kg^{-1} with an average value of 12.93 mg kg^{-1}. In Inceptisols, it was ranged from 1.25 to 51.25 mg $kg^{-1}$with a mean value of 10.11mg kg^{-1}. However, in Entisols varied from 1.50 to 42.75 mg kg^{-1} with an average of 6.59 mg kg^{-1}. It was low in most of the soils under all the soil order, which might be due to continuous removal of sulphur by crop in intensive cropping system. Ravate (2008) reported that sulphur content in Ausa and Nilangatahsil of Latur district were ranged from 3.62 to 84.61 mg kg^{-1}, respectively.

The mean values for organic sulphur, water soluble sulphur and non-sulphatesulphur in all the surface soil samples of Vertisols were recorded 51.40, 26.59 and 1590.06 mg kg^{-1}, respectively. In Inceptisols, the mean values of organic sulphur, water soluble sulphur and non-sulphatesulpur recorded were 54.54, 25.93 and 1186.36, respectively.In Inceptisols, the mean values of organic sulphur, water soluble sulphur and non-sulphatesulpur recorded were 54.54, 25.93 and 1186.36, respectively. However, in Entisols the mean

Table 3
Range and average value of sulphur fractions in soil

	Total sulphur	*Available sulphur*	*Organic sulphur*	*Water soluble sulphur*	*Non-sulphate sulphur*
Soil order	*mg kg^{-1}*				
Vertisols	300.00-2500.00 (1654.38)	2.00-57.75 (12.93)	18.50-93.75 (51.40)	9.62-52.00 (26.59)	273.00-2416.6 (1590.06)
Inceptisols	370.00-1875.00 (1251.02)	1.25-51.25 (10.11)	15.50-110.25 (54.54)	10.93-45.25 (25.93)	290.88-1828.2 (1186.36)
Entisols	162.50-1585.00 (561.27)	1.50-42.75 (6.59)	26.87-196.25 (95.37)	5.93-68.75 (33.83)	61.25-1521.38 (459.40)

values for organic sulphur, water soluble sulphur and non- sulphatesulphur recorded were 95.37, 33.83 and 459.40, respectively. The highest amount of organic sulphur content in Entisols and lowest organic S content in Vertisols was observed in soils. This variation in organic S content was attributed to variation in soil texture as well as organic carbon content and accumulation of large amount of soil organic matter and clay. These results are corroborated with results of Das, *et al.* (2012) in the soils of Assam and Das *et al.* (2006). Highest amount of water soluble S present in Entisols and lower in Inceptisols. Lower content of this might be due to concomitant leaching loss of sulphate from soil. Similar result reported by Das, *et al.* (2012) and Basumatari *et al.* (2010). Non-sulphate S is mostly made up of SO_4^{2} occluded in and adsorbed on carbonates or insoluble S compounds of Fe and Al in soil which remains unextractable after removal of organic carbon and SO_4-S (Balanagoudar and Satyanarayana, 1990) reported that appreciable quantity of sulphatesulphur was occluded to $CaCO_3$ and adsorbed on clay fraction in the soils of Vertisols and Alfisols of Karnataka.

REFERENCES

Basumatari, A., Das, K. N. and Borkotoki, B. (2010), Interrelationships of sulphur with soil properties and its availability index in some rapeseed-growing Inceptisols of Assam. *J. Indian Soc. Soil Sci.* **58**(4): 394-402.

Burman, U., Praveen-Kumar.and Harsh, L. N. (2002), Single tree influence on organic forms and transformation of nitrogen in arid soils. *J. Indian Soc. Soil Sci.* **50**(2): 151-158.

Bremner, J. M. (1965), In methods of soil analysis (Black, C. A. ed.) part 2, agronomy monograph no. 9, American Society of Agronomy, Madison, Wisconsin.

Chesnin, L. and Yein, C. H. (1951), Turbidimetric determination of available sulphur. *Soil Sci. Soc. America proc.* **15**: 149-151.

Das, I., Ghosh, K., Ray, S.C., Mukhopadhyay, P.K. and Ghosh, S.K. (2006), Status and distribution of sulphurvis-a-vis taxonomic class-wise distribution of sulphur in selected soil series of Inceptisols in West Bengal. *J. Indian Soc. Soil Sci.* **54**(3): 368-371.

Das, K. N., Basumatari, A. and Borkotoki, B. (2012), Forms of sulphur in some rapeseed-growing soils of Assam. *J. Indian Soc. Soil Sci.* **60**(1): 13-19.

Dhage, A. R. Mane, S. R. and Adsule, R. N. (2000), Available micronutrients in the soils of Shevgaontahsil (Ahemadnagar Dist.) in relation to soil characteristics. *J. Maharashtra Agric. Univ.* **25**(1) PP: 97-98.

Jackson, M.L. (1973), Soil Chemical Analysis, Prentice Hall of India, Pvt. Ltd,New Delhi.

Jagtap, V. R. (2007), Physico-chemical characteristics and status of NPK and some micronutrients in soils from Chakur and Shirur-anantpaltahsil of Latur district. *M.Sc. (Agri) thesis submitted to M.K.V. Parbhani.*

Joshi, D. C. (2000), National Symposium Gujarat Agricultural University, Junagarh. *Ext. Sum.* Vol. I. PP: 8-12.

Malewar, G. U., Dhamak, A. L. and Syed Ismail (2004), Variation of DTPA-extractable micronutrients with soil properties in semi-arid part of northern Marathwada in Maharashtra. *Ann. Agric. Res. New Series* **25**(3): 418-421.

Padole, V. R. and Mahajan, S. B. (2000), Potassium fixation characteristics of swell- shrink soils of Vidarbha (Maharashtra). *J. Maharashtra Agric. Univ.,* **25**(2): 134-138.

Rai, A. P., Rai, G. K. and Agrawal, H. P. (2010), Fraction and relationship of sulphur in some profile of Inceptisols in Varanasi district. *J. Indian Agric. Chem.* **43**(3): 163-170.

Raut, P. D. and Mali, C. V. (2003), Total sulphur and it's fractions in relation to pH and organic carbon in different soils of Latur district in Maharashtra. *J.Maharashtra Agric. Univ.,* **28**(1): 109-111.

Ravte, S.S. (2008), Studies on status of available secondary nutrient and micronutrient anions in Ausa and Nilangatahsils of Latur district. *M.Sc.(Agri), Thesis submitted to M.A.U. Parbhani.*

Setia, R. K. and Sharma, K. N. (2005), Effect of long-term differential fertilization on depth-distribution of forms of sulphur and their relationship with sulphur nutrition of wheat under maize-wheat sequence. *J. Indian Soc. Soil Sci.* **53**(1): 91-96.

Singh, B. and Singh, J. P. (2009), Nitrogen- A continuing enigma. *J. Indian Soc. Soil Sci.* **57**(4): 531-535.

Singh, K.K. and Singh, R. (2007), Distribution of Nitrogen and Sulphur forms in soil profiles of Mid-western Uttar Pradesh. *J. Indian Soc. Soil Sci.*, **55**(4): 476-480.

Soniya, K., Thakare and Ingle, S. N. (2011), Effect of nitrate contamination in soils of Jalgaon district. *J. Soils and Crops.* **21**(2): 309-313.

Subbiah, B.V. and Asija, G.L. (1956), Rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci.* **25**: 259-260.

Waghmare,M.S. and Takankhar, V.G. (2007), Status of available nutrients in soils of Nilangatahsil of Latur district. Paper presented in state level seminar on soil health enhancement for food and environmental security, organized by PCISSS, at *Marathwada Agril. Univ. Parbhani. Oct.* 12 and 13, 2007 *Abst. PP* 2.

Walkley, A. and Black, I.A. (1934), An examination of the degtlarelt method for determining soil organic matter proposed modification of the method. *Soil Sci.* **34**: 29-38.

Williams, C. H. and Steinberg, A. (1969), Soil sulphur fraction as chemical indices of available sulphur in some Australian soils.*Australian J. Agric. Res.* **10**: 340-350.