International Journal of Environment and Climate Change

Volume 12, Issue 12, Page 119-126, 2022; Article no.IJECC.93383
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Soil Fertility Status and Correlation of Available Macro and Micronutrients in Warangal District of Telangana State

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i121446

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93383

Original Research Articles

Received 25/08/2022
Accepted 03/11/2022
Published 16/11/2022

ABSTRACT

Fertility status of red and medium black soils and their correlation studies were carried out insoils of Warangal District (R) of Telangana State. All samples in red and medium black soils were neutral to alkaline in reaction and pH values ranged from 7.25 to 8.56 by medium black soilfollowed (6.50 to 7.52) by red soil with mean values of 7.64 in medium black soilfollowed 7.53 in red soil. The EC varies from 0.08 to 1.90 dS m^{-1} in red soil and 0.08 to 2.17 dS m^{-1} in medium black soil.The calcium carbonate ($CaCO_3$) content varies from 0.59 to 1.95% in red soil and 1.69 to 2.92% in medium black soil and maximum mean valuewas recorded in medium black soil (1.69%) followed by red soil (0.69%). Red soils were Loam to Clay loam whereas medium black soils were clay in texture. Organic carbon content ranges from 0.14 to 0.75% in red soil and from 0.50 to 0.79% in medium black soil with an average value of 0.38% in red soil and 0.53% in medium black soil. 81and 45% of

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soils were low, 15 and 55% in medium and none of the soil samples were found higher categoryin OC content in red soil and medium black soils, respectively. Available N, P, K and S content varied from 59 to 201kg ha^{-1}, 14 to 133kg ha^{-1}, 211 to 341kg ha^{-1} and 6.9 to 24.59 mg $kg^{-1}$with mean values of 144 kg ha^{-1}, 56 kg ha^{-1}, 247 kg ha^{-1} and 19.26 mg kg^{-1} in red soils, respectively. In medium black soils available N, P, K and S content varied from 100 to 276 kg ha^{-1}, 21 to 103 kg ha^{-1}, 332 to 450 kg ha^{-1} and 10.50 to 41.40 mg $kg^{-1}$with mean values of 177 kg ha^{-1}, 54 kg ha^{-1}, 398 kg $ha^{-1}$and 27.40 mg kg^{-1}, respectively. In red soils 100% samples were low in available N, 25%low, 32 % medium and 43% higher in available P_2O_5,1% medium and 99% higher in available K_2O and 62% low and 38% medium in available S. In medium black soils 100% samples were low in available N, 22% low, 38% medium and 40% higher in available P_2O_5, 38% medium and 62% samples were higher in available K_2O and 51% low and 49% medium in available S. The DTPA-Zn in 23% samples were deficient in medium black soil. In case of DTPA-Fe in 47 and 90% samples were found deficient in red and medium black soil, respectively. None of the samples in both soil groups were found deficient in Cu and Mn. In case of available-B in 29 and 34% samples were deficient in red and medium black soils, respectively. The data indicated that only 9.2% samples in medium black soil were deficient in case of available Mo. The nutrient index indicated that the red and medium black soils were low, medium and high in available N, P and K, respectively. Deficiency of micronutrients was in the order: Fe > B in red soils, Fe > B >Zn in medium black soils. Available N, P, K, S, Fe, Cu, Zn, Mn, B decreased, whereas Mo increased with increasing pH. Available N and P decreased, whereas K and S increased with increasing EC. Available N, P, K, S, Fe, Cu, Zn, Mn and B increased with increasing level of organic carbon.

Keywords: Red soil; medium black soil; available nutrients; nutrient index; correlation.

1. INTRODUCTION

Role of balanced plant nutrition is well-established for sustainable agricultural production. Present agriculturalsystems are exploitive of nutrients through intensive tillage, monocropping year after year, use of high yielding varieties, imbalanced use of nutrients coupled with limited use of organic manures, less recycling and burning of crop residues, soil erosion, undulated topography and indiscriminate use of irrigation water. Balanced use of organics, fertilizers and bio-fertilizers plays an important role to maintain soil fertility in long run. The availability of macro and micronutrients to plants is influenced by several soil characteristics. Similarly, different cropping systemsare suitable for different soil groups as regards to production and productivity. For understanding the reasons of deficiency of available nutrients in soils, correlation of physico-chemical properties with available macro and micronutrients was needed [1]. Also, detailed study on status of macro and micronutrients in major soil groups of Warangal district in Telangana State had not been undertaken so far. The district has majorily red (41%) and medium black soils (6%) [2]. Hence, present investigation was undertaken to study the status of macro, micronutrients and their relationship with important soil properties in red and medium black soils in Warangal district of Telangana State.

2. MATERIALS AND METHODS

2.1 General Characteristics of Study Area

The study area is located between 17.61 to 18.12N – latitude and 79.47 to 80.04E – longitude with an altitude ranging from 210 to 259 m above mean sea level. The agro-climatic region of Telangana state of India is Southern Plateau and Hills Region; the state is further divided into 3 sub agro-climatic zones and Warangal district comes under Central Telangana Zone. Total geographical area of Warangal district is 2.09 lakh ha. Out of this total area 1.0 lakh ha is Red soil and 0.5 lakh hais black soil. The red soil is found in entire district and black soil is found in some patches surrounded by red soil. The medium black soil is darker with dark grey-brown to dark grayish brown colour with black shades [3]. These soils are non calcareous in nature, no hard pan up to 120 cm depth was found and effective soil depth varies from 30 to 90 cm. Permeability and drainage conditions of these soils are poor. Annual rainfall ranges from 779 to 1213 mm, received mostly from south-west monsoon and maximum temperature varied between 29 and 39^0C and minimum varied between 16 and 25^0C. Predominant crops exist in this districtare cotton, rice, maize, redgram, greengram, mango and chillies.

2.2 Soil Sampling and Analysis

Eighty soil samples (0–15 cm) from eachsoil group of red soil and medium black soil and in all 160 soil samples were collected from different locations randomly. Samples were air-dried, ground in wooden pestle and mortar. These groundsoil samples were passed through 2-mm sieve and stored in properly labeled plastic bags for analysis. Processed soil samples were analyzed for particle size distribution as described by Piper [4]. The dry soil colour, infiltration rate, bulk density, organic carbon(OC), electrical conductivity (EC), pH (1:2 soil water ratio), $CaCO_3$ by rapid titration, available N, P,K and S were determined as per methods described by Soil Survey Staff [5] and Jackson [6]. The available Zn, Fe, Cu and Mn in soil samples were extracted with DTPA (0.005 *M* DTPA + 0.01 *M* $CaCl_2$+ 0.10*M* triethanolamine, pH 7.3) as per method described by Lindsay and Norvell [7]. Concentration of Zn, Fe, Cu and Mn in the DTPA extracts was determined using atomic absorption spectrophotometer. Available Mo was determined by ammonium oxalate method and B was extracted by hot water (boiling)and determinedcolorimetrically [8]. The correlation analysis of data was computed in relation to available major and micronutrients content with different physicochemical properties of the soils as suggested by Panse and Sukhatme [9]. The formula of nutrient index (NI) and classification of available nutrients as low (<1.5), medium (1.5 to 2.5) and high (>2.5) as suggested by Parker et al. [10] was evaluated as follows:

Nutrient index = [(1 × no. of samples in low categories)+ (2 × no. of samples in mediumcategories) + (3 × no. ofsamples in high categories)] / Totalnumber of samples.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties

The soil colour varies from red to yellowish brown in red soil and dark grey to dark grayish brown in medium black soil (Table 1). The bulk density of red soil and medium black soil ranged between 1.61 -1.72 Mg m^{-3}, 1.53-1.69 Mg m^{-3} withmean value 1.68 and 1.57 Mg m^{-3}, respectively. The higher mean value of bulk density was measuredin red soil followed by mediumblack soil. The infiltration rate ranges from 3.8 to 5.6 cm h^{-1} in red soil, 3.2 to 5.1cm h^{-1} in mediumblack soil. Among the soils, infiltration rate was higher inred soil (4.2 cm h^{-1}) followed by medium black soil (3.9 cm h^{-1}).All the samples in redand medium black soil were neutral toalkaline in reaction and pH values ranged from 7.25 to 8.56 in medium black soil followed by 6.50 to 7.52in red soil with mean values of pH were 7.64 in medium black soil and 7.53 in red soil. The higher pH could be due to increase in accumulation of exchangeable sodium and calcium carbonate. The EC varies from 0.08 to 1.90 dS m^{-1} in red soil and 0.08-2.17 dS m^{-1} in medium black soil. The maximum mean values of EC were recorded in medium black soil (0.55dS m-1) followed by red soil (0.47dS m-1). The calcium carbonate ($CaCO_3$) content varies from 0.59-1.95% in red soil and1.69-2.92% in medium black soil. The maximum mean value of $CaCO_3$ was recorded in medium black soil (1.69%) followed by red soil (0.69%). As per rating limit proposed by FAO [8], none of the soil samples were found in calcareous ($CaCO_3$ content < 5%). red soils were Loam to Clay loam in texture, whereas texture of medium black soils are clay.

Organic carbon contents range from 0.14 to 0.75% with an average value of 0.38% in red soil and 0.50 to 0.79% with an average value of 0.53%in medium black soil (Table 1). According to Muhr et al. [11] rating limit, 81and 45% of soils are in low (< 0.50%), 15 and 55% in medium (0.50 to 0.75%) and none of the soil samples were found in higher category (> 0.75%) in OC content in red soil and medium black soils, respectively (Fig. 1, 2). The majority of the samples come under low OC content in these soils may be attributed to the poor vegetation and high rate of organic matter decomposition under hyperthermic temperature regime which leads to extremely high oxidizingconditions. Removal of the surface soil containing high OC due to erosion was responsible for the lower OC. Besides this, due to finer-textured nature these red and black soils contain OC in medium range. The results confirm the finding of Meena et al. [12].

3.2 Available Nitrogen and Effect of Soil Characteristics

Available N content varied from 59 to 201 kg ha^{-1}, with an average value of 144 kg ha^{-1} in red soil and 100 to 276 kg ha^{-1} with an average value of 177 kg ha^{-1} in medium black soil (Table 1). On the basis of the rating as suggestedby Subbiah and Asija [13], the red and mediumblack soils were 100%low (< 280 kg N ha^{-1}) and non of the soil samples comes under medium and low category inavailable N status (Fig. 1,2). A significantand positive correlation of available N was observedwith OC (r = 0.4164).Available N was negativeand non significantly correlatedwith pH (r = -0.1079) and EC (r = -0.2041). (Table 2). This might be due to increasedrate of denitrification at lower values. Similar resultswere also reported by Meena et al. [12].

3.3 Available Phosphorus and Effect of Soil Characteristics

Available P content varied from 14 to 133 kg ha^{-1}, with an average value of 56 kg ha^{-1} of red soil and 21 to 103 kg ha^{-1}, with an average value of 54 kg ha^{-1} in medium black soil (Table 1). On the basis of the limits suggested by Muhr et al. [11], the red soil and medium black soilwere 25 and 23% low (< 29 kg P_2O_5 ha^{-1}) , 32 and 38% medium (29 to 59 kg P_2O_5 ha^{-1}) and 43 and 40% higher (>59 kg P_2O_5 ha^{-1}) in available P_2O_5, respectively (Fig.1, 2). A non significant and positive correlation of available P was observed (Table 2) with OC (r = 0.0318). This relationship might be due to the presence of more than 50% of P in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P-fixation with Al and Fe, thus reduce P adsorption/ fixation [14]. Available P was non significant and negatively correlated with EC (r = -0.1888) and pH (r = -0.0713). This is because at higher pH, calcium precipitates with P as Ca-phosphate and reduce P availability [14]. Similar results were also reported by Meena et al. [12].

3.4 Available Potassium and Effect of Soil Characteristics

Status of available K in the soils ranged from 211 to 341 kg ha^{-1} with an average of 247 kg ha^{-1} in red soil and 332 to 450 kg ha^{-1} with an average value of 398 kg ha^{-1} in medium black soil (Table 1). According to Muhr et al. [11], in red and medium black soilsnone of the soil samples comes under low category(<145 kg K_2O ha^{-1}), only 1 and 38% medium (< 145 -340kg K_2O ha^{-1}), 99 and 62% samples were high (>340 kg K_2O ha^{-1}) in available K_2O, content, respectively (Fig. 1, 2). A non significant and positive correlation of available K was observed (Table 2) with OC (r = 0.1564) and EC (r = 0.2158).This might be due to creation of favourable soil environment with presence of high organic matter. Similar results were also reported by Meena et al. [11]. Available K showed negative and non-significant correlation with pH (r = -0.0690).

3.5 Available Sulphur and Effect of Soil Characteristics

Available S in the studied soils varied from 6.90 to 24.59 kg ha^{-1} with an average value of 19.26 kg ha^{-1}in red soiland10.50 to 41.40 kg ha^{-1} with an averagevalue of 27.40 kg ha^{-1} in medium black soil (Table 1). On the basis of the ratingsuggested by Hariram and Dwivedi [15] as low (<20 kg ha^{-1}), medium (20 to 40 kg ha^{-1}) and high (> 40kg ha^{-1}) for available S in red and medium black soils were 62 and 51% low, 38 and 49% in medium and none of the soil samples were found in high category, respectively (Fig. 1, 2). A significant positive correlation of available S was observed (Table 2) between EC (r = 0.4710) and OC (r = 0.482). This may be due to organic S constitutes the major share of total S present in soil. Available S was negatively and significantly correlated with pH (r = -0.593). The result resembles to the findingsof Hariram and Dwivedi [15].

3.6 Available Micronutrients and Effect of Soil Characteristics

The DTPA-Zn in red and medium black soil varied from 0.51 to 3.53 and 0.28 to 2.65 mg kg^{-1} and corresponding mean values were 1.33 and 1.21 mg kg^{-1}, respectively (Table 1). As per critical limit (< 0.6 mg kg^{-1}) of Zn as suggested by Bansal and Takkar [16] the per cent deficiency of DTPA-Zn were 23 in medium black soil. The availability of Zn increased non significantly (Table 2) with increase in OC (r = 0.1215). The DTPA-Zn was negative and non significantly correlated with pH (r = -0.0158) whereas significantly negatively correlated with EC (r = -0.4337). The results confirm the findings of Sharma et al. [17] and Bhanwaria et al. [18].

The content of DTPA-Fe in soils varied from 0.44 to 20.75 mg kg^{-1} with an average value of 5.35mg kg^{-1} in red soil and 0.49 to 10.22 mg kg^{-1} with an average value of 2.15 mg kg^{-1} in medium black soil (Table 1). Considering the critical limits (> 4.5 mg kg^{-1}) proposed by Lindsay and Norvell [7], 47 and 90% soils were found deficient in red and medium black soils, respectively. The DTPA-Fe had non significant and positive correlation (Table 2) with OC (r = 0.0911) and EC (r = 0.2185) whereas negative and non significant correlation with pH (r =-0.0158). Non-significant and positive correlation was seen with DTPA-Fe and EC. Similar results were also reported by Sharma et al. [17] and Bhanwaria et al. [18].

The DTPA-Cu content in soil samples varied from 0.58 to 4.34 mg kg^{-1} with mean value of 1.66 mg kg^{-1} in red soil and 0.62 to 29.90 mg kg^{-1} with mean value of 4.98 mg kg^{-1}in medium black soil (Table 1). Considering critical limits (< 0.2 mg Cu kg^{-1}) as suggested by Lindsay and Norvell [7], none of the soil samples in both soil groups were found deficient in Cu. The availability of Cu increased non significantly with increase of OC (r = 0.1175) and EC (0.4337) whereas non significantly decreased with increase in pH (r = -0.0507).The result resembles to the findings of Sharma et al. [17] and Bhanwaria et al. [18].

Available Mn in the soil samples varied from 6.41 to 27.52 mg kg^{-1} with mean value of 16.07 mg kg^{-1} in red soil, 6.56 to 42.11 mg kg^{-1} with mean value of 19.07 mg kg^{-1} in medium black soil (Table 1). Considering the critical limits (> 2 mg kg^{-1}) as suggested by Lindsay and Norvell [7], none of the samples in both soil groups were found deficient in Mn. The DTPA-Mn showed non significant and positive correlation with OC (r = 0.0452), whereas non significantly decreased with increasing of pH (r = -0.0158). The results are close conformity with the findings of Sharma et al. [17] and Bhanwaria et al. [18]. Electrical conductivity had significantly positive relationship with DTPA-Mn (r = 0.2941).

The available B content in red and medium black soil varied from 0.29 to 2.10 and 0.48 to 2.88 and corresponding mean values were 1.56 and 1.95 mg kg^{-1}, respectively (Table 1). Considering the critical limits (> 0.52 mg kg^{-1}) as suggested by Lindsay and Norvell [7], 29 and 34 % samples deficient in red and medium black soils, respectively).The DTPA-B showed significant and positive correlation with OC (r = 0.5140), whereas non significantly decreased with increasing of pH (r = -0.4880). The results are close conformity with the findings of Sharma et al. [17] and Bhanwaria et al. [18]. Electrical conductivity had non significantly negative relationship with DTPA-B (r = -0.0320).

Table 1. Soil physical, physico-chemical and chemical properties of soil

S.No	Soil parameters	Red soil		Medium Black soil	
		Range	Mean	Range	Mean
1	Dry Soil colour (Munsell)	2.5YR3.5/6 Red to Yellow	-	10YR2.5/1 dark grey to dark grayish brown	-
2	Soil texture	Loam to Clay loam	-	Clay	-
4	BD (Mg m^{-3})	1.61-1.72	1.68	1.53-1.69	1.57
5	pH	6.50-7.52	7.53	7.25-8.56	7.64
6	Infiltration Rate(cm h^{-1})	3.8-5.6	4.2	3.2-5.1	3.9
7	Ec (dSm^{-1})	0.08-1.90	0.47	0.08-2.17	0.55
8	CaCO3 (%)	0.59-1.95	0.69	1.69-2.92	1.69
9	Oc (%)	0.14-0.75	0.38	0.50-0.79	0.53
10	Available Nitrogen(kg ha^{-1})	59-201	144	100-276	177
11	Available Phosphorus (kg ha^{-1})	14-133	56	21-103	54
12	Available Potassium (kg ha^{-1})	211-341	247	332-450	398
13	Available S (kg ha^{-1})	6.90-24.59	19.26	10.50-41.40	27.40
14	Available Zinc (mg kg^{-1})	0.51-3.53	1.33	0.28-2.65	1.21
15	Available Copper (mg kg^{-1})	0.58-4.34	1.66	0.62-29.90	4.98
16	Available Iron (mg kg^{-1})	0.44-20.75	5.35	0.49-10.22	2.15
17	Available Manganese (mg kg^{-1})	6.41-27.52	16.07	6.56-42.11	19.07
18	Available Molybdenum (mg kg^{-1})	0.26-1.98	0.74	0.10-1.45	0.65
19	Available Boron (mg kg^{-1})	0.29-2.10	1.56	0.48-2.88	1.95

Table 2. Correlation between soil properties and available nutrients

Nutrient	pH	Ec	Oc
N	-0.1079	-0.2041	0.4164*
P	-0.0713	-0.1888	0.0318
K	-0.0690	0.2158	0.1564
S	-0.5930	0.4710	0.4820
Cu	-0.0507	0.4337	0.1175
Zn	-0.0158	-0.4337*	0.1215
Fe	-0.0158	0.2185	0.0911
Mn	-0.0158	0.2941*	0.0452
B	- 0.4880*	-0.0320	0.5140*
Mo	0.8570*	-0.0040	-0.6120*

**Significant at 5% level*

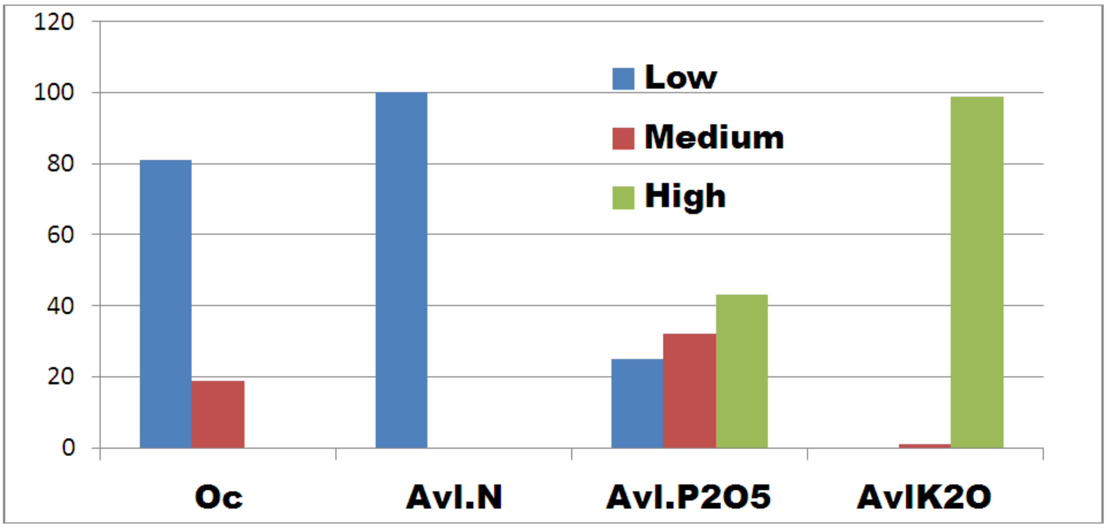

Fig. 1. Status of organic carbon and available nutrients in red soil

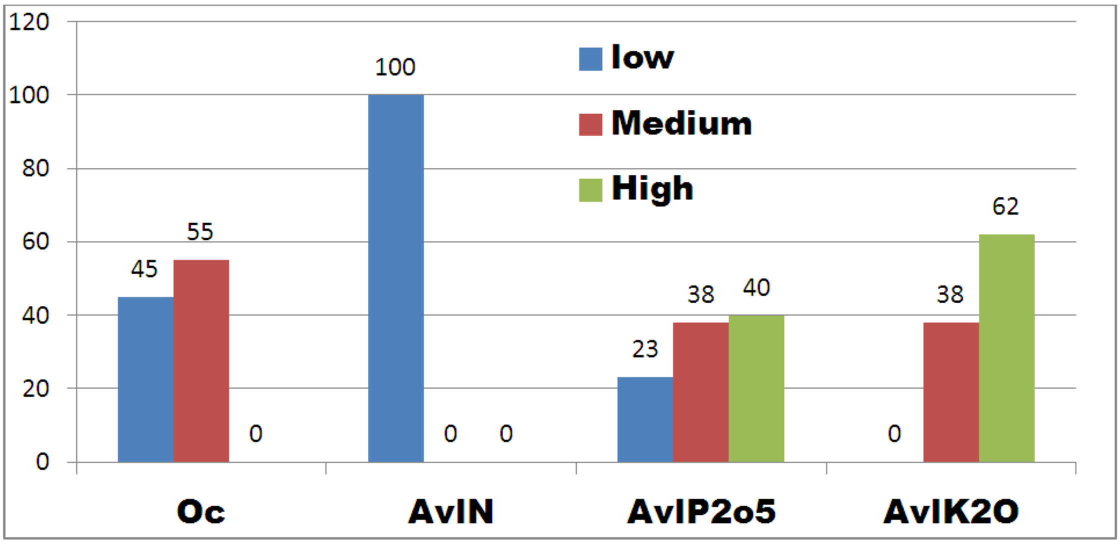

Fig. 2. Status of organic carbon and available nutrients in medium black soil

Table 3. Nutrient index of available nutrients in two soil groups

Available nutrient	Red soil	Black soil
Organic carbon	1.19	1.51
Nitrogen	1.00	1.00
Phosphorus	2.18	2.18
Potassium	2.99	2.63

The available Mo content in red and medium black soil varied from 0.26 to 1.98 and 0.10 to1.45 mg kg^{-1} and corresponding mean values were 0.74 and 0.62 mg kg^{-1}, respectively (Table 1). The data indicated that only 9.2% samples in medium black soil were deficient in available Mo taking critical limit as 0.2 mg kg^{-1} [19]. The DTPA-Mo showed significant and positive correlation with pH (r = 0.8570), whereas non significantly decreased with increasing of Ec (r = -0.0040). The results are close conformity with the findings of Sharma et al. [17] and Bhanwaria et al. [18]. Organic carbon content had significantly negative relationship with DTPA-Mo (r = -0.6120).

3.7 Soil Nutrient Index

Considering concept of soil nutrient index the soils of studied area was found in low category in red soils and medium category in medium black soils of organic carbon content in two soil groups (Table 2). The values of organic carbon content worked out from nutrient index for red and medium black soils were 1.19 and 1.51, respectively. The available nitrogen in red and medium black soil found in lower category, the nutrient index value for available nitrogen in red and medium black soils was 1.0. The available P in red and medium black soil found in medium category, the nutrientindex value for available P in red and medium black soils was 2.18. As per nutrient index value, available K was high in red and medium black soils were 2.99 and 2.63, respectively.

4. CONCLUSIONS

All the samples in red and medium black soil were neutral to alkaline in reaction. In general, the soils were low in soluble salts, organic carbon and calcium carbonate content. The nutrient index indicates that the red and medium black soils were low, medium and high in available N, P and K, respectively. Deficiency of micronutrients was in the order: Fe> B in red soils, Fe >B>Zn in medium black soils. Available N, P, K, S, Fe, Cu, Zn, Mn, B decreased, whereas Mo increased with increasing pH. Available N and P decreased, whereas K and S increased with increasing EC. Available N, P, K, S, Fe, Cu, Zn, Mn and B increased with increasing level of organic carbon.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93383