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Short Communication

Status of Available Major and Micronutrients in Arid Soils of Churu District of Western Rajasthan

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The major and micronutrients govern the fertility of the soils and control the yields of the crops. Soil fertility evaluation of an area or region is an important aspect in context of sustainable agricultural production, particularly for arid region where, sparse and highly variable precipitation, extreme variation in diurnal temperature, high evaporation and low humidity, the alluvial and aeolian landforms have given rise to the variability in soils. Besides, acute moisture deficit, wind erosion is most serious limiting factor limiting biological productivity of the district. The region had extreme fallowing in past even during the good rainfall years. But because of increase in population and its activities lot of area is being brought under cultivation, even dunes of several meters heights are also cultivated. In present era of technological advancement in agriculture it is of immense interest to study the fertility status of soils. Although the widespread deficiencies of major and micronutrients in arid Rajasthan have been reported by Joshi *et al.* (1989) and Gupta *et al*. (2000), the information on availability of major and micronutrients of the study area is meager and mainly based on the widely scattered sampling that is hardly sufficient to bring the variability inherent in the soils of the area. Therefore, a comprehensive study was undertaken to know the fertility status of soils occurring in the district and an attempt was also made to correlate micronutrient content of the soils with other soil properties.

The study area (Churu district) is located between 27^0 24' to 29^0 00' N latitude and 73^0 40' to 75^0 41' E longitude, covering about 13593 km^2 area in the western Rajasthan. The climate of the district is arid, has a mean annual rainfall of 353 mm, high temperature, high evapotranspiration, and high wind speed during summer with dust storms. *Bajra* (*Pennisetum typhoides*), *moong* (*Vigna radiata*), *moth*, sesame (*sesamum indicum*), *guar* (*Cyamopsis tetragonoloba*) and castor (*Ricinus communis*) by and large the common crops being grown in the rainfed conditions in the area. At places wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), mustard (*Bracica* spp.) and gram (*Cicer arietinum*) are grown under irrigated conditions, particularly on alluvial soils of in extreme south-eastern parts of the district.

Random soil samples from 0-30 cm depth were collected from 200 sites representing eight dominant soil series of the district, keeping in view the physiographic characteristics in different cross sections of the area as well as the variation in texture. Processed soil samples were analyzed for particle size distribution (Piper 1950), and other soil characteristics such as, pH, EC, $CaCO_3$ and CEC following standard procedures (Jackson 1973). Organic carbon was determined following Walkley and Black (1934), available phosphorus by Olsen reagent (Olsen *et al.* 1954) and available potassium by flame photometry as described by Jackson (1973). Available iron, manganese, zinc and copper in the soil were extracted with DTPA reagent (Lindsay and Norvell 1978) and were determined with the help of atomic absorption spectrophotometer. Simple correlation coefficient equations were computed relating micronutrient content with other physicochemical properties of the soils as suggested by Panse and Sukhatme (1961).

General Soil Site Characteristics

Some important and relevant physiochemical properties of the different soil series have been presented in table 1. The pH values of soils varied from 7.2 to 9.6 with a pooled mean value of 8.4; within this about 82% samples had pH between 7.9 and 8.5 and 18% samples had pH values above 8.6. This

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Table 1. Physicochemical properties (weighted mean) of the soils

Soil Series	Classification	pH (1:2)	EC (dS m^{-1})	Texture	Silt (%)	Clay (%)	$CaCO_3$ (%)	WHC (%)
Soils associated with sand dunes								
Dune complex	Typic Torripsamments	8.5	0.33	fs	1.3	3.7	0.50	20.5
Very deep brown soils with hummocky relief								
Molasar	Typic Torripsamments	8.3	0.12	fs	4.2	5.0	T	24.3
Soils associated with sandy plain with scattered hummocks								
Chirai	Typic Haplocambids	8.4	0.52	fs-ls	3.2	6.6	0.75	23.7
Very deep yellowish brown soils of sandy plain with hummocky relief								
Modasar	Typic Torripsamments	8.4	0.14	fs	3.4	4.8	0.50	21.8
Soils associated with sandy plain with scattered hummocks								
Devas	Typic Torripsamments	8.5	0.29	ls	5.5	6.7	2.50	24.0
Very deep dark brown medium to moderately fine textured soils								
Sarupdesar	Fluventic Haplocambids	8.3	0.25	sl	5.8	9.0	T	26.0
Very deep dark brown medium to moderately fine textured soils								
Masitawali	Fluventic Haplocambids	8.3	0.14	ls-sl	8.8	11.0	T	27.4
Very deep brown to dark brown medium to moderately fine textured alluvial soils								
Naurangpura	Typic Torrifluvents	8.6	1.09	sl-l-sicl	22.5	19.7	9.0	34.7

fs: fine sand, ls: loamy sand, sl: sandy loam, l: loam, sicl: silty clay loam, T: traces

indicates that soils are in general mildly to moderately alkaline in nature. On the basis of limit suggested by Muhr *et al.* (1963), most of the samples (97%) were found normal (EC < 1.0 dS m^{-1}) and remaining 3% samples were found in the category of soluble salts critical for germination (EC 1.0 to 2.0 dS m^{-1}). The soils vary from sand to loam, clay loam with clay content ranging from 2.5 to 25% and that of silt from 1.6 to 30%. As per FAO classification (FAO 1973), 94% surface soil samples were non-calcareous ($CaCO_3$ content < 5%) and remaining 6% slightly calcareous in nature ($CaCO_3$ content 5-15%).

Available Major Nutrients

The mean value of available major nutrients and their coefficient of variation within the series are presented in table 2. Organic carbon (OC) content in these soils ranged from 0.05 to 0.40% with the pooled mean (average of 200 samples) of 0.13%. All the soil samples rated low in the soil organic carbon content. This also reflects on the poor available nitrogen status of soils. Dhir (1977), Gupta *et al.* (2000) and Mahesh Kumar *et al.* (2009a), also reported the lower content of organic carbon in arid soils of Rajasthan. The low content of organic matter in these soils has been attributed to high temperature, low rainfall, scanty and scrub vegetation cover and sandy texture of the soils. High temperature and good aeration in these soils increased the rate of oxidation of organic matter resulting in the reduction of soil organic carbon content (Meena *et al*. 2006; Singh *et al.* 2007; Mahesh Kumar *et al.* 2009b).

The available phosphorus in different soils series ranged from 7 to 80 kg P_2O_5 ha^{-1} with a pooled mean value of 18.6 kg P_2O_5 ha^{-1}. On the basis of limits suggested by Muhr *et al.* (1963), 67.5% samples contained low (< 11.2 kg P ha^{-1}), 27.5% medium (11.2-25 kg P ha^{-1}) and only 5.5% samples showed high content of available phosphorus (>25 kg P ha^{-1}). Gupta *et al.* (2000) also reported that the available phosphorus content varies widely in arid soils and the mean content in different soil series is less than 20 kg P_2O_5 ha^{-1}, but the alluvial soils contain slightly higher amount. The coarse textured soils of Dunes, Molasar, Modasar, Devas and Chirai are mostly deficient in phosphorus content, whereas the medium to moderately fine textured soils of Naurangpura, Masitawali and Sarupdesar series have comparatively higher amount of available phosphorus. The higher amount of phosphorus in these soils is inherited from the parent material from which the soils have been formed and also may be due to carry-over effect of continuous application of phosphatic fertilizers for the past 2-3 decades (CAZRI 2004; Singh *et al.* 2007). These soils are cultivated in both *rabi* and *kharif* seasons with support of ground water irrigation and have received more fertilizers (urea and DAP) and organic manures. Kenny *et al.* (2002) also reported an increase of available phosphorus due to continuous cultivation in Frazer valley of Canada. The available potassium content varied from 108 kg K_2O ha^{-1} in Dune complex to 837 kg K_2O ha^{-1} in Naurangpura soil series with a pooled mean of 258 kg K_2O ha^{-1}. According to Muhr *et al.* (1963), 17.5%

Table 2. Range and mean values of available major and micronutrients in soils of Churu district

Soil series	OC (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	DTPA-extractable (mg kg^{-1})			
				Fe	Mn	Zn	Cu
Dune complex	0.05-0.12 (0.07)	4.1-18.3 (13.0)	108-189 (156)	4.8-7.0 (5.7)	4.0-10.1 (5.8)	0.18-1.4 (0.76)	0.14-.82 (0.43)
Molasar	0.05-0.22 (0.12)	5.7-52.6 (19.5)	115-660 (228)	3.6-17.2 (7.3)	4.5-17.2 (11.7)	0.24-3.8 (0.87)	0.24-1.8 (0.85)
Chirai	0.06-0.19 (0.11)	5.7-56.3 (19.5)	155-567 (248)	2.7-12.9 (5.7)	4.5-22.6 (9.7)	0.28-4.3 (0.79)	0.16-2.0 (0.71)
Modasar	0.06-0.14 (0.08)	6.4-24.5 (14.8)	135-229 (195)	3.9-9.2 (6.4)	4.2-10.0 (7.2)	0.20-.96 (0.47)	0.14-1.6 (0.42)
Devas	0.07-0.23 (0.15)	5.9-68.9 (24.2)	135-527 (266)	2.8-14.0 (6.4)	4.5-19.0 (9.4)	0.34-1.4 (0.69)	0.18-2.0 (0.96)
Sarupdesar	0.09-0.35 (0.18)	11.4-77.0 (30.9)	121-660 (312)	4.9-32.0 (9.8)	7.0-29.0 (16.4)	0.24-3.4 (0.92)	0.52-2.8 (1.2)
Masitawali	0.12-0.28 (0.17)	9.8-52.2 (20.6)	162-504 (264)	4.5-10.2 (6.8)	6.7-14.2 (9.1)	0.20-1.3 (0.67)	0.20-2.0 (0.59)
Naurangpura	0.09-0.40 (0.20)	22.9-80.0 (53.8)	236-837 (375)	5.8-30.4 (10.9)	6.3-35.0 (17.1)	0.54-4.6 (1.4)	0.56-1.9 (1.1)

*Figures in parenthesis indicate the mean values

Table 3. Range, mean, and coefficient of variation of available micronutrients in soils of Churu district

Soil series	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})	
	Range	CV	Range	CV	Range	CV	Range	CV
Dune complex	4.8-7.0 (5.7)	15.1	4.0-10.1 (5.8)	42.6	0.18-1.4 (0.76)	57.2	0.14-0.82 (0.43)	64.2
Molasar	3.6-17.2 (7.3)	37.5	4.5-17.2 (11.7)	50.2	0.24-3.8 (0.87)	77.6	0.24-1.8 (0.85)	55.1
Chirai	2.7-12.9 (5.7)	46.8	4.5-22.6 (9.7)	34.2	0.28-4.3 (0.79)	90.2	0.16-2.0 (0.71)	71
Modasar	3.9-9.2 (6.4)	29.7	4.2-10.0 (7.2)	28.5	0.20-0.96 (0.47)	54.2	0.14-1.6 (0.42)	107.5
Devas	2.8-14.0 (6.4)	40.2	4.5-19.0 (9.4)	46.2	0.34-1.4 (0.69)	41.3	0.18-2.0 (0.96)	63.5
Sarupdesar	4.9-32.0 (9.8)	47.8	7.0-29.0 (16.4)	38.1	0.24-3.4 (0.92)	64.1	0.52-2.8 (1.2)	43.6
Masitawali	4.5-10.2 (6.8)	25.5	6.7-14.2 (9.1)	23.8	0.20-1.3 (0.67)	51.4	0.20-2.0 (0.59)	90.4
Naurangpura	5.8-30.4 (10.9)	79.9	6.3-35.0 (17.1)	53.2	0.54-4.6 (1.4)	92.9	0.56-1.9 (1.1)	45.7

*Figures in parenthesis indicate the mean values

samples were high (>280 kg K ha^{-1}), 64.5% were medium (135-280 kg K ha^{-1}) and only 18% samples tested low (<135 kg K ha^{-1}) in potassium content. This indicates that the soils of the district have sufficient amount of available potassium to sustain the climatically adapted crops like, *bajra*, *moong*, *moth*, cluster bean, *etc*. provided the recommended dose of potassium is supplied.

Available Micronutrients

The content of Fe, Mn, Zn and Cu varied from 2.7 to 32.0, 4.0 to 35.0, 0.18 to 4.6 and 0.14 to 2.8 mg kg^{-1} with the mean values of 7.3, 11.4, 0.82 and 0.87 mg kg^{-1}, respectively (Table 3). Based on the critical limit for Fe as 4.5 mg kg^{-1} soil suggested by Katyal and Rattan (2003) the soils of the district are well supplied with available iron and only 15% soil sample are deficient in available Fe. The coarse textured soils associated with Dunes, Molasar, Modasar and Chirai series were found to be deficient at places. These results are comparable with the findings of Joshi and Dhir (1981) and Sharma *et al*. (1985), where available Fe in arid soil of western Rajasthan was reported to be between 3.4 and 8.8 mg kg^{-1}.

Taking 2.0 mg kg^{-1} as threshold value for available manganese (Katyal and Rattan 2003) all the soils are adequate in its content. The medium to moderately fine textured soils of Masitawali and Naurangpura series generally had higher content than the other soils. These results are in close agreement with those reported by Joshi and Dhir (1983) and Sharma *et al.* (1985).

In light of 0.6 mg kg^{-1} DTPA extractable Zn as the critical limit (Katyal and Rattan 2003), nearly 38% of the samples showed low test value for Zn (<0.6 mg kg^{-1}), 57% had shown the Zn between 0.6 to 2.0 mg kg^{-1} and only 5% samples had Zn value above 2.0 mg kg^{-1}. The moderately fine textured soils of Naurangpura series recorded the highest mean content for available Zn. Considering the critical limits of 0.20 mg kg^{-1} (Katyal and Rattan 2003) for copper all the soil have sufficient amount of available copper. About 96% of samples have more than 0.20 mg kg^{-1} while 20% of the samples have more than 1.5 mg Cu kg^{-1}. The higher content of Cu was recorded in medium to moderately fine textured soils and lowest in Dunes.

Relationship between Available Micronutrients and Soil Characteristics

The data on simple correlation studies between available micronutrient and soil properties (OC, pH $CaCO_3$ and clay content) have been presented in table 4. The significant and positive correlation of Fe, Mn and Cu with organic carbon content of the soils (r= 0.325, r= 0.409 and r= 0.508, respectively) was obtained which indicates the importance of organic matter in promoting the availability of these micronutrients in the soils. The availability of these ions (Fe, Mn and Cu) increased with the increase in organic matter because organic matter acts as chelating reagent. Similar kinds of relationship between Fe, Mn and Cu with organic carbon were also reported by Sharma and Kolarkar (1983), Sharma *et al.* (1985) and Sharma *et al.* (2003). Available Fe, Mn, Zn and Cu were negatively correlated with $CaCO_3$ (r= -0.101, r= -0.129, r= -0.007, and r= -0.030, respectively). The lower content of Mn in calcium carbonate dominated soils is also reported by Sharma *et al.* (1985), in arid soils of Rajasthan and by Sharma and Motiramani (1964) in soils of Madhya Pradesh. The soil pH was found to be significantly and negatively correlated with available Fe, Mn and Zn (r= -0.317, r= -0.434, and r= - 0.378, respectively), but it did not show any such relationship with Cu. An inverse relationship of pH and $CaCO_3$ with available micronutrients cations has also been reported by Katyal and Agarwala (1982). Significant and positive correlation was also observed between Fe, Mn and Cu with clay content (r= 0.243, r= 0.310, and r= 0.186 respectively).

Table 4. Correlation coefficient (r) values of pH, organic carbon, calcium carbonate and clay with micronutrients

Soil properties	Fe	Mn	Zn	Cu
pH	-0.317	-0.434	-0.378	0.017
OC	0.325*	0.409*	0.134**	0.508*
$CaCO_3$	-0.101	-0.129	-0.007	-0.030
Clay	0.243*	0.310*	0.162**	0.186*

*Significant at 1% level of significance
** Significant at 5% level of significance

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