Distribution of Micronutrients in Soil in Rainfed Production Systems of India

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Distribution of Micronutrients in Soil in Rainfed Production Systems of India

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ABSTRACT: Soil samples at twentyone locations of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) were characterized for micronutrient availability of Zn, Fe, Mn, Cu and B based on profile sampling. These twenty one locations cover agro-ecological regions from 2.3 to 12.3, semi-arid, arid and sub-humid climate, soils of Vertisols, Vertic sub-groups, Alfisols, Inceptisols and Aridisols. Rainfall ranged from 412 to 1378 mm among locations. Various physico-chemical properties of 21 profiles indicated that most of the locations were low in organic carbon showing less than 0.5 per cent. Clay content varied widely among soil types. Low organic matter in these soils was one of the important factors contributing to low soil fertility. Available Zn was below critical limit in Rajkot, Anantapur, Rewa, Akola, Bellary, Bijapur and Solapur, Agra, SK.Nagar, Arjia, Hoshiarpur and Rakh Dhiansar. Iron was deficient in Rajkot, Bellary and Bijapur. Out of 21 centres, 11 (Varanasi, Agra, Phulbani, Rajkot, Rewa, Akola, Bellary, Bijapur, Solapur, Arjia and SK. Nagar) are boron deficient.

Key Words: Micronutrients, soil types, rainfed production systems.

Rainfed agriculture in India extends over 97 m ha consisting nearly 67 per cent of the net cultivated area, contributes 44 per cent of the country's food grain production and supports 40 per cent of the country's human population. Agriculture in rainfed areas is uncertain because of its full dependence on rain and generally poor fertility of soils and degraded soil quality. Phosphorus and potassium are two major essential nutrients required in sufficient quantities for higher crop yields. Alfisols, Vertisols, Aridisols, Entisols and Inceptisols are major soil orders, which occur predominantly in rainfed regions of India. Low levels of organic carbon, weak soil profile development, alkaline to slightly acidic reaction in the surface layer, coarse to medium texture and low biological activity are important characteristics of dry land soils (Singh *et al.*, 2001). Among production constraints, low soil fertility is a major limitation for increasing productivity of dryland crops. Emerging macro nutrient deficiencies in these regions were reported by Srinivasarao *et al.* (2006). Present paper deals with availability and distribution of available micro nutrients in dry land regions of India.

Materials and Methods

Study area

Profile soil samples have been collected from representative soil types under major production systems at 21 different dryland centers of AICRP considering the variables: production system, soil type or soil taxonomy and fertility status (Map 1). Representative soil profile samples from following production systems have been collected: Upland rice, groundnut, soybean, cotton, rabi sorghum, pearl millet, finger millet and maize based systems. Details of production system, location, agro-ecological region, climate, soil type, soil depth, rainfall and length of growing season were reported earlier (Srinivasarao *et al*., 2006). All the four locations under rice based production system viz., Varanasi, Faizabad, Phulbani and Ranchi were sub-humid climate with average rainfall above 1050 mm and length of growing period varying between 150-210 days. Soils under groundnut based production system were deep Vertisols and shallow Alfisols with arid climate and average rainfall is around 600 mm. Soils under soybean production system were

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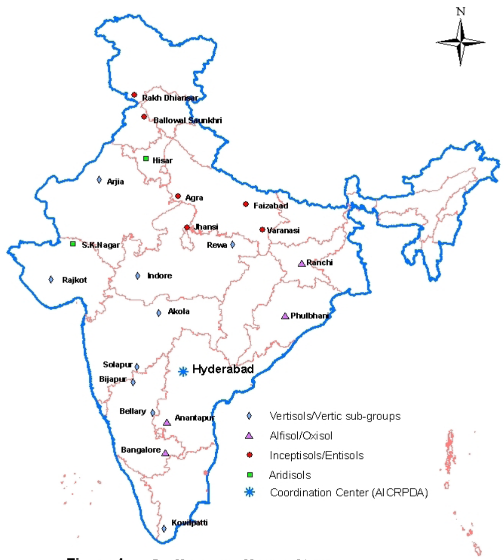

Figure 1: Soil sampling sites
All India Coordinated Research Project for Dryland Agriculture in India

under semi arid and sub-humid climate with mean annual rainfall around 1000 mm. Soils of this production system were deep Vertisols. Cotton based production system includes locations of Akola and Kovilpatti. Both locations represented. semi-arid climate with mean average rainfall of around 800 mm. Rabi sorhum based production system includes Bellary, Bijapur and Solapur. Soils of all these three locations were deep Vertisols and mean rainfall varied from 500 to 723 mm. Pearlmillet based production system covered Agra, Hisar and Sardar Krishinagar with arid to semi arid climate and mean annual rainfall of 412-665 mm. Bangalore under fingermillet production system was under semi arid climate with deep Alfisols and mean annual rainfall 926 mm. Maize based production system covered Arjia, Hoshiarpur and Rakh Dhiansar belonging to semi-arid and sub-humid climate with mean rainfall of 656, 1000 and 1180 mm respectively. Various physico chemical properties of 21 profiles were reported earlier (Srinivasarao *et al.*, 2006) and organic carbon content in surface soils is presented in Figure 2. Available micronutrients from soils were extracted using DTPA reagent (DTPA 0.005 M + TEA 0.1 M + $CaCl_2$ 0.01 M, pH 7.3) and determined for Zn, Fe, Cu and Mn by atomic absorption spectro-photometer (AAS) (Lindsay and Norvell, 1978). Available boron was extracted in hot water and determined by colorimetrically through yellow colour development by Azomethine-H (John *et al.,* 1975) Various relationships between available nutrients and soil properties were done as per the methods suggested in Gomez and Gomez (1984).

Results and Discussion

Micronutrients: Zinc

Profile mean, range and standard deviation (SD) values for 21 profiles under different rainfed production systems are presented in Table 1. Profile mean of available Zn values ranged from 0.38 to 1.74 mg kg^{-1} under rainfed rice production system, from 0.23-0.38 mg kg^{-1} in soils under groundnut based system, 0.44 to 2.93 mg kg^{-1} in soils under soybean based system, 0.58 to 1.85 mg kg^{-1} in soils under cotton based system, 0.22 to 0.86 mg kg^{-1} in soils under rabi sorghum based systems, 0.30 to 2.00 mg kg^{-1} under pearlmillet based system, 0.65 mg kg^{-1} under fingermillet based production system, 0.55 to 0.70 mg kg^{-1} in soils under maize based systems.

Surface soils of Phulbani under rice based production system, Rajkot and Anantapur under groundnut based production system, Rewa under soybean production system, Akola under cotton production system, Bellary, Bijapur and Solapur under rabi sorghum based production system, Agra and SK. Nagar under pearlmillet production system, Arjia, Hosharpur and Rakh Dhiansar under maize based production system showed low available Zn below critical limit of 0.85 mg kg^{-1} (Fig.3). In most of the profiles, surface layers showed higher available Zn and decreased with depth of the profile. Decrease in available Zn with depth was earlier reported by Gupta *et al.* (1984) and Prasad and Gajbhiye (1999). While reporting available Zn status of 10 locations under pulse growing regions of India, Srinivasarao *et al.* reported that nine out of 10 locations were found to be Zn deficient. Most of the soils showing deficiency in available Zn were recorded low in organic carbon content. Because of widespread deficiency in available Zn in soils of semi arid tropics, Rego *et al.* (2005) reported the large scale responses of dryland crops to Zn application to the extent of 70 per cent. Based on soil type, soils of Indore showed the highest available Zn status (2.60 mg kg^{-1}) and the lowest was found in Solapur (0.23 mg kg^{-1}), both belonging to Vertisols.

Iron

Profile mean available Fe content varied from 7.4 to 26.2 mg kg^{-1} under rainfed rice based production system, from 1.9 to 3.7 mg kg^{-1} under groundnut based system, from 10.6-10.7 mg kg^{-1} under soybean based system, 4.7 to 5.9 mg kg^{-1} under cotton based system, 2.6 to 15.5 mg kg^{-1} under rabi sorghum based system, 4.4 to 5.9 mg kg^{-1} under pearl millet based system, 13.6 mg kg^{-1} under finger millet based system and 5.5 to 13.6 mg kg^{-1} under maize based system.

Available Fe status in surface soils (0-15 cm) of Rajkot under groundnut production system, Bellary and Bijapur under rabi sorghum based production system was below critical limit of 4.5 mg kg^{-1}. However, most of the profiles showed available Fe content above critical limit (Fig.4). Based on soil type, available Fe status in surface layer varied from 2.67 (Bellary) to 50.14 mg kg^{-1} (Ranchi). Available Fe content of present soils was within ranges reported earlier by Dhane and Shukla (1995) and Murthy *et al.* (1997).

Copper

Profile mean available copper content varied from 0.75 to 1.09 mg kg^{-1} under rainfed rice production system, 1.3 to 2.3 mg kg^{-1} under groundnut based system, 1.28 to 2.14 mg kg^{-1} under soybean based production system, 1.20 to 2.52 mg kg^{-1} under cotton based system, 1.23 to 2.50 mg kg^{-1} under rabi sorghum based system, 0.53 to 0.93 mg kg^{-1} under pearl millet based system, 1.34 mg kg^{-1} under finger millet based system and 0.66 to 0.98 mg kg^{-1} under maize based system.

Available Cu content was sufficient in all the profiles (Fig.5). In some profiles i.e., Faizabad, Phulbani, Ranchi, Anantapur, Rewa, Akola, Bangalore and Arjia showed decreasing trend with depth.

Manganese

Available Mn content of the profiles mean varied from 5.7 to 56.2 mg kg^{-1} under rainfed rice based production system, 3.4 to11.1 mg kg^{-1} under groundnut based system, 10.8 to 25.3 mg kg^{-1} under soybean based system, 6.8 mg kg^{-1} under cotton based system, 3.4 to 24.1 mg kg^{-1} under rabi sorghum based system, 5.6 to 11.8 mg kg^{-1} under pearl millet based system, 11.1 mg kg^{-1} under finger millet based system and from 7.6 to 13.0 mg kg^{-1} under maize based system. Available Mn status was sufficient in surface layers of all the profiles (Takkar,1996) (Fig.6).

Boron

Boron is one of the important emerging micro nutrient deficiencies in present day agriculture which limits the crop productivity. Even under dryland conditions, out of 21 locations studied, eleven centres showed deficiency in surface soils ($<$0.6 mg kg^{-1}). Surface soils of Varanasi, Agra, Phulbani, Rajkot, Rewa, Akola, Bellary, Bijapur, Solapur, Arjia and SK. Nagar were deficient in available B (Fig. 7). Based on soil type, available B in surface soils varied from 0.19 mg kg^{-1} (Anantapur) to 0.94 mg kg^{-1} (Indore).

Profile mean available B status varied from 0.18 to 0.26 mg kg^{-1} under rainfed rice based system, from 0.25 to 0.33 mg kg^{-1} under groundnut based system, 0.38 to 0.87 mg kg^{-1} under soybean based system, 0.35 to 0.73 mg kg^{-1} under cotton based system, 0.39 to 3.07 mg kg^{-1} under rabi sorghum based system, 0.33 to 0.93 mg kg^{-1} under pearl millet based system, 0.42 mg kg^{-1} under finger millet based system and from 0.24 to 0.49 mg kg^{-1} under maize based system.

Relationship of available micronutrients with soil properties

Soil pH had negative correlation with available micronutrient content in soils. Except with available B, EC had negative correlation with available Zn, Fe, Cu and Mn in most of the profile. $CaCO_3$ also showed negative correlation where as organic carbon content of soils showed positive correlation with available micronutrients. Relationship of micronutrients with various size particles was variable from negative to positive (Takkar, 1996).

Conclusion

As soils were low in organic matter and deficient in micro nutrients in several locations, nutrient management strategies should include improving soil organic matter by regular additions of crop residues or FYM along with supplementation of limiting nutrients for improving productivity levels of dryland crops.

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Table 1: Available micronutrient status in various soil types under diverse rainfed production systems of India

Location	Available micronutrient (mg kg^{-1})				
	Zn	Fe	Cu	Mn	B
Rice based production system					
Varanasi					
Mean	0.62	20.1	1.06	10.1	0.26
Range	0.21-1.10	13.0-46.0	0.69-1.99	4.7-17.5	0.08-0.66
SD	0.33	11.7	0.45	5.0	0.19
Faizabad					
Mean	1.74	7.4	1.05	5.7	0.18
Range	1.66-1.98	2.6-10.5	0.52-1.70	1.9-9.9	0.02-0.58
SD	0.12	3.0	0.46	2.9	0.19
Phulbani					
Mean	0.38	10.0	0.75	56.2	0.22
Range	0.26-0.44	6.8-13.8	0.52-1.01	52.0-59.3	0.15-0.27
SD	0.06	2.3	0.18	2.5	0.04
Ranchi					
Mean	0.72	26.2	1.09	22.0	0.20
Range	0.38-1.20	15.4-50.1	0.62-1.86	15.4-37.5	0.14-0.33
SD	0.27	12.6	0.41	8.5	0.06
Groundnut based production system					
Rajkot					
Mean	0.23	3.7	2.30	3.4	0.33
Range	0.15-0.32	2.1-4.5	0.23-3.29	1.0-6.3	0.08-0.59
SD	0.07	0.9	1.25	1.8	0.16
Anantapur					
Mean	0.38	1.9	1.30	11.1	0.15
Range	0.19-0.77	0.6-6.0	0.97-1.63	5.2-22.0	0.07-0.27
SD	0.21	2.0	0.25	5.9	0.08

Location	Available micronutrient (mg kg^{-1})				
	Zn	Fe	Cu	Mn	B
Soybean based production system					
Indore					
Mean	2.93	10.6	2.14	25.3	0.87
Range	2.60-3.20	8.0-12.2	1.46-2.61	15.7-30.5	0.65-1.06
SD	0.24	1.6	0.35	5.3	0.14
Rewa					
Mean	0.44	10.7	1.28	10.8	0.38
Range	0.15-1.04	6.0-17.6	0.81-2.00	4.2-21.4	0.30-0.54
SD	0.32	4.2	0.40	6.7	0.09
Cotton based production system					
Akola					
Mean	0.58	5.9	2.52	6.8	0.35
Range	0.46-0.86	4.3-8.7	2.24-2.82	5.3-9.5	0.15-0.55
SD	0.14	1.5	0.21	1.8	0.14
Kovilpatti					
Mean	1.85	4.7	1.20	6.8	0.73
Range	1.80-1.94	3.0-5.8	0.90-1.32	6.4-8.2	0.31-1.19
SD	0.05	1.2	0.14	0.7	0.30
Rabi sorghum based production system					
Bellary					
Mean	0.23	2.6	1.23	3.4	1.46
Range	0.12-0.38	1.9-3.8	0.92-1.84	2.7-4.3	0.71-2.23
SD	0.09	0.7	0.34	0.6	0.65
Bijapur					
Mean	0.32	3.9	2.50	5.0	3.07
Range	0.25-0.38	3.7-4.5	1.75-3.10	3.7-6.5	0.76-5.27
SD	0.05	0.3	0.61	1.0	1.94
Solapur					
Mean	0.22	5.1	2.42	6.1	0.39
Range	0.19-0.25	4.6-5.6	2.23-2.58	4.1-10.9	0.21-0.52
SD	0.02	0.4	0.11	2.3	0.12
Jhansi					
Mean	0.86	15.5	2.20	24.1	0.52
Range	0.50-1.90	13.1-21.7	2.00-2.46	20.4-27.6	0.39-0.80
SD	0.49	3.1	0.18	3.3	0.14

Location	Available micronutrient (mg kg^{-1})				
	Zn	Fe	Cu	Mn	B
Pearlmillet based production system					
Agra					
Mean	0.45	5.9	0.84	11.8	0.93
Range	0.33-0.54	4.4-7.7	0.58-1.04	11.0-12.9	0.32-1.40
SD	0.08	1.2	0.17	0.8	0.43
Hisar					
Mean	2.0	4.4	0.93	5.6	0.39
Range	1.8-2.3	2.7-5.5	0.89-1.01	4.4-6.9	0.25-0.64
SD	0.2	0.9	0.05	1.1	0.14
S.K. Nagar					
Mean	0.3	5.8	0.53	8.5	0.33
Range	0.3-0.5	4.9-8.4	0.41-0.62	5.3-9.6	0.31-0.37
SD	0.1	1.3	0.09	1.6	0.03
Fingermillet based production system					
Bangalore					
Mean	0.65	13.6	1.34	11.1	0.42
Range	0.22-0.85	12.5-15.4	0.99-1.63	5.2-22.0	0.33-0.51
SD	0.20	1.0	0.27	5.9	0.06
Maize based production system					
Arjia					
Mean	0.55	6.9	0.98	8.9	0.49
Range	0.46-0.64	4.6-9.2	0.41-1.69	5.0-14.2	0.20-0.78
SD	0.06	2.0	0.49	3.1	0.23
Hoshiarpur					
Mean	0.70	5.5	0.66	7.6	0.24
Range	0.41-0.84	4.8-6.1	0.41-0.94	7.0-8.6	0.02-0.59
SD	0.14	0.5	0.19	0.6	0.21
Rakh Dhiansar					
Mean	0.60	13.3	0.75	13.0	0.36
Range	0.42-0.82	12.2-14.5	0.55-0.99	8.3-19.2	0.20-0.81
SD	0.15	0.9	0.14	4.6	0.22

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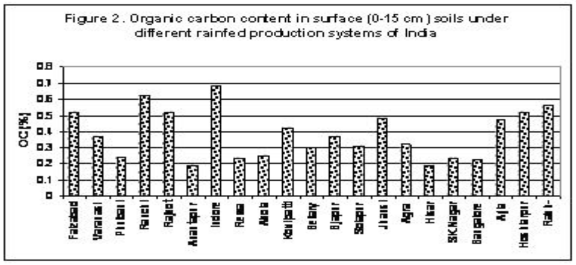
Figure 2. Organic carbon content in surface (0-15 cm) soils under different rainfed production systems of India

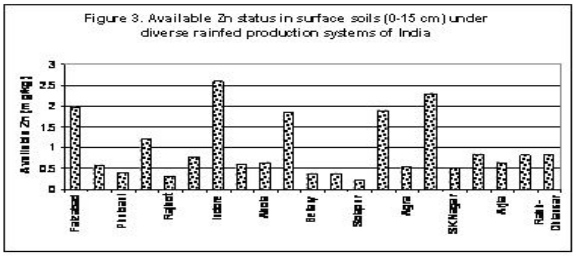
Figure 3. Available Zn status in surface soils (0-15 cm) under diverse rainfed production systems of India

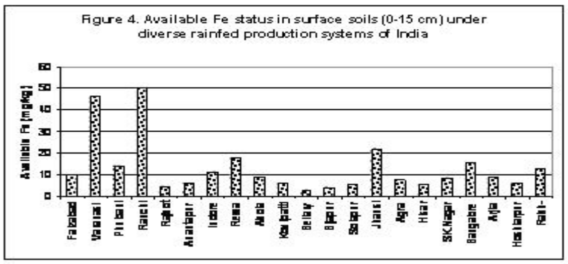
Figure 4. Available Fe status in surface soils (0-15 cm) under diverse rainfed production systems of India

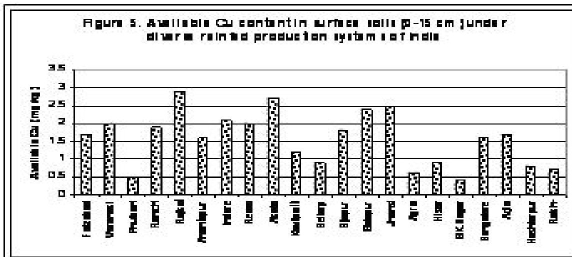
Figure 5. Available Cu content in surface soils (0-15 cm) under diverse rainfed production systems of India

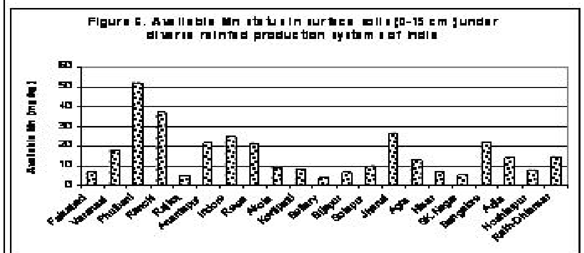
Figure 6. Available Mn status in surface soils (0-15 cm) under diverse rainfed production systems of India

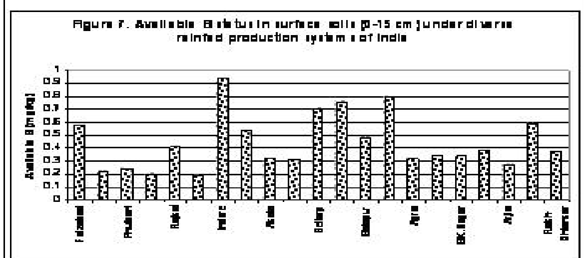
Figure 7. Available B status in surface soils (0-15 cm) under diverse rainfed production systems of India

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