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Kinetic release behavior of DTPA-extractable manganese in soils of different cropping systems and total manganese content associated with soil texture

NARENDER[1], R S MALIK[2] and SHIVAKUMAR L[3]

CCS Haryana Agricultural University, Hisar, Haryana 125 004

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ABSTRACT

In coarse textured alkaline soils of India, manganese deficiency is a emerging in some crops. Understanding the releasing pattern of manganese in soil under different cropping systems and distribution of total manganese content with different soil textures, a field survey and laboratory experiment were conducted in the Department of Soil Science, CCS HAU, Hisar. Results showed that DTPA-manganese content release in different cropping systems varies from soil to soil as well as system to system. In paddy-wheat cropping system the releasing of manganese was up to 40 days and thereafter the release of manganese appear remain constant and in cotton-wheat, sugarcane-sugarcane cropping systems it was up to 50 days, whereas in pearl millet-wheat, pearl millet-mustard and fallow-mustard cropping system, the releasing of manganese was up to 30 days and thereafter the manganese release remain constant in the leachate. Maximum manganese releasing was found up to 10 days and thereafter it gradually decreased in the leachate with increased in incubation interval. Magnitude of inherent release of manganese is governed by many factors, i.e. type and amount of clay, manganese status, alternate wet and dry cycles, pH, moisture content etc. However, manganese associated with different soil textures were found in the order: Silt > Clay > Sand (52.8 > 32.3 > 14.9%) of total soil manganese, respectively. Among all cropping systems, silt and clay particles showed greater affinity towards manganese adsorption may be due to their high surface areas and nutrient retention capacity.

Key words: Adsorption, Cropping system, Leachate, Manganese, Texture

Extension of rice cultivation in coarse textured and alkaline soils of Haryana also leads to widespread deficiency of micronutrients, particularly, manganese in wheat crop which is emerging up year by year. During submergence, solubility of manganese increases appreciably because of its reduction and continuous leaching from upper to lower soil layers during rice cultivation results in its deficiency in the succeeding winter season crops especially wheat (Gangoi 1984). No doubt, manganese requirements of plants are generally low, but with the increasing use of high analysis micronutrient free fertilizers, manganese deficiency is likely to be intensified particularly in light texture soils due to leaching losses and is going to be a major constraint in releasing yield potential of high yielding varieties of wheat (Nayyar *et al.* 1990). Manganese occurs in various forms in soil together with smaller amount associated with organic matter, mechanism of manganese distribution in different fractions helps to know its retention in soil and release behavior of plants (Shuman 1979). Variations in soil properties, however, play a major role in influencing the distribution of manganese among various chemical pools. Due to its cationic nature and solubility of its common salt, leaching losses of manganese are generally high. Therefore, the movement of manganese in the soil determines the magnitude of its losses in drainage water and soil profile.

Manganese an essential micronutrient and toxic element for higher plants, in different cropping systems releasing behaviour and transport mechanisms of soil, it is also helps in the downward movement as well as recycling of manganese to the surface layers (Sharma and Singh 2002). Systematic information regarding distribution of total manganese under different cropping systems in major soils of India in general and Haryana in particular is scant. Purpose of this study was to know the mechanism behavior of manganese distribution in different soil textures to know its retention in soil and release to plants and total manganese content associated with soil texture

MATERIALS AND METHODS

In order to study the releasing behaviour of manganese in soils of different cropping system and total manganese content in different soil fractions, soil samples were collected from 0-15 cm depth from six prominent cropping systems (i.e. paddy-wheat, cotton-wheat, pearl millet-wheat, pearl millet-mustard, fallow-mustard and sugarcane-sugarcane) representing the major soil groups of Haryana. The soil

[1]Research Associate (e mail: narenderhisar@gmail.com), [2]Principal Scientist (e mail: ranbirsinghmalik@gmail.com), [3]Ph D Scholar (e mail: shivalgowda@gmail.com), Department of Soil Science.

samples were air dried under shade, ground and passed through a 2 mm sieve. The basal soil samples were again mixed and stored in cloth bags for further laboratory studies. For this experiment, a 50 g surface soil collected in triplicate from each major cropping systems in the state was taken and incubated without any addition of manganese for 0, 10, 20, 30, 40, 50 and 60 days or till a constant values of manganese appear in the leachate. For the estimation of DTPA extractable-manganese, 50 g soil was taken in 250 ml volumetric flask and 100 ml of DTPA solution was added to it. The flask were tightly corked and kept for shaking on a horizontal electric shaker for 2 hours at a constant temperature of 25ºC. The solution was then filtered using Whatman No. 42 filter paper and stored in 100 ml plastic viols. The manganese content in the extract was determined by using Atomic Absorption Spectrophotometer.

The pH and electrical conductivity (EC) were determined in (1:2) soil: water suspension as per the method described by Richards (1954). Organic carbon (OC) was estimated by wet digestion method (Walkley and Black 1934). Calcium carbonate ($CaCO_3$) was estimated by rapid titration method (Puris' 1930). Mechanical analysis was done using international pipette method (Piper 1966). Available-manganese content in soil samples was determined by DTPA methods of Lindsay and Norvell (1978) by using Atomic Absorption Spectrophotometer, whereas total - manganese content in soil fractions were used as a method prescribed by Page *et al.* (1982) and estimated on Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Selected properties of surface soils of different cropping system

Surface soil samples (0-15 cm) were collected from different cropping systems and analysed for pH, electrical conductivity (EC), organic carbon (OC), calcium carbonate ($CaCO_3$) content and soil texture (Table 1). It revealed that pH of surface soil in all the cropping systems were neutral to alkaline in reaction ranging from 7.26 to 9.05 with a mean of 8.02. The electrical conductivity of soils among all cropping systems varied from 0.43 to 0.70 dS/m with an average of 0.54 dS/m. Organic carbon and calcium carbonate content varied from 0.16 to 0.66% and 0.00 to 0.76% with mean of 0.39 and 0.42%, respectively meaning thereby that the cropping systems were almost low in organic carbon content. Texturally the soils was classified as loamy sand in paddy-wheat, cotton-wheat and pearl millet-wheat cropping system, whereas in pearl millet-mustard, fallow-mustard cropping system were classified as sand and in sugarcane-sugarcane cropping systems it was classified as sandy loam (Table 1).

Kinetic release behavior of available manganese in soil of different cropping system

The releasing behavior of soil manganese was found different in cropping systems (Table 2 and Fig 1). Inherent behavior of manganese is governed by many factors, i.e. type and amount of clay, manganese status, alternate wet and dry cycles, pH, moisture content etc. There are substantial gaps in knowledge of manganese in the bulk soil due to difficulties in studying the typically small, low abundance, low-crystalline, manganese oxides. The results revealed that DTPA-Mn content in paddy-wheat cropping system releasing manganese up to 40 days thereafter the releasing of manganese remains almost constant and in cotton-wheat, sugarcane-sugarcane cropping systems its release become constant in the leachate after 50 days whereas, in pearl millet-wheat, pearl millet-mustard and fallow-mustard cropping systems, the manganese releasing behavior remains constant in the leachate after 30 days and maximum manganese release was found up to 10 days, and thereafter

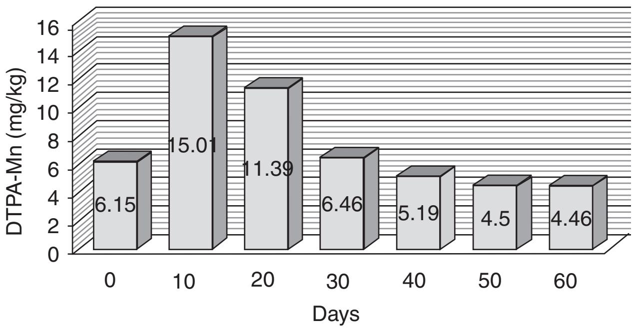

Fig 1 Average periodically release behaviour of manganese in soils of different cropping system

Table 1 Initial physico-chemical characteristics of various cropping system

Cropping system	pH (1:2)	EC (1:2)	OC (%)	$CaCO_3$ (%)	Particle size (%)			Textural class
					Sand	Silt	Clay	
Paddy– Wheat	7.88	0.46	0.66	0.47	73.16	16.98	9.85	Loamy sand
Cotton– Wheat	7.26	0.69	0.46	0.00	78.08	12.98	8.93	Loamy sand
Pearl millet –Wheat	7.36	0.49	0.33	0.30	78.66	14.40	6.93	Loamy sand
Pearl millet– Mustard	9.05	0.43	0.16	0.76	93.06	2.46	4.46	Sand
Fellow–Mustard	8.35	0.70	0.18	0.66	89.55	5.05	5.40	Sand
Sugarcane– Sugarcane	8.25	0.52	0.58	0.35	68.06	19.23	12.70	Sandy loam
Range	7.26 – 9.05	0.43 – 0.70	0.16 – 0.66	0.00 – 0.76	68.06 – 93.06	2.46 – 19.23	4.46 – 12.70	SL-LS
Mean	8.02	0.54	0.39	0.42	80.09	11.85	8.04	LS

Table 2 Periodic release behaviour of manganese under different cropping system

Cropping system	DTPA - manganese (mg/kg)							Mean
	Days							
	0	10	20	30	40	50	60	
Paddy – Wheat	5.28	13.33	10.10	5.86	3.82	3.81	3.78	6.56
Cotton – Wheat	7.32	15.88	14.08	11.26	8.07	5.03	5.00	9.52
Pearl millet – Wheat	7.40	15.18	10.64	2.92	2.89	2.82	2.74	6.37
Pearl millet – Mustard	4.51	14.48	7.96	2.68	2.65	2.64	2.60	5.36
Fallow – Mustard	5.21	15.11	10.73	5.21	5.19	5.18	5.14	7.39
Sugarcane – Sugarcane	7.19	16.10	14.83	10.84	8.56	7.52	7.50	10.36
Mean	6.15	15.01	11.39	6.46	5.19	4.50	4.46	

it gradually decreased in the leachate (Fig 1). Manganese minerals are quite insoluble at both alkaline and neutral pH values regardless of the redox potential (Krauskopf and Bird 2003). It can be precipitated carbonate species where pH was 7.1 or higher (Willow and Cohen 2003).

Total manganese content associated with soil particles

Soil fractions played a vital role on the total manganese content in soil of various cropping systems. The data on total manganese content associated with soil particles (Table 3 and Fig 2), which revealed that maximum total manganese was found associated with silt particles ranging from 238 to 278 mg/kg with mean of 250 mg/kg and constituted 52.78% of total soil manganese. Clay fractions of manganese ranged from 142 to 168 mg/kg with mean of 154 mg/kg, and sand fractions from 52 to 96 mg/kg with mean of 72 mg/kg, and constituted 32.35 and 14.86% of total soil manganese, respectively (Table 3 and Fig 2). Manganese associated with different soil fractions was found in the order of: Silt > Clay > Sand. (Nazif *et al.* 2006, Verma *et al*. 2005) reported that in the cropping systems, silt and clay showed greater affection towards manganese fractions may be due to its higher content in the soils. These shows that the additive effect of organic carbon was found to be more pronounce in manganese oxide.

Hence, the result of this study showed that surface soils

Table 3 Total manganese content (mg/kg) in different soil fraction of various cropping system

Cropping system	Soil fraction			Total manganese
	Sand	Silt	Clay	
Paddy – Wheat	68	245	156	469
Cotton – Wheat	96	278	168	542
Pearl millet– Wheat	52	242	148	442
Pearl millet– Mustard	82	262	156	500
Fallow –Mustard	64	238	142	444
Sugarcane – Sugarcane	66	240	152	458
Range	52-96	238-278	142-168	
Mean	72	250	154	

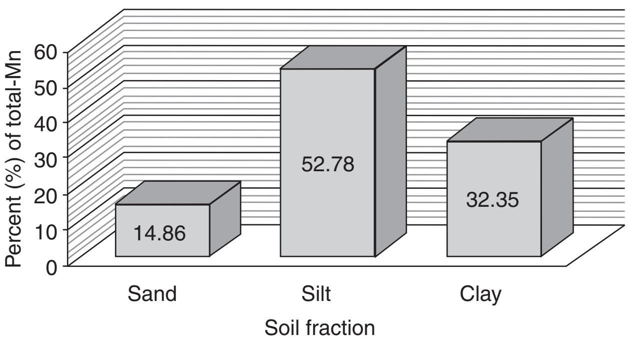

Fig 2 Percent contribution of total manganese content in different soil fraction

of all cropping system were neutral to alkaline in reaction and total manganese content associated with different soil particles was found in the order of: Silt > Clay > Sand, respectively. Silt and Clay particles in all cropping systems showed greater affinity towards Mn adsorption may be due to their high surface areas and nutrient retention capacity. These mechanisms will help to develop Mn fertilization scheduling improve the yield and quality of crops in coarse textured and alkaline soils of India.

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