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Soil Micronutreint status in chromium contaminated soil on influence of organic amendments

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Abstract
To determine the influence of contamination of soil with chromium on micronutrient content in rice plants, A pot experiment was conducted in net house of Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 2015-16. In order to neutralize the effect of the contamination of soil with chromium, organic amendments like FYM and Vermicompost were applied. The effect of soil contamination with chromium depended on the dose of chromium and the type of the neutralizing agent applied. Five levels of chromium *viz*., 0, 20, 40, 60 and 80 ppm with and without vermicompost @ 5 ton ha^{-1} and Farm yard manure @ 10 ton ha^{-1} were taken. Results indicated that micronutrients in post harvest soil of rice decreased with increasing Cr concentration (0, 20, 40, 60, 80 ppm). The micronutrients like copper, zinc, manganese, iron significantly increased with the application of Vermicompost and FYM. Rice crop can withstand up to 80 ppm of chromium with Vermicompost and can tolerate up to 60 ppm with FYM. Hence, toxic effect of Cr on rice crop may be mitigated by improving micronutrient status of soil more effectively with Vermicompost and FYM application.

Keywords: Micronutrients, FYM, vermicompost

Introduction

In recent years, contamination of the environment by Cr, especially hexavalent Cr, has become a major area of concern. Chromium is used on a large scale in many different industries, including metallurgical, electroplating, production of paints and pigments, tanning, wood preservation, Cr chemicals production, and pulp and paper production. At many such sites, leaching and seepage of Cr (VI) from the soils into the groundwater poses a considerable health hazard. Increasing levels of heavy metals in the environment pose serious threats to water quality, soil ecosystem, human health and living organisms (An *et al.*, 2001; Wingenfelder *et al*., 2005; Vinodhini and Narayanan, 2008) [3, 31, 30]. Cr, Ni, Zn, Cu and Cd are considered as priority metals from the point of view of potential health hazards to human. Hexavalent chromium has high toxicity for humans and animals (McBride *et al*., 1994) [18] and commonly interferes with beneficial use of effluents for irrigation and industrial applications. They are also the groundwater contaminants at industrial installations (Mier *et al.*, 2001; Malakootian *et al.*, 2009) [20, 17].
The mobility and toxicity of Cr^{6+} can be reduced by converting it to the reduced state of Cr^{3+} by means of organic matter and inorganic reducing agents in the, soil (Aceves *et al.*, 2007) [1]. These Organic sources may be organic manures, green manure, rural wastes, crop residues, biofertilizers FYM and vermicompost. The positive effect of vermicompost application on crop growth, yield and soil properties is well documented and established (Kumar *et al.*, 2017a; Kumar *et al.*, 2017b; Kumar *et al.*, 2018) [13, 12]. Several organic amendments can improve phytostabilization and the production of plant by decreasing the solubility, leaching and bioavailability of trace elements (Mench *et al.*, 2010; Angelova *et al.*, 2013) [19, 4]. The immobilizing effect of such amendments are thought to act through various complex processes e.g. formation of stable compounds with organic ligands, surface precipitation and ion exchange (Kumpiene *et al.*, 2008; Ahmad *et al.*, 2011a) [15, 2]. Organic amendments may enhance the soil fertility and microbial activity, leading to the amelioration of the soil quality as a whole. These overall modifications generally decrease the mobility and the bioavailability of trace elements, even if temporarily and thus promote the reestablishment of vegetation and increase plant growth (Branzini and Zubillaga, 2012) [7]. The effect of organic amendments on the mobility and the bioavailability of metals (loid) depends on the nature of the organic matter itself, its microbial degradability, its effects on soil chemical and physical proprieties, as well

as on the particular soil type and metals (loid) concerned (Angelova *et al.*, 2013) [4]. However very few comparative studies have been performed so far and the choice of a particular organic amendment in assisted phytostabilization strategies often remain empirical (Hattab *et al.*, 2015) [9]. Immobilization of metals in contaminated soils using amendments is a remediation technique that decreases mobility and phytoavailability of metals in the soils and their uptake by plants (Sabir *et al.*, 2013; Rizwan *et al.*, 2016; Rehman *et al.*, 2017) [28, 26, 25]. In the present study, we investigated the effect of Farm yard manure (FYM) and Vermicompost (VC) applied at different levels on micronutrient status in chromium contaminated soils.

Material Methods

Pot experiment was conducted in Net house of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi taking rice as a test crop in 2016-17 during kharif season, to study the effect of different Cr concentrations (0, 20, 40, 50, 60, 80 ppm) with and without application of FYM and Vermicompost. Processed 10 kg soil was filled in each polythene lined pots. The pots were irrigated up to field capacity and moisture level is maintained. Pots were treated with required amount of Cr through potassium dichromate ($K_2Cr_2O_7$) i.e. Cr (VI), with five different levels like (0, 20, 40, 60, 80 mg/kg soil) and maintained contamination for 15 days. After15 days of application of chromium, the organic farmyard manure (FYM) *i.e.*, as 50gm/10kg soil and vermicompost (25g/10kg soil) applied to the soil and mixed thoroughly. Pots were incubated for 15 days with organic amendments and watered at field capacity and four week old-seedlings were transplanted on august 1st and five seedlings were transplanted in each pot. All the pots received uniform dose of NPK, and irrigation had supplied to maintain field capacity. The crop was grown up to maturity. Micronutrient elements like Zn, Mn, Cu and Fe were studied before and after harvesting as per investigation required.

Table 1: The Properties and Method References

Properties	Method	Reference
Available Fe (ppm)	Atomic Absorption Spectrophotometer	Lindsay and Norwell (1978)
Available Cu (ppm)		
Available Mn (ppm)		
Available Zn (ppm)		

DTPA extractable micronutrients

Available Zn, Mn, Cu and Fe in soil samples were determined by the method of **(**Lindsay and Norvell, 1978) [16]. In this method, 10 g of soil was extracted with 20 mL DTPA extracting solution by shaking for 2 hours on a shaker. The suspension was then filtered and trace elements were determined by atomic absorption spectrophotometer (UNICAM-969) using respective cathode lamps.

Results & Discussions

The present experiment was conducted to study the "Effect of FYM and vermicompost (VC) phytoremediation in chromium contaminated soil by using rice (*Oryza sativa* L.)" in the net house environment, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh.

In this experiment data has been recorded regarding effect of FYM and vermicompost on micro-nutrient content and uptake of chromium of rice grown in chromium contaminated soil. The data recorded were analyzed statistically drawing the valid conclusions. Differential responses exhibited by varying experimental variables were discussed in this chapter as follows.

Effect of FYM and VC on DTPA –extractable micronutrients content in post-harvest chromium contaminated soil

Available Cu

Highest available Cu were recorded with the treatment Cr0+VC (1.87ppm) followed by Cr0+FYM (1.83 ppm) and then Cr0 (1.57 ppm) *i.e.*, non- amended the soil, respectively (Tables 2). At the time of harvest, available Cu increased by 13% in vermicompost amended soil and 10% in FYM amended the soil, as compared to the control Cr0 (Table 2 Fig 1). Cr 20+VC is at par with Cr0+VC.Interaction effect of organic amendments and chromium was found non-significant. The treatment Cr0+VC is at par with Cr20+VC. The available Cu in the soil was generally found lower in range. Upon increasing chromium concentration at first Cu content increase but upon the higher concentration of chromium, the Cu content further decreased. So in order to make Cu available in the soil we are adding organic amendments. These organic amendments will supply all micronutrients. But upon an increase in chromium concentration even in the amended soil, we find a decrease in available Cu. The interaction between chromium and organic amendments found non-significant. Uptake of both macronutrients (e.g., N, P, K) and micronutrients decreased with increase of Cr (VI) in irrigation of paddy and also, decreased uptake of the micronutrients Mn, Fe, Cu, and Zn was detected by Liu *et al*. Copper is known to form strong bond with OM in soil, reducing its availability (Balasoiu *et al.*, 2001). Similar strong correlation between Cu and OM irrespective of soil type was found in our study. Application of organic amendments results in higher Cu sorption on clay mineral surfaces forming organo-mineral complex (Arias *et al.*, 2002; Hizal and Apak, 2006) [5, 10].

Available Fe

A critical perusal data presented under table (Table 2 and Fig 1) showed that available Fe in soil was in medium range. A significant increase was recorded with the application of FYM and Vermicompost. The available Fe ranged from (15.41 to 12.17 ppm). Minimum Fe content present in control maximum in organic amended pots *i.e.*, with the treatment Cr0+VC followed by Cr0+FYM.

FYM improved the availability of N, Fe, and Zn and P in soil similar results reported by Ranganathan and salvseelan (1997) [24]. Vermicompost treated pots have more available Fe than farmyard manure (FYM), this might be due to the reason that more exchangeable cations were found highest in vermicompost followed by FYM amended soil compared to the control (Kundu *et al*. 2007). Cr^{6+} also decreased Fe concentration in spinach (Gopal *et al*., 2009) [11] and sunflower (Gupta *et al*., 2000) [23] the decrease in Fe concentration in leaf tissue in response to Cr toxicity is suggestive of Cr (vi) interference in the availability of Fe, leading to impairment of Fe metabolism (Gopal *et al.*, 2009) [22].

Available Mn

Highest available Mn was recorded with the treatment Cr0+

VC (1.22 ppm) followed by treatment Cr0+FYM (1.06 ppm) and then Cr0 (0.76ppm) i.e., non- amended the soil, respectively (Table 3). At the time of harvest, available Mn increased by 2.7% in vermicompost and 0.9% in FYM soil compared to the control (Table 3). Interaction effect of organic amendments and chromium was found non - significant.

Generally, initial soils are medium in available Mn content in the soil. Upon addition of organic amendments, there was an increase in soil available Mn. But with an increase in chromium concentration, the available K decreased in both amended and non-amended soil. High content of Cr may displace the nutrients from physiological binding sites and consequently decrease uptake and translocation of essential elements. In watermelon plants grown in the presence of Cr, an increase in concentrations of P and Mn and decrease in Fe, Cu, Zn, and S contents in leaves was observed (Dube *et al*., 2003) [6].

Available Zn

Highest available Zn was recorded with the treatment Cr0+VC (1.68 ppm) followed by Cr0+FYM (1.62 ppm) and then Cr0 (1.41ppm) i.e., non- amended the soil, respectively (Tables 3). At the time of harvest, available Zn increased by 13% in Vermicompost amended soil and 10% in FYM amended the soil, as compared to the control Cr0 (Table 3 Fig 2). Cr 20+VC is at par with Cr0+VC.Interaction effect of organic amendments and chromium was found non-significant. The treatment Cr0+VC is at par with Cr20+VC.

The available Zn in the soil was generally found lower in range. Upon increasing chromium concentration at first Zn content increase but upon the higher concentration of chromium, the Zn content further decreased. So in order to make Zn available in the soil we are adding organic amendments. These organic amendments will supply all micronutrients. But upon an increase in chromium concentration even in the amended soil, we find a decrease in available Zn. The interaction between chromium and organic amendments found non -significant. This might be due to high content of Cr may displace the nutrients from physiological binding sites and consequently decrease uptake and translocation of essential elements. The progressively increase in DTPA extractable zinc might be explained by the formation of chelating complex with organic material and also due to the slow mineralization of applied organic matter in soil which after extracting the zinc from the different insoluble compounds, successively formation of ligand complex and after decomposition of organic matter, zinc become slowly unavailable. Similar reports are available elsewhere (Sanchez-Monedero *et al*., 2004; Kizilkaya, 2004) [29, 11].

Table 2: Effect of FYM and Vermicompost on soil micronutrients copper and iron status content in chromium contaminated soil

	Treatments	Copper	Iron
T1	Cr0 + NPK	1.57	13.8
T2	Cr20 + NPK	1.57	13.06
T3	Cr40 + NPK	1.22	11.82
T4	Cr60 + NPK	1.20	11.37
T5	Cr80 + NPK	1.19	12.17
T6	Cr0 + NPK + FYM	1.83	14.67
T7	Cr20 + NPK + FYM	1.76	14.13
T8	Cr40 + NPK + FYM	1.57	12.50
T9	Cr60 + NPK + FYM	1.47	12.99
T10	Cr80 + NPK + FYM	1.22	12.89
T11	Cr0 + NPK + VC	1.87	15.41
T12	Cr20 + NPK + VC	1.73	13.67
T13	Cr40 + NPK + VC	1.60	13.50
T14	Cr60 + NPK + VC	1.50	13.17
T15	Cr80 + NPK + VC	1.38	13.00
	SEM	0.006	0.345
	CD%	0.228	1.666

Table 3: Effect of FYM and vermicompost on soil micronutrients manganese and zinc status content in chromium contaminated soil

	Treatment	Manganese	Zinc
T1	Cr0 + NPK	0.76	1.41
T2	Cr20 + NPK	0.60	1.16
T3	Cr40 + NPK	0.55	1.06
T4	Cr60 + NPK	0.47	0.83
T5	Cr80 + NPK	0.40	0.79
T6	Cr0 + NPK + FYM	1.06	1.62
T7	Cr20 + NPK + FYM	1.04	1.53
T8	Cr40 + NPK + FYM	0.59	1.40
T9	Cr60 + NPK + FYM	0.58	1.23
T10	Cr80 + NPK + FYM	0.50	1.80
T11	Cr0 + NPK + VC	1.22	1.68
T12	Cr20 + NPK + VC	1.12	1.53
T13	Cr40 + NPK + VC	0.91	1.43
T14	Cr60 + NPK + VC	0.74	1.40
T15	Cr80 + NPK + VC	0.72	1.38
	SEM	0.017	0.007
	CD%	0.3727	0.247

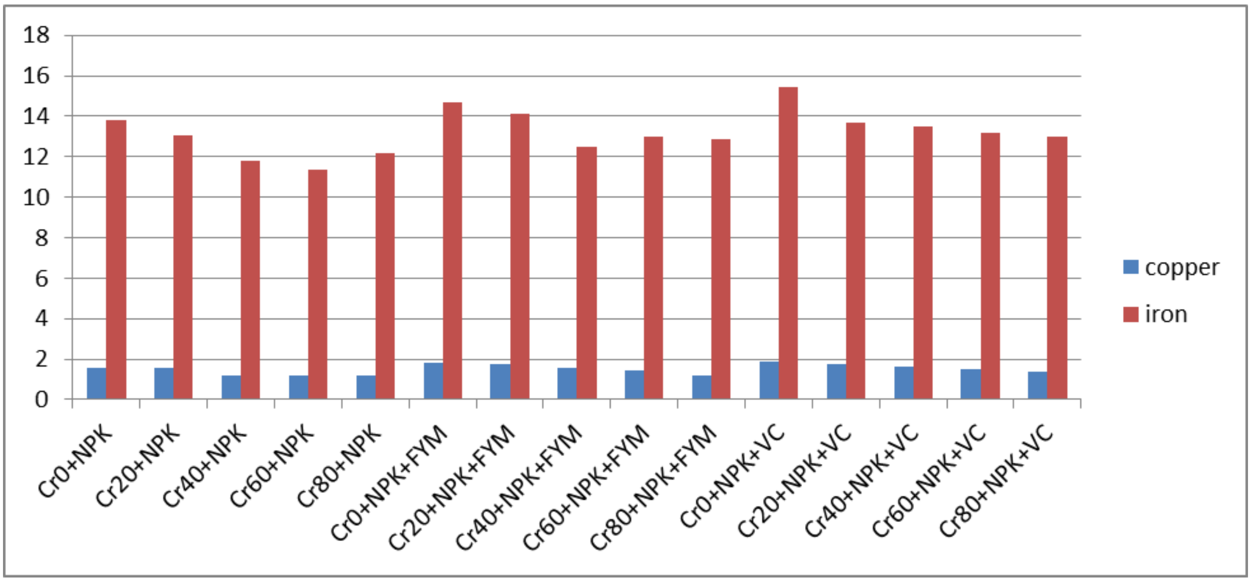

Fig 1: Effect of FYM and Vermicompost on soil micronutrients copper and iron status content in chromium contaminated soil

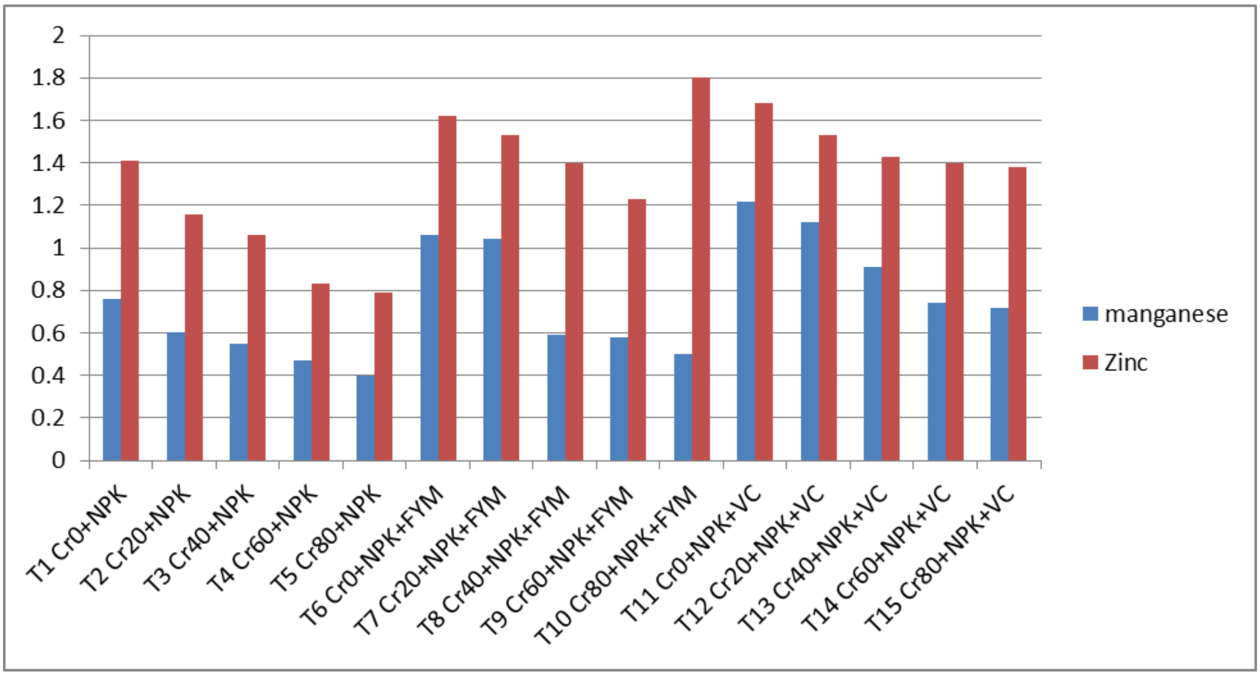

Fig 2: Effect of FYM and vermicompost on soil micronutrients manganese and zinc status content in chromium contaminated soil

Conclusion

The experiment depicted that the micronutrients of post harvest soil changed with application of chromium along with amendments (VC &FYM). The Fe, Mn, Cu, Zn content of post-harvest soil decreased with increase in the levels of chromium i.e., maximum decrease was observed in treatment Cr80. However, the treatment of Cr20 and Cr40 were found statistically at par with treatment Cr0. The addition of these organic amendments has significantly increased available micronutrient content like Fe, Mn, Cu, Zn in soil. The highest micronutrient content was found in Vermicompost treated pots followed by FYM treated pots. Available Fe, Mn, Cu, Zn was recorded highest with the treatment Cr0+VC followed by Cr0+FYM and then Cr0 i.e., not- amended the soil. High content of Cr may displace the nutrients from physiological binding sites and consequently decrease uptake and translocation of essential elements. Vermicompost treated pots have more available micronutrients than Farmyard manure (FYM), this might be due to the reason that more exchangeable cations were found highest in Vermicompost followed by FYM. Organic amendments will improve soil health in terms of OM content and available micronutrients.

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