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Effects of Application of Soil Amendments on Concentrations of Heavy Metals and Quality of Berseem Grown on Soil Irrigated with Sewage Water

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ABSTRACT

The pot culture experiment for two consecutive years was conducted at Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri to study the influence of various soil amendments on concentrations of heavy metals *viz.* Cd, Cr, Ni and Pb in berseem fodder crop. The pots were filled with soil irrigated with sewage water for more than thirty five years. The soil was treated with different amendments *viz.* FYM, gypsum, fly ash and their combinations. All the pots were supplied with recommended dose of chemical fertilizers by maintaining five plants per pot. The experiment was laid out in CRD with eight treatments and three replications. Initial soil properties were pHe 8.38, ECe 4.1 dSm^{-1}, organic carbon 7.6 g kg^{-1}, calcium carbonate 83.8 g kg^{-1}, heavy metals *viz.* Cd, Cr, Ni and Pb were 0.35, 2.60, 2.23, 10.34 mg kg^{-1}, respectively. Total four cuttings of berseem in each year were taken and analyzed for heavy metal concentrations. Two years pooled mean showed that, there was significant effect of different soil amendments on decreasing concentration of cadmium, chromium and lead as compared to control. Pooled mean of both years showed that the combined application of FYM + gypsum + fly ash each @ 10 g kg^{-1} soil (T_8) registered significantly lower concentration of Cd, Cr and Pb in berseem as compared to rest of the treatments, but found at par with treatment (T_5) FYM + gypsum each @ 10 g kg^{-1} soil. The reduction in concentrations of these heavy metals were higher in treatments where FYM was applied either alone or in combination with other amendments followed by gypsum and fly ash. Pooled mean values of two years showed significantly higher crude protein content due to application of FYM + gypsum + fly ash each @10 gkg^{-1} soil (T_8) and at par with treatment T_5. Pooled mean of two years showed numerically higher crude fiber due to treatment T_8 (application of FYM + gypsum + fly ash each @ 10 g kg^{-1} soil) followed by T_5 (application of FYM + gypsum each @ 10 g kg^{-1} soil). Significantly higher Acid Detergent Fiber (ADF) was recorded in T_2 (application of FYM @10 g kg^{-1} soil) followed by T_3 (application of gypsum @ 10 g kg^{-1} soil) treatment.

Key words: ADF, Berseem, Crude protein, Heavy metals, NDF, Sewage water irrigated soil.

INTRODUCTION

Industrial and domestic wastewater reuse is now considered a basic component of integrated water management, especially in countries in the arid and semiarid regions of the world (Lazarova and Asano, 2005). Large-scale urbanization and industrialization is leading to production of huge quantities of effluents all over the world. Industrial and domestic effluents are either used or disposed on land for irrigation purposes that have both pros and cons. Sewage effluents from municipal origin are rich in OM and also contain appreciable amounts of major and micronutrients that are essential for crop growth (Brar *et al*., 2002). Generally, reusing wastewater for irrigation in agricultural cultivation is a common practice in many countries. However, depending on the source of the sewage, wastewater may contain potentially harm-ful components such as heavy metals and pathogens, which can accumulate in soil and biological systems and prove to be hazardous (Rattan *et al*., 2005).

Technologies commonly used for remediation of heavy metal contaminated soils are generally expensive and may cause some additional environmental and health risks like carcinogenicity, kidney failure, asthma and dermatitis (ATSDR, 2005). *In-situ* immobilization of heavy metals with the addition of soil amendments could decrease phytoavailability of these metals. Conventionally, organic matter is used for *in-situ* immobilization of heavy metals in soils which could be more attractive and cost effective option. Other inorganic amendments like gypsum, fly ash could be used to insolubilize heavy metals in calcareous soils. Regarding the use of additives/amendments for reducing the heavy metal pollution in soil and plants, gypsum was observed to decrease heavy metal toxicity (Govindrajan, 2003).

The agricultural land around Sina river in Ahmednagar city of Maharashtra, India, is being irrigated with sewage water accumulated from urban and industrial area and

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utilized for growing various agronomic, horticulture and forage crops, since last 35 years. To study the effects of application of various soil amendments on concentration of heavy metals and quality parameters of berseem crop grown on sewage water irrigated soil, present research work was carried out in a pot culture experiment. The objectives of the experiment was to study the effects of application of different soil amendments on heavy metals concentration and quality parameters of berseem *viz.* crude protein, crude fiber, ADF (Acid detergent fiber) and NDF (Neutral detergent fiber).

MATERIALS AND METHODS

The sewage water from Ahmednagar city and industrial area is discharged into Sina river. This water is being used for irrigation since last thirty five years for the cultivation of vegetables, fodder crops and field crops. Sewage irrigated surface soils was collected from this area in Ahmednagar district of Maharashtra and used as growth media for pot culture experiment during *rabi* 2009-10 and 2010-11. The pot culture experiment was carried out at Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri with berseem as test crop, cultivar Vardan. Soil amendments *i.e*. FYM, gypsum and fly ash were used as alone and in combination for this study. Treatment details were T_1-control, T_2- FYM @ 10 g kg^{-1} soil, T_3- gypsum @ 10 g kg^{-1} soil, T_4- flyash (T_4) @ 10 g kg^{-1} soil, T_5- FYM + gypsum each @ 10 g kg^{-1} soil, T_6- FYM + fly ash each @ 10 g kg^{-1} soil, T_7- gypsum + fly ash each @ 10 g kg^{-1} soil and T_8- FYM + gypsum + fly ash each @ 10 g kg^{-1} soil with RDF for berseem @ 20:80:40 kg ha^{-1} N:P:K to all treatments. Five healthy plants were maintained and total four cuts per year were taken for determination of heavy metals concentration. Oven dried plant samples were grinded and digested in triacid mixture were used for estimation of heavy metals concentration by use of Atomic Absorption Spectrophotometer (Zoroski and Burau, 1977). Quality parameters *viz.* Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were determined by gravimetric method. Crude protein was estimated by multiplying total N x 6.25 (Thimmaiah, 1999). The pot culture experiment was conducted in completely randomized design with three replications. The experimental data were subjected to statistical analysis for assessing the effects due to treatments as per the method prescribed by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Heavy metal concentration

The data pertaining to concentration of cadmium, nickel and lead (Table 1) revealed that there was significant influence of different soil amendments on concentration of these elements in berseem crop. Pooled mean of two years (four cuttings per year) showed that treatment T_8 (application of FYM+gypsum+fly ash each @10g kg^{-1} soil) registered significantly lower concentration of cadmium, nickel and lead as 33.0, 189.5 and 143.6 ppm, respectively in berseem. The reduction in concentration of these heavy metals were higher in treatments where FYM was applied either alone or in combination with others followed by gypsum and fly ash. The concentration of chromium in berseem was observed numerically higher in control treatment. However, the data in Table 1 showed that, treatments comprising application of FYM alone or in combination with gypsum and fly ash recorded lower concentration of chromium as compare to other treatments, indicated application of soil amendments found to be useful in decreasing the concentration of heavy metals.

Significant reduction in nickel concentration in berseem due to application of FYM might be because of low availability of nickel due to formation of insoluble nickel - organic matter complexes (Karaca, 2004). Decrease in lead concentration in berseem due to FYM application alone or in combination with gypsum and fly ash might be the result of increase of soil sorption capacity in the presence of FYM (Blum, 1999). The low absorption of lead by berseem in FYM associated treatments as compared to control might be attributed to its high retention in soil complex system (Berti and Jacobs 1996).

Table 1: Effect of application of soil amendments on total concentration of heavy metals in berseem.

Tr. no.	Treatment	Pooled mean (two years)			
		Total concentration of heavy metals (ppm)			
		Cadmium	Chromium	Nickel	Lead
T_1	Control	67.4	43.9	349.3	270.6
T_2	FYM@10 g kg^{-1} soil	42.3	24.2	228.2	170.3
T_3	Gypsum @10 g kg^{-1} soil	45.4	29.1	242.5	179.6
T_4	Fly ash (FA) @10 g kg^{-1} soil	47.5	31.7	251.8	186.5
T_5	FYM + gypsum each @10 g kg^{-1} soil	37.5	22.8	210.6	155.9
T_6	FYM + FA each @10 g kg^{-1} soil	41.9	26.0	230.2	170.8
T_7	Gypsum + FA each @10 g kg^{-1} soil	43.3	27.7	238.4	177.5
T_8	FYM + gypsum + FA each @10 g kg^{-1} soil	33.0	25.0	189.5	143.6
	S.E. +	0.9	5.9	9.6	6.8
	C.D. (5%)	2.7	NS	28.2	19.9

Table 2: Effect of application of soil amendments on quality parameters of berseem.

Tr. no.	Treatment	Pooled mean (per cent)			
		Crude protein	Crude fiber	ADF	NDF
T_1	Control	10.35	15.69	25.36	42.35
T_2	FYM@10 g kg^{-1} soil	12.77	15.73	34.58	42.28
T_3	Gypsum @10 g kg^{-1} soil	11.73	15.70	32.22	42.95
T_4	Fly ash (FA) @10 g kg^{-1} soil	10.68	15.68	21.19	42.39
T_5	FYM + gypsum @10 g kg^{-1} soil each	15.37	16.26	29.58	41.62
T_6	FYM + FA @10 g kg^{-1} soil each	14.24	16.20	29.97	43.39
T_7	Gypsum + FA @10 g kg^{-1} soil each	12.89	16.18	26.44	44.37
T_8	FYM + gypsum +FA @10 g kg^{-1} soil each	16.13	16.33	30.70	42.75
	S.E. +	0.88	0.10	0.32	0.83
	C.D. (5%)	2.52	NS	1.07	NS

The typical behavior of lead in contaminated soil included high retention (McBride, 1995), low mobility (Sheppard and Thibault, 1992) and low bioavailability (Kadar, 1994 and Alloway, 1990).

Organic matter plays important role in accumulation and transportation of metals through formation of chelates of various stabilities. Humic acid, fulvic acid and humin are the most stable compounds resulting from bio-chemical decomposition of organic matter (Stevenson and Cole, 1999). Stability of organic matter complexes with divalent heavy metal ions varied in the decreasing order of Cu > Ni > Pb > Co > Ca > Zn > Mn (McBride, 1989). At high pH concentration of dissolved organic carbon (DOC) and its complexation with heavy metals was high due to more solubility of organic matter (Sparks, 1995). Different mechanisms for the retention of metals by organic matter include physical adsorption, electrostatic attraction, hydrogen bonding and coordination complexation (Stevenson, 1994), might be the reason for decrease in heavy metals uptake by berseem due application of FYM as compare to control. Elrahman *et al*., (2012) also reported reduced heavy metals concentration in wheat crop due to application of gypsum. Reduction in heavy metals concetration due to fly ash addition might be because of fly ash have maximum active surface area due to its fine particle size, where the heavy metals get adsorbed on them Sankar *et al.* (1997).

Quality parameters

The data pertaining to quality parameters presented in Table 2 revealed that significantly higher crude protein content was observed in berseem due to application of FYM + gypsum + fly ash each @10 g kg^{-1} soil (T_8), over the rest of treatments except T_5 (application of FYM + gypsum each @10 g kg^{-1} soil) and T_6 (application of FYM + FA each @10 g kg^{-1} soil).

Application of combined use of all three amendments improved the nitrogen content of the berseem which is reflected in increase of crude protein content. Plant uptake of NH_4^+-N and NO_3^-N can be improved by increasing the concentration of Ca^{2+} in the root environment (Bailey 1992), which might explain the findings of increased nitrogen and crude protein content. The results are in corroboration with the findings of Daur and Tatar (2013), who observed significant increase in crude protein of berseem due to gypsum application. Data regarding the crude fiber percentage (Table 2) exhibited that, though all the treatments affected crude fiber content, it was non-significant. Pooled mean showed that numerically higher crude fiber (16.33%) was recorded in T_8 (application of FYM + gypsum + fly ash each @ 10 g kg^{-1} soil) followed by T_5 (16.26%). Acid detergent fiber (ADF) content of berseem was significantly higher due to application of FYM @10 gkg^{-1} soil (T_2). Lower ADF was recorded in control treatment (25.36%). Numerically higher NDF was reported due to application of gypsum + fly ash each @10 g Kg^{-1} soil (T_7) followed by application of FYM+ FA each @ 10 g kg^{-1} soil (T_6), which were 44.37 and 43.39 per cent increased over control, respectively. Daur and Tatur (2013) also reported non significant effect on neutral detergent fiber (NDF) of berseem due to gypsum application.

CONCLUSION

The present study concluded that application of FYM + gypsum + fly ash each @ 10 g kg^{-1} soil, on sewage water irrigated soil, significantly decreased the concentration of heavy metals *viz.* Cd, Ni and Pb in berseem crop and improved the quality of berseem fodder for crude protein and ADF. Further elaborative study is necessary.

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