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EFFECT OF LEAD AND FYM ON GROWTH AND YIELD OF WHEAT GROWN IN BLACK CLAY SOILS

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ABSTRACT

A pot experiment on wheat (Triticum aestivum L.) was conducted with seven levels of lead (0, 25, 50, 75, 100, 200 and 300 mg kg^{-1}) and two levels of FYM (0 and 10 t ha^{-1}) in CRD with 3 replications at Indore during 2009-10. The results indicated that the growth and yield parameters (number of tillers per plant, plant height, length of earhead) and grain and straw were yield influenced by Pb and FYM application. The lower level of lead 25 mg kg^{-1} favourably influenced the growth and yield parameters of wheat. There was a decreasing trend in dry matter accumulation in wheat plant with increasing levels of Pb. Application of 25 mg Pb kg^{-1} produced 17.3 % higher grain yield over control. Application of 50 mg Pb kg^{-1} decreased grain yield more than 10 % over control, so the level might be treated as threshold phytotoxic level for experimental soil. The content and uptake of lead in wheat grain and straw increased with increase in Pb levels over control. Wheat had shown a favourable response to FYM application. Lead content in soil increased with increasing its levels in soi over no lead applicationl. FYM addition reduced the toxic effect of Pb to some extent by formation of organo-complexes.

Keywords: Lead, FYM, wheat, growth, lead content, available lead, grain yield, sarol

INTRODUCTION

Due to rapid industrial development and urbanisation during the last two decades in India, disposal of industrial effluents has become a serious problem. The application of industrial and city effluents to land has also been becoming popular during recent years as an alternative means of treatments and disposal (Chhonkar *et al.*, 2000). The unscientific disposal of untreated or under treated effluents has resulted in accumulation of heavy metals in land and water bodies. Cultivated areas under peri-urban agriculture are the worst affected by this problem. The heavy metals accumulating in soil may get entry into human and animal food chain through the crops grown on it. Lead is one of the major chemical pollutants of the environment and is highly toxic to man also. Wheat (*Triticum aestivum* L.) is one of the major rabi crops grown in black soils (Vertisols and associated soils). These soils are predominantly found in Malwa Plateau of Madhya Pradesh and designated as Sarol (*Typic Haplusterts*) and Malikheri (*Fluentic Ustochrepts*) soil series. Most of these areas are facing scarcity of good quality irrigation water and the farmers of the Peri-urban areas are diverted to use untreated sewage and industrial effluents to grow crops and vegetables. Application of such water results in accumulation of heavy metals such as Cd, Pb, Cr, Ni, Co and As in soil and becomes phytotoxic to plants (Sharma *et al.*, 2004, Kharche *et al.*, 2011). The application of organic materials in polluted soil may form complexes with metal ion and reduce their absorption by plants (Mengel and Kirkby, 1987 and Narwal *et al.*, 1992). The present study was, therefore, conducted to find out the effect of Pb and FYM on growth, yield and chemical composition of wheat and nutrient availability in soil.

MATERIALS AND METHODS

A pot experiment was conducted at Salt Affected Soils Project, College of Agriculture, Indore (M.P.), during *rabi* season 2009-10 by growing wheat as test crop. The soil for the pot experiment was collected from surface horizon (0-15 cm) belonging to Sarol soil series from the college farm. Initial properties of experimental soil were: sand 23.2%, silt 24.4 and clay 52.3%, pH 7.5, EC 0.41 dS m^{-1}, organic carbon 4.8 g kg^{-1}, available N 218.9, P 12.5 and K 798 kg ha^{-1}, and DTPA-Fe 17.8, Mn 29.1, Cu 3.9, Zn 0.65 and Pb 1.2 mg kg^{-1}, respectively. Treatments consisted of seven levels of Pb (0, 25, 50, 75, 100, 200 and 300 mg L^{-1}) and two levels of FYM, (0 and 10 t ha^{-1}) replicated three times in a CRD. China clay pots (30 cm x 30 cm) of approximately 20 kg capacity were used for the present study. The pots were lined with polythene to prevent leaching losses of macro-micro nutrients as well as Pb. A piece of PVC pipe (35 cm length) with slant cut at the lower end having holes upto the height of 10 cm was placed in the centre of the pots to facilitate application of irrigation water with upward flux. The pots were filled with 20 kg soil in a polyethylene bag after passing through 2 mm sieve. To ensure uniform application of lead as

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well as basal dose of N, P and K, the total soil was divided into 10 equal parts. FYM (organic carbon 121 g kg^{-1}, N 0.59, P 0.32 and K 0.84 %, total Fe 4064, Mn 396, Cu 72, Zn 186 mg kg^{-1} and Pb nil) was mixed in the soil at the time of pot filling. Application of lead as per the treatment was done through solution. The required amount of water was calculated to bring the field capacity moisture level containing Pb for 2 kg soil. This method was repeated for next nine installment of 2 kg soil. After filling, the polyethylene bags were tide from the top and kept for 7 days to attain equilibrium. After 7 days, pots were left open for 24 hours for proper aeration. Healthy certified seeds (25) of wheat (var. GW 173) were dibbled 4.0 to 5.0 cm deep in each pot and covered with loose soil. Thereafter, a little irrigation was given. Twenty plants were maintained after germination in each pot. The pots were irrigated on the basis of IW: CPE ratio at 20 days interval. The last irrigation was given before 10 days of crop harvesting. The application of N, P_2O_5 and K_2O was done as per recommended dose (100:50:50) as diammonium phosphate, urea and muriate of potash, respectively. Plant samples collected at different growth stages (CRI, tillering, milk and at harvest) of wheat and were subjected to chemical analysis. The resamples were dried in hot air oven at 55ºC. Dried samples were ground in a stainless steel mill and digested in diacid mixture ($HClO_4$:HNO_3::1:2.5) for analysis of Pb. Lead content was determined by using AAS (Perkin-Elmer AA 100). The soil samples were collected from each pot with the help of stainless steel auger after crop harvest. These samples were air dried and prepared in a wooden mortar and pestle to pass through 2 mm sieve. The DTPA extractable Pb (Lindsay and Norvell, 1978) was determined in the soil samples using atomic absorption spectrophotometer. At the time of harvest wheat grain and straw yield per pot was also recorded.

RESULTS AND DISCUSSION

Growth parameters

The growth parameters viz. number of tillers, plant height, length of earhead at harvest stage (Table 1) were invariably affected significantly due to Pb and FYM application. Higher values of these parameters were recorded with the application of 25 mg Pb kg^{-1} level and thereafter a significant decreasing trend in the above said parameters was noticed with increasing levels of Pb. High concentration of lead in soil may however, greatly restrict plant growth (Khan and Khan, 1983). On the contrary various other growth inhibiting and promoting effects of lead in plants have been reported by Brewer (1995). The maximum plant height of wheat (71.0 cm) at harvest was observed by level 25 mg Pb kg^{-1} and showed a non-significant difference with control. The maximum level of Pb (300 mg kg^{-1}) decreased plant height to the tune of 14.8% over control. With low level of Pb (25 mg kg^{-1}), the application of FYM (10 t ha^{-1}) showed favourable influence on plant height. It might be due to the fact that FYM application improves not only physical properties of the soil but it also increased its nutrient status. Similar findings have also been reported by Ramamurthy and Shiva Shankar (1996). The higher rates of Pb application retarded the growth parameters of wheat viz. plant height, number of tillers and length of earhead which ultimately affected the grain and straw yield of wheat. Similar reduction in growth parameters due to Pb application was observed by Verma and Dubey (2003).

Table 1: Effect of Pb and FYM on different growth parameter of wheat at harvest

Pb (mg kg^{-1})	Effective tillers			Earhead length (cm)			Plant height (cm)		
	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean
	0	10		0	10		0	10	
0	4.0	4.5	4.2	9.1	9.3	9.2	68.4	70.6	69.5
25	4.1	4.6	4.3	9.3	9.4	9.3	70.8	71.2	71.0
50	3.4	3.8	3.6	8.5	8.8	8.6	65.3	68.1	66.7
75	3.2	3.6	3.4	8.2	8.4	8.3	63.1	66.5	64.8
100	3.1	3.5	3.3	7.8	8.2	8.0	62.4	65.1	63.7
200	3.0	3.4	3.2	7.5	8.0	7.8	60.7	63.7	62.2
300	3.0	3.4	3.2	7.2	7.9	7.5	57.4	61.0	59.2
Mean	3.4	3.8		8.2	8.6		64.0	66.6	
CD (P=0.05)	Pb - 0.26, FYM 0.14			Pb - 0.21, FYM 0.12			Pb - 0.85, FYM 0.46		
	Pb x FYM NS			Pb x FYM NS			Pb x FYM NS		

Dry matter yield (DMY)

The results revealed that more dry matter was accumulated (g pot^{-1}) between tillering and milk stages of wheat (Table 2). The lower level (25 mg Pb kg^{-1}) accumulated 11.7% more dry matter over control at milk stage of wheat plant. Sidhu and Narwal (2006) also observed the beneficial effect of lead on the growth of maize at its lower level of application (25 mg Pb kg^{-1}). However further increase in supply of Pb significantly reduced the dry matter yield of the crop. The application of FYM increased significantly dry matter yield at each level of applied lead. This increasing trend was 5.7% at crown root initiation, 5.2% at tillering and 3.9% at milk stage by the application of FYM 10 t ha^{-1} over control. This may be attributed to the proper mineralization of FYM and increased dry matter yield of wheat. Similar higher values of yield attributes in rice were also reported by Davari and Sharma (2010).

Table 2: Effect of Pb and FYM on dry matter yield (g pot^{-1}) at different growth stages of wheat

Pb (mg kg^{-1})	Crown Root Initiation			Tilliring			Milk		
	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean
	0	10		0	10		0	10	
0	1.29	1.31	1.30	8.70	9.10	8.90	30.85	31.70	31.28
25	1.21	1.27	1.24	8.90	9.60	9.25	34.90	35.00	34.95
50	1.16	1.24	1.20	6.85	6.90	6.88	28.25	29.70	28.98
75	1.01	1.17	1.09	6.45	6.85	6.65	26.55	27.25	26.90
100	0.93	0.97	0.95	6.35	6.75	6.55	24.30	25.50	24.90
200	0.92	0.94	0.93	5.70	6.10	5.90	23.05	24.60	23.83
300	0.86	0.87	0.87	5.25	5.45	5.35	20.05	21.60	20.83
Mean	1.05	1.11		6.89	7.25		26.85	27.91	
CD (P=0.05)	Pb - 0.04, FYM 0.02			Pb - 0.32, FYM 0.17			Pb - 0.97, FYM 0.52		
	Pb x FYM 0.05			Pb x FYM NS			Pb x FYM NS		

Grain and straw yield

Apart from individual effect, combined effect of FYM and Pb was also significant with respect to grain yield (Table 3).This implies that the beneficial impact of FYM and Pb on wheat growth, accelerated further, if used simultaneously. Such beneficial effects of FYM and Pb application at lower rates have been reported by Saini and Gupta (1997) in light and heavy textured soils. They also observed that the level (80 mg Pb kg^{-1}) alleviated mean grain yield of wheat by 14.06 % in clay loam soil. Similar results have been reported by Khan and Khan (1983) who observed some beneficial effects of Pb and Cd at their lower doses and toxicity at higher levels. In the experimental black soil, the grain yield increased by 17.3 % over control with the application of lower level of Pb (25 mg Pb kg^{-1}). The highest level of Pb (300 mg Pb^{-1}) reduced the grain yield by more than 29% over respective control. Increase in yield at lower level of Pb may partly be attributed to its stimulatory effect on the uptake of essential nutrients whereas; at higher levels adverse effect could be ascribed to the ionic imbalance in plants. Decrease in grain yield of wheat due to Pb application was also reported by Johnson and Eaton (1980) and Saini and Gupta (1997).

Table 3: Effect of Pb and FYM on grain and straw yield (g pot^{-1}) of wheat at harvest

Pb (mg kg^{-1})	Grain Yield			Straw Yield		
	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean
	0	10		0	10	
0	26.50	29.05	27.78	32.60	34.55	33.58
25	31.45	33.70	32.58	34.35	35.70	35.03
50	23.55	25.35	24.45	29.30	30.65	29.98
75	21.65	21.80	21.73	28.00	29.75	28.88
100	20.45	20.65	20.55	25.90	27.60	26.75
200	20.05	20.25	20.15	23.00	24.50	23.75
300	19.50	19.80	19.65	22.60	22.95	22.78
Mean	23.31	24.37		27.96	39.38	
CD (P=0.05)	Pb - 0.75, FYM 0.40			Pb – 1.41, FYM 0.75		
	Pb x FYM 1.07			Pb x FYM NS		

The FYM (10 t ha^{-1}) application showed its beneficial effect on wheat grain and straw yield. Straw yield followed the same trend as observed in wheat yield. The lower level of Pb (25 mg kg^{-1}) produced higher grain and straw yield, and therefore, these levels showed a narrow ratio of grain and straw as compared to higher levels of Pb application. Saini and Gupta (2001) and Chandel *et al*. (2013) also observed similar improvement in grain and straw yield by increasing rates of FYM. They also observed that an application of FYM @ 1.0 % enhanced grain yield by 20.5 and 11.0 % in sandy and clay loam soil as compared with no manure.

Lead content and uptake

Lead application to wheat crop has increased its content and uptake in grain and straw over control (Table 4). The edible portion of wheat i.e. grain contained lower Pb content as compared to straw portion. It ranged from 1.10 to 10.75 mg kg^{-1} in grain and 2.50 to 13.40 mg kg^{-1} in wheat straw. The higher content of Pb in straw was also observed by Saini and Gupta (2001) in wheat crop. Highest Pb content (10.75 and 13.40 mg kg^{-1} in grain and straw) and uptake (0.21 and 0.33 mg pot^{-1} in grain and straw) were recorded in 300 mg Pb kg^{-1} level of applied Pb, whereas the lowest values were recorded in control. The uptake of Pb by straw showed a significant decreasing trend due to FYM application. Comparatively higher (0.28 mg pot^{-1}) Pb uptake in straw was recorded in control than 10 t ha^{-1} FYM level (0.24 mg pot^{-1}). A significant decreasing trend in lead content and uptake was noticed due to addition of FYM. The minimum Pb content (8.35 mg kg^{-1}) in straw was recorded in no FYM over 10 t ha^{-1} (10.47 mg kg^{-1}) treatment. The interactive effect of Pb×FYM showed significantly decreasing trend in Pb content. The maximum Pb content (12.6 and 14.8 mg kg^{-1}) was recorded in grain and straw by the combination of 300 mg Pb kg^{-1} and no FYM.

Table 4: Effect of Pb and FYM on Pb content (mg kg^{-1}) and Pb uptake (mg pot^{-1}) in wheat grains and straw

Pb (mg kg^{-1})	Grain			Straw		
	FYM (t ha^{-1})		Mean	FYM (t ha^{-1})		Mean
	0	10		0	10	
0	1.2 (0.03)*	1.0 (0.03)	1.10 (0.03)	2.8 (0.09)	2.2 (0.08)	2.50 (0.09)
25	5.8 (0.12)	3.9 (0.08)	4.85 (0.10)	7.6 (0.26)	6.7 (0.24)	7.15 (0.25)
50	6.5 (0.15)	4.3 (0.11)	5.40 (0.13)	9.6 (0.28)	7.8 (0.24)	8.70 (0.26)
75	7.1 (0.15)	5.6 (0.12)	6.35 (0.14)	11.2 (0.31)	8.6 (0.26)	9.90 (0.28)
100	8.4 (0.17)	6.1 (0.13)	7.25 (0.15)	12.7 (0.33)	9.8 (0.27)	11.25 (0.30)
200	11.1 (0.22)	7.8 (0.16)	9.45 (0.19)	14.6 (0.34)	11.4 (0.28)	13.00 (0.31)
300	12.6 (0.25)	8.9 (0.18)	10.75 (0.21)	14.8 (0.36)	12.0 (0.30)	13.40 (0.33)
Mean	7.53 (0.15)	5.37 (0.13)		10.47 (0.28)	8.35 (0.24)	
CD (P=0.05)	Pb - 0.26 (0.01), FYM 0.14 (0.01) Pb x FYM 0.37 (0.01)			Pb - 0.47 (0.02), FYM 0.25 (0.01) Pb x FYM 0.67 (0.02)		

** Figures given in parenthesis are Pb uptake (mg pot^{-1})*

Typical lead content of many food plants and trees are in the range of 1 ppm (Mitchell and Reith, 1966). This high concentration of lead in soil may however, greatly restrict plant growth. FYM application (10 t ha^{-1}) reduced the Pb content and its uptake by wheat plants at harvest and helped in minimizing its toxic effect to some extent. This might be due to the fact that soil organic matter strongly adsorbed the heavy metals and helped in formation of insoluble organo-metal complexes. Significant interaction of Pb and FYM are also capable to reduce its toxicity as compared to treatment without FYM. MacLean *et al.* (1969) also reported the similar beneficial effect of organic matter in reducing Pb content in plants in sandy loam soils.

Lead availability

The results on DTPA extractable Pb in soil after harvest of wheat are presented in Table 5. The DTPA-Pb increased significantly with increasing rates of Pb. The maximum DTPA-Pb (38.33 mg kg^{-1})

was observed with 300 mg Pb kg^{-1} level. The FYM application significantly decreased DTPA-Pb in soil. The lower level (25 mg Pb kg^{-1}) showed DTPA extractable Pb of 8.12 mg kg^{-1} soil which was very low as suggested by Breckel (1991) of 10 mg Pb kg^{-1} soil. The extractable Pb decreased from 24.19 to 19.43 mg Pb kg^{-1} due to FYM addition (10 t ha^{-1}). Interaction between Pb × FYM levels was found to be significant.

Table 5: Effect of Pb and FYM on extractable Pb (mg kg^{-1}) in soil after wheat harvest

Pb (mg kg^{-1})	**FYM (t ha^{-1})**		**Mean**
	0	**10**	
0	1.03	0.97	1.00
25	8.48	7.75	8.12
50	22.62	18.69	20.66
75	26.14	20.05	23.10
100	32.62	25.01	28.82
200	36.20	29.16	32.68
300	42.24	34.41	38.33
Mean	24.19	19.43	
CD (P=0.05) Pb - 1.07 , FYM 0.57, Pb x FYM 1.52			

Maximum DTPA extractable Pb (42.24 mg kg^{-1}) was observed under the application of 300 mg Pb kg^{-1} + no FYM, whereas minimum DTPA extractable Pb (0.97 mg kg^{-1}) was noticed in no lead + 10 t ha^{-1} FYM treatments. Lead availability was dependent on various factors like CEC, organic matter content and pH of soil. It is the experimental soil having high CEC and alkaline pH values that ultimately influenced Pb accumulation in soil. Singh (2002) also reported similar findings. On the other hand, FYM application tended to decrease Pb availability in soil after harvest of wheat. The 10 t FYM ha^{-1} application reduced the lead availability from 24.19 to 19.43 mg kg^{-1}. This might be due to enhancement of organic carbon content in soil that ultimately made some insoluble organo-metal complexes that reduced the availability of Pb in soil. Similar observations were made by Blaylock *et al.*(1997) and Singh (2002) which clearly indicated that if wastes rich in P and organic matter (such as sewage water and sludge) are applied to the soil, very little hazards due to Pb are expected.

Correlation study

The correlation study between lead and other parameter of soil properties and wheat crop was worked out and presented in Table 6. The lead showed a significant positive correlation with Pb content in grain (0.98**) and DTPA lead (0.87**). On the other hand lead showed significant negative correlation with grain yield of wheat (-0.67**) and straw yield (-0.88**). Lead application increased its concentration in the soil which affects the grain and straw yield adversely. The data related to grain and straw yields as affected by lead are also supported these findings. A significant negative correlation was also observed by Saini and Gupta (2001) between Pb concentration in wheat grain and straw with their respective yields. On the other hand, lead content in wheat showed a positive response with its application in experimental soil.

Table 6: Correlation coefficient (r) between Pb and parameters of soil and wheat crop

Parameter	**'r' value**
Wheat grain yield	-0.67**
Wheat straw yield	-0.88**
Pb content (grain)	0.98**
DTPA – Pb	0.87**

From the results, it may be concluded that the lower level of lead (25 mg kg^{-1}) favorably influenced the growth and yield parameters of wheat. There was a decreasing trend in dry matter accumulation in wheat plant with increasing levels of Pb. Application of 25 mg Pb kg^{-1} produced 17.3 % higher grain yield over control. The higher lead of Pb decreased wheat grain yield more than 10 % over control. Wheat had shown a favourable response to FYM application. Lead content in wheat increased with increasing its levels whereas FYM addition reduced the toxic effect of Pb to some extent.

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