World Journal of Agricultural Sciences 3 (2): 204-209, 2007
ISSN 1817-3047

Role of Some Organic Residues as Tools for Reducing Heavy Metals Hazard in Plant

A.A. Yassen, Nadia, M. Badran and Sahar M. Zaghloul

Department of Plant Nutrition, National Research Centre, Dokki, Giza, Egypt

Abstract: A Pot experiment was carried out in the greenhouse of National Research Centre Dokki, Giza to study the effect of some organic residues (farmyard manure, peanut residue and potassium humate) on (Cd, Pb and Zn) heavy metals toxicity of spinach plants grown on a polluted soils compared with a non polluted one. Results pointed out that, the used organic residues; increased plant heights, leaves number / plant and yield as compared with control treatment in both polluted and non polluted soil. Data also, revealed that NPK content and uptake decreased in spinach plant in the soil contaminated with heavy metals whereas the application of organic residues increased NPK content and uptake. Application of organic residues to the soil, positively reduced Cd, Pb and Zn concentration in the plant under study as compared with control of both polluted and non polluted soils.However, the applied organic residues resulted in an increase in total Zn, Pb and Cd in both polluted and none polluted soil as compared with the control and NPK treatments. Finally it may concluded that the natural organic residues that were proved for a long time, to be as efficient tools inducing agricultural productivity, may can be used also to improve the quality and safety of growing plants. This goal can be achieved through the role of such materials in reducing the concentration or activity of heavy metals in soil solution and hence in growing plants, in spite of the increase that may occur in their total content in soil as a result of manures application

Key words: heavy metals · organic residues · pollution · yield-chemical composition

INTRODUCTION

Several inorganic pollutants, particularly heavy metals, are known to accumulate in surface soil as a result of contamination from local industrial and agricultural activities and sometimes from aerial transport. Obata and Umebayashi [1] and Kabata -Pendias and Pendias [2].

Organic fertilizers may play an important role in nutrients solubility and improve both physical and chemical properties of soil but may lead to accumulation of some heavy metals in soil, particularly under heavy application of such fertilizers. However, heavy metals have a tendency to accumulate through different reactions with some humic substances. Surface sorption, chelation, coagulation and peptization. As well as ion exchange are possible mechanisms for such reactions. All reactions between organic matter and cation lead to the formation of water-soluble and /or water- insoluble complexes Kabata-Pendias and Pendias [3] and Oudeh *et al.* [4].

Soil contamination by heavy metals reduces the quality of the cultivated plant which often limits and sometimes disqualifies the soil quality from the production of safe food products or animal feed. Frossard [5] Heavy metals not only reduce the yield of crops but they are also related to the accumulation of xenobiotics and modify the content of other chemical elements Das *et al.* [6].

Ciecho *et al.* [7] and Zdzisław Ciecko *et al.* [8] found that application of compost, brown coal or bentonite may contaminate the soil with heavy metals, increase N, P and K in plants. Pierzynski and Schwab [9] showed that the addition of cattle or poultry manure to contaminated alluvial soil significantly decreased Zn, Pb and Cd concentration in Soya bean compared with the control. Gaweda *et al.* [10] observed that organic matter (peat) reduced Pb concentration in lettuce and carrot plants. Fecenko *et al.* [11] found that after sodium humate application the Cd concentration was decreased in grain and straw of barley.Scherer et al [12] studied the influence of application of two rates and two types of compost to soils with different heavy metals content. Their results, showed an increase in yield more than the control under all the studied treatments. Also, they found decrements in Pb, Cd and Zn contents in the above ground parts of plant material.

Spinach (*Spinucia oleracea* L) is one of most popular leafy vegetables grown in Egypt that represents a good

Corresponding Author: Dr. A.A. Yassen, Department of Plant Nutrition, National Research Centre, Dokki, Giza, Egypt

source of vitamins B and C as well as some minerals such as iron, calcium and magnesium. Spinach was used as an indicator plant in this study. The main purpose of the present investigation is to study the influence of some organic residues (farmyard manure and peanut residue) under polluted and non polluted soil conditions on growth, yield and chemical composition of spinach plant.

MATERIALS AND METHODS

A pot experiment was carried out in the greenhouse at National Research Centre Dokki, Giza to study the possibilities of reducing heavy metals toxicity by using some organic residues (farmyard manure and peanut residue) and potassium humate on spinach plant under non polluted and polluted soil conditions. The main characteristics of the investigated soil were pH 7.40, EC 0.67 dSm^{-1}, OM 1.11 %, total N 68.5 $mg.kg^{-1}$, total P 14.1 $mg.kg^{-1}$, total K 45.7 $mg.kg^{-1}$, Sand 27.80 %, Silt 37.21%, Clay 34.89 % and CaCO3 3.57 %., Pb15.3 $mg.kg^{-1}$, Cd 0.52 $mg.kg^{-1}$ and Zn 24.6 $mg.kg^{-1}$. Chemical and physical properties of the investigated farmyard manure and peanut residues were analyzed in Table 1.

The soil samples used first non polluted and second polluted with mixed heavy metals were added at rates of (300, 100 and 100 mg kg^{-1} soil of Zn, Pb and Cd) as, Zinc sulphat, lead chloride and cadmium chloride respectively. The soil samples were uniformly packed in plastic pots (30cm diameter and 30 cm height) at a rate of 10 kg of air dried soil. Farmyard manure and peanut residue were mixed thoroughly with the soil before transplantation.

The experimental work included the following treatments:

- Control.
- NPK Fertilizer (recommended dose)
- Farmyard manure at a rate of 5 ton /fed
- Farmyard manure at a rate of10 ton / fed
- Peanut residue at a rate of 5 ton / fed
- Peanut residue at a rate of 10 ton / fed
- Potassium humate at a rate (5 kg /fed).

The different treatments were arranged in a Completely Randomized Design with three replicates. Basal doses of phosphorus and potassium were added as superphosate (50 mg kg^{-1} P_2O_5) and potassium sulphat (40 mg kg^{-1} soil K_2O). The moisture content in the pots was maintained at field capacity.

Ten seeds of Spinach (*Spinucia oleracea* L.), cv. Dokki were sown on the first week in December and thinned to five plants. Plants were harvested after 60 days from plantation thinning. Plant height (cm) leaves No. / plant, fresh and dry weight were recorded and prepared for analysis. Total nitrogen in plant was determined according to the method described by Bremner and Mulvaney [13]. Other sub samples of the plant dry matter produced were wet ached using sulfuric - perchloric acid mixture Cottenie *et al.* [14]. The clear digest was subjected to analysis for phosphorus (spectrophotometerically) and potassium using Flame photometer. The total heavy metals (Zn, Pb and Cd) were determined by Atomic Absorption Spectrophotometer according to Cottenie *et al.* [14].

The data were statistically analyzed according to Snedecor and Cochran [15] using the least significant different (LSD) at 0.5%.

RESULTS AND DISCUSSION

Vegetative growth: Results of vegetative growth parameters indicate the followings:

Under polluted soil conditions

Plant height: All the tested treatments increased spinach height about 50% in case of NPK treatment or more in case of all the organic sources but without no significant differences among them.

Leaf No./plant: (LNPP): Although the NPK treatment induced the LNPP, the obtained increase did not differ significantly from the control treatment. All the organic applications significantly increased the LNPP by values from about 68% (with K- humate) up to about 180% (with peanut residue 2).The tested treatments could be arranged ascending in the order:control<K-

Table 1: Some properties of farmyard manure, peanut residue and potassium humate under study

							(mg kg^{-1})	
Contents	O.C %	pH	EC dsm^{-1}	N %	P %	K %	Zn	Pb	Cd
Farmyard manure	53.69	8.64	2.25	0.78	0.33	0.65	42.10	24.20	2.20
Peanut residue	62.80	8.22	1.85	1.88	0.58	2.05	17.20	0.89	1.10
Potassium humate	47.65	2.11	4.36	1.20	0.05	0.12	21.05	7.35	1.35

Table 2: Effect of some organic residues on vegetative growth of spinach grown on non polluted and polluted soil

	Non pollution				With pollution				Reduction
Treatments	Plant height (cm)	Leaf No. of plant	Fresh weight (g)	Dry weight (g)	Plant height (cm)	Leaf No of plant	Fresh weight (g)	Dry weight (g)	% in dry weight due to pollution
Control	22.10	9.31	14.40	2.60	15.40	6.70	8.91	1.52	40.2
NPK	29.10	14.15	24.90	3.33	23.10	8.13	16.22	2.00	39.9
FYM 1	35.30	16.70	34.70	5.14	23.40	13.60	25.70	3.41	33.7
FYM 2	34.10	18.23	44.60	6.00	25.30	14.01	28.91	4.36	27.3
Peanut residue 1	33.40	21.54	50.70	7.31	24.60	16.10	31.15	5.21	28.7
Peanut residue 2	38.60	23.90	56.90	8.44	26.20	18.77	33.16	5.71	32.3
K- H	36.70	14.82	33.80	4.67	24.60	11.26	21.14	3.16	34.5
LSD 0.05	5.71	3.14	7.24	0.73	3.26	2.09	3.76	0.78	-

FYM1: 5 ton/fed FYM2: 10 ton/fed Peanut residue1: 5 ton/fed Peanut residue2: 10 ton/fed, Potassium humate: K-H: (5 kg fed^{-1})

Humate < FYM1< FYM2<Peanut 1< Peanut2. It may be concluded that peanut residues even in the low level (peanut 1) favored both K-humate and farmyard manure even at the higher rateFYM 2 in the respect to increasing the LNPP.

Spinach fresh weight (SFW): Data of spinach fresh weight Table 2 reveal that the spinach fresh weight (SFW) responded soundly to all the applied treatments as compared to the control (the unpolluted soil). These results are in agreement with those obtained by Gagnon *et al.* [16] and Yassen *et al.* [17]. As in case of plant height and leaf No./ plant (LNPP), the spinach fresh weight response to NPK treatment was the least (82%) over the control. All the applied residues as well as the FYM surpasses in their effect that due to the NPK was maximized under the 2nd rate (10ton) of peanut residues (272%)over the control treatment.

Almost similar trend due to applied treatments inducing effect on growth parameters observed with plant height and leaf No/ plant was obtained again with (SFW) which was: Control<K-humate <FYM1<FYM2<Peanut1<Peanut2, but the difference between the 2nd rate of FYM and the 1st rate of peanut insignificant. Organic matter seems to be more effective in blocking the heavy metals mobility probably through adsorption on the surface of such materials and hence retarding their plant toxicity. These results could be explained according to Pierzynski and Schwab [9] and Scherer *et al.* [12].

Spinach dry weight: (SDW): Data of spinach dry weight indicate that the dry weight of spinach results showed in general a pattern almost similar to that revealed by the fresh weight where all the treatments followed the same order of arrangement and also the same pattern of significance except for the control and NPK treatments where the dry weight of both treatments did not differ significantly.

Under normal (non polluted soil) conditions:
Growth under non polluted soil conditions reveals that:

1. All the tested parameters of spinach vegetative growth behaved almost similarly under polluted and non polluted soil conditions.
2. As mentioned previously, except to plant height parameter, the other three growth parameters i.e. LNPP, fresh weight and dry weight showed the same ascending order as follows:
   Control<K-humate<FYM1<FYM2<Peanut1<Peanut2
3. The reduction in growth parameters of spinach due to the applied treatments decreased under heavy metals polluted soil compared to non polluted in the following order: control (40.2%) > NPK (39.9%) > K-humate (34.5%) > FYM1(33.7%) > peanut2(32.3%) > peanut1(28.7%) >FYM2(27.3%). Such trend emphasizes the concept of organic farming as the reduction in the yield due to applied pollution was minimized under FYM and peanut residues treatments but maximized under NPK mineral fertilizing, however, K- humate which represents a mineral organic source behaved in between the two groups of fertilizers. Accordingly one may state that manuring or organic farming could partially or entirely remediate the hazard effect of soil heavy metals pollution.

Generally, there is a positive relationship between increasing the rate of organic fertilizer addition and plant growth parameters of Spinach. It means that, the plant which received the highest rate (10 ton/fed.) showed the best plant growth compared the lowest rate (5 ton/fed.)

Table 3: Effect of some organic residues on N, P and K content of spinach under non polluted and polluted soil

	Non pollution			With pollution		
Treatments	N %	P %	K %	N %	P %	K %
Control	1.63	0.43	2.81	1.22	0.29	2.10
NPK	2.51	0.71	3.23	1.80	0.44	2.51
FYM 1	2.64	0.74	3.54	1.80	0.46	2.78
FYM 2	2.81	0.78	4.00	2.11	0.48	2.91
Peanut residue 1	3.11	0.79	3.81	2.37	0.49	3.01
Peanut residue 2	3.66	0.80	4.22	2.41	0.54	3.21
K- H	2.80	0.72	3.55	1.94	0.46	2.66

FYM1: 5 ton/fed FYM2: 10 ton/fed Peanut residue1: 5 ton/fed Peanut residue2: 10 ton/fed, K-H: potassium humate (5kg/fed)

Table 4: Effect of some organic residues on N, P and K uptake of spinach under non polluted and polluted soil

	Uptake mg pot^{-1}					
	Non pollution			With pollution		
Treatments	N	P	K	N	P	K
Control	42.38	11.18	73.06	18.54	4.40	31.90
NPK	83.58	23.64	107.56	36.00	8.80	50.20
FYM 1	135.70	38.04	181.96	61.38	15.68	94.80
FYM 2	168060	46.80	240.00	91.99	20.92	12687
Peanut residue 1	227.34	57.75	278.51	123.48	25.53	15682
Peanut residue 2	308.90	67.52	356.17	137.61	30.83	18329
K- H	130.76	33.62	165.76	61.13	14.53	84.06

FYM1: 5 ton/fed FYM2: 10 ton/fed Peanut residue1: 5 ton/fed Peanut residue2: 10 ton/fed, K-H: potassium humate (5 kg fed^{-1})

It's known that with increasing the organic matter addition, the soil content of nutritional elements increases consequently the plant growth was enhanced. The obtained findings are in good harmony with those of other investigators such as Melloni *et al.* [18]. and Piramonti, *et al.* [19].

Chemical composition:

Macro nutrients: Data recorded in Table 3- 4 indicate that NPK content and uptake were decreased in spinach plant when grown in a heavy metals contaminated soil. These decreases probably due to the adverse effect of heavy metals on plant growth rather than to the interference between these heavy metals (Cd and Pb) and nutrients. In this concern Obata and Umebayashi[1] reported that Cd may be considered harmful to plasma membrane of root cells, causing water and K adsorption to be inhibited or K to leak out from root cells. Also, Dahdoh *et al.* [20-21] concluded that Pb addition depressed N and P concentration in the shoot of alfalfa and rocket plants. On the other hand application of organic matter increased N, P and K content and uptake as compared with the control under polluted soil. These results are agreement with Ciecho *et al.* [7] who reported that a serious accumulation of nitrogen was observed in the grain and straw of *Zea maize* as a result of compost application.

Increasing the rate of organic matter (10 ton/fed.) slightly increased N, P and K content and uptake of plant as compared with the low rate (5 ton/fed.) under polluted and none polluted soil conditions. However there was an interaction effect between the rate and source of the organic fertilizer. Peanut residue was superior than the other treatments. The lowest values of N, P and K were observed in plants which received potassium humate as an organic fertilizer source.

As comparison between polluted and none polluted soil, data show that application of organic fertilizer increased N, P and K content and uptake in non polluted soil as compared with the polluted one. The increase in these nutrients uptake may be due to increasing the dry matter yield.

It can be concluded that the decrease in macronutrients are probably due to the presence of heavy metals in soil which affect plant growth and decrease dramatically dry matte yield. This reduction in plant growth is likely to be due to the disturbance and imbalance between the different essential elements, meanwhile application of organic residues reduce the harmful effect of such heavy metals and hence improves the yield production of spinach plants.

Effect of organic residues on heavy metals content in Spinach plants: Data in Table 5 shows that cadmium, lead and zinc concentrations in spinach plants increased with increasing amounts of added heavy metals to the soil compared with untreated one. These results are in agreement with Yang and Lee [22] on lettuce, Guo- Yan *et al.* [23] on spinach and Hunag and Cunningham [24] on maize. They found that soil treated with heavy metals (Cd & Pb) increased the content of plant tissues.

Application of organic residues (FYM, peanut and potassium humate) to the soil significantly reduced Cd, Pb and Zn concentration in plant as compared with the control under both polluted and none polluted soil conditions.

Comparison between polluted and none polluted soils, may led to a conclusion that FYM and peanut residues decreased Zn content in spinach plant by about

Table 5: Effect of some organic residue on Zn,, Cd and Pb content of spinach under non polluted and polluted soil

	(ppm)					
	Non pollution			With pollution		
Treatments	Zn	Cd	Pb	Zn	Cd	Pb
Control	87.66	3.14	8.99	167.23	27.98	24.99
NPK	68.14	2.44	6.66	143.37	23.22	18.32
FYM 1	56.33	1.85	5.12	126.76	19.11	16.01
FYM 2	53.12	1.64	4.40	122.11	17.84	14.44
Peanut residue 1	48.78	1.60	4.91	117.63	16.44	14.99
Peanut residue 2	44.04	1.01	3.78	111.77	14.66	11.60
K- H	58.71	1.33	4.00	128.41	15.22	15.00

FYM1: 5 ton/fed FYM2: 10 ton/fed Peanut residue1: 5 ton/fed Peanut residue2: 10 ton/fed, K-H: potassium humate (5 kg fed^{-1})

Table 6: Effect of some organic residues on Zn, Cd and Pb content in soil after harvesting of spinach under polluted and none polluted soil

	(ppm)					
	Non pollution			With pollution		
Treatments	Zn	Cd	Pb	Zn	Cd	Pb
Control	38.34	0.50	14.5	56.40	18.70	29.66
NPK	31.43	0.42	12.9	49.92	15.62	25.11
FYM 1	58.91	0.33	18.10	85.33	20.37	38.31
FYM 2	63.66	0.38	20.67	88.47	20.86	42.71
Peanut residue 1	43.73	0.21	15.17	70.18	21.22	36.30
Peanut residue 2	47.16	0.24	16.30	73.92	22.42	36.47
K- H	44.22	0.26	15.00	70.32	20.60	47.11

FYM1: 5 ton/fed FYM2: 10 ton/fed Peanut residue1: 5 ton/fed Peanut residue2: 10 ton/fed, K-H: potassium humate (5 kg fed^{-1})

24% and 30% respectively in the contaminated soil whereas it was 34% and 44% under FYM and peanut residues in uncontaminated soil. Similar results were obtained by Pierzynski and Schwab [9]. They found that the addition of cattle manure and or poultry litter to a contaminated alluvial soil significantly decreased Zn concentration in soybean plants compared with the control.

As for organic residues applied i.e.FYM and peanut residues to the soil, Cd concentration in spinach plant grown on soil without heavy metals application was reduced by about 41% and 49%, respectively versus reductions at about 31% and 41% in Cd contraction under contaminated soil conditions, respectively. Similar results were obtained by Scherer *et al.* [12] Stated that using two compost sources with different contents of heavy metals resulted in a decrease in Cd concentration in the above ground plant parts.

Data also, declared that Pb content was depressed (by about 35% and 40%) at both FYM and peanut residues in none polluted soil and about 43% & 45% in the polluted soil. Gaweda *et al.* [10] observed that organic residues reduced Pb concentration in lettuce and carrot plants after the addition of different levels of organic matter as peat to the soil contaminated with Pb. From the above results, it can be concluded that K-humate had the lowest effect in decreasing the hazard effect of heavy metals as compared with FYM and peanut residues. Generally high rate of organic residues was superior in decreasing the hazard effect of heavy metals.

Effect of organic residues on heavy metals content in soil after harvesting: Data in Table 6 summarizes the effect of adding some organic materials on heavy metals (Zn, Pb and Cd) in soil after harvesting spinach plants, it is clear that organic residues resulted in an increase in total Zn, Pb and Cd in both polluted and none polluted soil as compared with the control and NPK treatments. These results are in harmony with More [25] who stated that the addition of organic residues increased total heavy metals (Zn, Cu, Pb and Cd).

Total Zn and Pb increased in soil after harvesting of spinach plant grown on the soil treated with FYM in both polluted and none polluted soil whereas the opposite trend was noticed with Cd in peanut residue treatment.

In general organic residues can be arranged as follows: soil + FYM < soil + peanut residue < K- humate in total heavy metals remained soil.

REFERENCES

1. Obata, H. and M. Umebayashi, 1997. Effect of cadmium on mineral nutrient concentration in plant differing in tolerance for cadmium. J of Plant Nutrition, 20: 97-105.
2. Kabata-Pendias, A. and H. Pendias, 2001. Trace elements in soil and plants 3rd ed. CRC Press, Boca Raton, FL.
3. Kabata-Pendias, A. and H. Pendias, 2001. Trace Elements in Soil and Plants 2nd ed. CRC Press, Boca Raton, Florida, pp: 70-78.
4. Oudeh, M., M. Khan and J. Scullion, 2002. Plant accumulation of potentially toxic elements in sewage sludge as affected by soil organic matter level and mycorrhizal fungi. Environ. Pollution, 116: 293-300.
5. Frossard, R., 1993. Contaminant uptake by plants. In: Schulin, R., *et al.* (eds.): Soil Monitoring. Birkhauser Verlag, Basel: 7 -24.

6. Das, P., S. Samantaray and R. Rout, 1998.. Studies on cadmium toxicity in plants: A review. Environ. Pollut. 98: 29-36.
7. Ciecho, S., M. Kalembasa, Wyszkowski and E. Rolka, 2004. the effect of elevated cadmium content in soil on the uptake of nitrogen by plants. Plant Soil Environ., 50: 283-294.
8. Zdzisław Ciecko, Stanisław Kalembasa, Mirosław Wyszkowski and Elzbieta Rolka, 2004. The effect of soil contamination with cadmium on the phosphorus content in plants. Environmental Development, 7, Issue 1.
9. Pierzynski, G.M. and A.P. Schwab, 1993. Bioavailability of zinc, cadmium and lead in metal contaminated alluvial soil. J. Environ. Qua., 22: 249- 254.
10. Gaweda, M. D. Gerasopoulos, C.H. Olymppios and H. Passam, 1995. The effect of organic matter in soil on the lead level in edible parts of lettuce and carrot. Acta. Horticulturae, 379: 221-228.
11. Fecenko, L., P. Malis and H. Kovacik, 1995. Effect of sodium humate on the yield formation and quality of spring barley. Zeszyty Problemowe Postepow Nauk Rolniczych, Z., 42: 31-36.
12. Scherar, H.W., U.Knauff and W. Werner, 1997. Influence of compost application to soils with different heavy metals concentrations on the biotransfer of heavy metals into plants. Agriebiological Research, 50: 205-213.
13. Bremner, J.M. and C.S. Mulvaney, 1982. Nitrogen total In: A.L. Page *et al*. (ed) Method of soil analysis. Part 2, 2nd ed Agron.Monogr 9 ASA and SSSA Madison, W.L., pp: 595-642.
14. Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical Analysis of Plant and Soil. Laboratory of Analytical and Agrochemistry, State Univ. Ghent., Belgium, pp: 100-129.
15. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods, 7th ed. Iowa Stat Univ.,Press Amer, Iowa, USA.
16. Gagnon, B. and S. Berrouards, 1994. Effect of several organic fertilizer on growth of greenhouse tomato transplants. Candian J. Plant Sci., 74: 167-178.
17. Yassen, A.A., S.M. Arafat and Sahar M. Zaghloul, 2002. Feather meal as a potential source of organic nitrogen fertilizer. J. Agric. Sci. Mansoura Univ., 27: 6467-6476.
18. Melloni, R., C.M.R. Duate and E.J. Cardoso, 1995. Influence of compost and or effective microorganisms on the growth of cucumber rand on the incidence of Fusariumwilt. Summa-Phytophological, 21: 21-24.
19. Piramonti, F., G. Stringari and G. Zorzi, 1997. Use of compost in soilless cultivation. Compost Science and Utilization, 5: 38-46.
20. Dahdoh, M.S.A., El-S. Demerdashe, S. Foda and H.J. El- Kassas, 1996. Effect of organic matter interaction on lead status insoil and plant grown in calcareous soil. Egypt. J. Soil Sci., 36: 233 -244.
21. Dahdoh, M.S.A., El -S. Demerdashe, S. Foda and H.J. El-Kassas, 1996. Effect of phosphate addition on some plants grown on Pb-polluted soil. Egypt. J. Soil Sci., 36: 245-256.
22. Yang, Y.J. and B.Y. Lee, 1990. Effect of heavy metal treatment on the growth and uptake in hydroponically cultured lettuce. J. Korean Society for Hort., 31: 37 -41.
23. Guo-Yan, H. Marchner and Y.T. Gue, 1995. Uptake, distribution and binding of cadmium and nickel in different plant species. J. Plant Nutr., 18: 5691-2706.
24. Hunag, J.W. and S.D. Cunningham, 1997. Lead phytoextraction species variation in lead uptake and translocation. New -Phtologist., 134: 75-84.
25. More, S.D., 1994. Effect of farm wastes and organic manures on soil properties, nutrient availability and yield of rice and wheat grown on sodic vertoisol. J. of the Indian Society of Soil Sci., 42: 253-256.