SHORT COMMUNICATION

HEAVY METAL CONCENTRATION IN GRAINS AND SOILS AS INFLUENCED BY ORGANIC, INTEGRATED AND CHEMICAL SOURCE OF NUTRITION IN MAIZE-WHEAT SYSTEM

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The long-term experiment with maize-wheat sequence was initiated during 1996-97 at the experimental farm of the department of Agronomy, Agrometeorology and Forestry, Punjab Agricultural University, Ludhiana. On the same field the investigation was expanded to organic (pure), integrated (partial) and chemical farming systems during *Kharif* and *rabi* 2002-03. The application of farmyard manure, green manure and crop residues decreased heavy metal (lead, nickel and cadmium) concentration in grains of maize and wheat as well as in soils and uptake of heavy metal by maize and wheat grains as compared to use of chemical fertilizers alone as a source of nutrients.

Key words: **Chemical farming, heavy metals, maize-wheat cropping system, organic farming**

The effect of prolonged and over usage of chemicals on soil results in human health hazards and pollution of environment. In the recent years, the concern has been focused increasingly on environmental pollution and its ill effect on man and animals. The public concern over the effects of environmental pollution has increased substantially in the last century with the industrial revolution and as a consequence of an enhanced understanding of the risk to human health. There are some reports which indicate that heavy metals pollution arises as a result of various anthropogenic activities such as continuous use of fertilizers (Singh and Sekhon 1977). Almost all the heavy metals are potentially hazardous elements to microorganism, plants, animals and human beings. The recent interest in heavy metal content in plants arises from the investigations revealing the harmful health effect of their high dietary intake. Their excess causes disorders like gastroenteritis, hypertension, cardio vascular disease, pulmonary emphysema, cancer and osteoporosis (Wagner 1993). In true sense, organic farming is a production system, which avoids or largely excludes the use of synthetic fertilizers, growth regulators, livestock additives and pesticides. It relies on agronomic management practices, crop rotation, crop residues, animal manure, legumes, green manures, off-farm organic wastes and aspect of biological pest control to maintain soil productivity. Keeping this in view, a study was initiated on organic farming, integrated nutrient management and chemical farming on heavy metal concentration in economic yield and in soils.

The present investigations were carried out during *Kharif* and *rabi* seasons of 2002-03 at department of Agronomy, Agrometeorology and Forestry, Punjab Agricultural University, Ludhiana (on already in progress experiment since *kharif* 1996) on a loamy sand soil (Typic Ustochrept) to assess the effect of continuous application of plant nutrients through organic and chemical forms on heavy metal content, uptake and to monitor the changes of heavy metal in soil. The

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experiment was arranged in a randomized block design with 4 replications comprised of 8 treatments (Table 1), consisting of 2 farming systems i.e. organic and chemical farming and 4 nutrient supply systems. In the chemical farming system, 125 kg N/ha and 25 kg $ZnSO_4$/ha were applied to maize crop and to wheat 125 kg N/ha, 62.5 kg P_2O_5/ha and 30 kg K_2O/ha i.e. recommended level of fertilizer (Rec.) with or without green manuring (GM) to *kharif* crop/with (RI) or without (R0) residue incorporation, Rec.-GM-RI or Rec.-GM-R0 or 25 % more N than recommended were added. N was applied through urea, P_2O_5 through single super phosphate and K_2O through muriate of potash, while in organic farming well rotten farmyard manure was applied on air-dry weight basis at 20 t/ha each to maize (M_{20}) and wheat (W_{20}) along with crop residues incorporation (M_{20}-W_{20}-RI) for first five years. Later on the quantity of FYM was reduced to 10 t/ha (M_{10}) to maize along with green manuring [with and without crop residues incorporation (RI and R0)] and 15 t FYM/ha (W_{15}) to wheat (with and without crop residues incorporation)(M_{10}-W_{15}-GM-RI, M_{10}-W_{15}-RI, M_{10}-W_{15}-R0). Green manuring of sunnhemp (*Crotalaria juncea*) 45 days old (17-20 t/ha) was done 5-7 days before sowing maize. Crop residues were incorporated at harvest as per treatments. The sowing of maize (Var. Paras) and wheat (Var. PBW 343) was done on June 8, 2002 and November 3, 2002 using 20 kg and 100 kg seed/ha, respectively. Heavy metals (Cd, Ni and Pb) in grain samples were analyzed by digesting them in di-acid mixture (HNO_3 and $HClO_4$, 4:1) and estimated them on atomic absorption spectrophotometer. The heavy metals from soil samples were determined from 1:2, soil- extractant ratio using DTPA-TEA buffer (0.005 M DTPA + 0.001 M $CaCl_2$ + 0.1 M TEA, pH 7.3) as per the method proposed by Lindsay and Norvell (1978).

The data presented in Table 1 clearly indicated that chemical fertilizer treatments (Rec. and Rec.+25 % N) had significantly more lead concentration in maize grains (18.8 to 21.5 µg/g) as compared to organic farming treatments (12.8 to 15.0 µg/g) and partial organic treatments (16.3 to 16.5 µg/g). The nickel concentration was 15 to 20 per cent less in integrated nutrient

Table 1. Effect of organic and chemical farming on lead, nickel and cadmium concentration, their uptake and soil content (0-15 cm) layer in maize-wheat cropping system

Treatments*	Heavy metal concentration in grain (µg/g)						Heavy metal uptake by grains (g/ha)						Heavy metal conc. (µg/g) in soil (0-15 cm)		
	Lead		Nickel		Cadmium		Lead		Nickel		Cadmium		Lead	Nickel	Cadmium
	Maize	Wheat	Maize	Wheat	Maize	Wheat	Maize	Wheat	Maize	Wheat	Maize	Wheat			
M_{20}-W_{20}-RI	12.80	13.25	2.25	3.75	0.5	0.5	70.8	28.6	12.4	8.1	2.8	1.1	0.12	0.9	ND
M_{10}-W_{15}-GM-RI	13.50	14.25	1.25	3.25	0.5	0.5	71.8	28.1	6.6	6.4	2.7	1.0	0.10	1.2	ND
M_{10}-W_{15}-RI	14.30	15.50	2.75	4.00	0.5	0.5	70.2	28.8	13.5	7.4	2.5	0.9	0.14	1.2	ND
M_{10}-W_{15}-R0	15.00	15.00	2.75	4.25	0.5	0.5	70.8	28.6	13.0	7.6	2.4	0.9	0.16	1.1	ND
Rec.-GM-RI	16.50	16.00	3.00	4.00	0.5	0.5	89.0	34.0	16.2	8.5	2.7	1.1	0.14	1.3	ND
Rec.-GM-R0	16.30	16.25	4.00	4.50	0.5	0.5	86.6	33.6	21.2	9.3	2.7	1.0	0.16	1.4	ND
Rec.+25% N	21.50	17.50	4.25	5.00	0.5	0.7	110.6	32.9	21.9	9.4	2.6	1.3	0.36	1.5	ND
Rec.	18.80	20.25	5.00	4.50	0.5	0.5	93.7	35.9	24.9	8.0	2.5	0.9	0.26	1.4	ND
C.D. (P=0.05)	2.8	2.5	NS	NS	NS	NS	11.59	NS	2.32	NS	NS	NS	NS	NS	NS

*Details of treatment are given in text

management and 45 to 75 per cent less than organic farming systems over recommended treatments (5.0 μg/g). The cadmium concentration (0.5 μg/g) in maize grains was similar in all the treatments. The lead uptake varied from 70.2 to 71.8 g/ha in organic farming and 86.6 to 89.0 g/ha in integrated farming treatments. All the organic farming treatments were at par and recorded significantly less lead uptake by maize grain over integrated farming treatments and recommended treatments (Rec. and Rec.+25 % N). Similarly, nickel uptake by maize grain was significantly less in all the fully organic farming treatments over rest of treatments. The M_{20}-W_{20}-RI treatment showed 50.2 per cent less nickel uptake as compared to chemical farming treatment (24.9 g/ha). The cadmium uptake was almost similar in all the treatments ranging between 2.4 to 2.8 g/ha. Prugar (1999) reported that the residues of pesticides and heavy metals were lower in organic produce. Organic fodder crops were more palatable than conventional fodder crops in feeding trials and benefits in animal health were recorded and concluded that in some respects the quality of organic produce exceeds that of conventional produce.

The lead and nickel concentration in wheat grain in all the organic farming treatments and both the partially organic farming treatments was comparatively lower than both the chemical fertilizer treatments. However, the cadmium concentration was same (0.5 μg/g) in all the treatments. The lead uptake in wheat grain under organic farming treatments varied from 28.1 to 28.8 g/ha, which was 19.8 to 21.7 per cent less than recommended treatment (35.9 g/ha). Ram (1998) reported that chemical fertilizers are the carriers of heavy metals and contribute a significant quantity of heavy metals to the soil due to their use for a longer time. The Rec.-GM-RI and Rec.-GM-R0 treatments showed 34.0 and 33.6 g/ha nickel uptake by wheat grains which was 5.3 and 6.4 per cent less than recommended chemical fertilizer treatment (35.9 g/ha). The cadmium uptake by fully organic treatments varied from 0.9 to 1.1 g/ha followed by partially organic treatments 1.0 to 1.1 g/ha. The fully and partially organic farming treatments showed less cadmium uptake than fully chemical farming treatments 0.9 to 1.3 g/ha. The uptake of lead and nickel by wheat grain was less in all the organic farming treatments due to their lesser concentration under these treatments as compared to the treatment receiving recommended chemical fertilizers. Contents of cadmium, lead and mercury were higher in conventional intensive agriculture than in organic grown grain crops of wheat, barley, rye and millet (Petr 1999).

Application of farmyard manure, green manure and crop residues decreased heavy metal (nickel and lead) in soil over chemical fertilizers alone as a source of nutrients (Table 1). In pure organic treatments nickel status varied from 0.10 to 0.16 μg/g as compared to 0.26 μg/g in chemical fertilizers (Rec.) treatment and lead amount varied from 0.9 to 1.2 μg/g as compared to 1.4 μg/g in alone chemical fertilizers. The cadmium was not detected in all the treatments. The heavy metal concentration decreases in soils as the organic manures forms insoluble organo-metallic complexes with the metal and binds heavy metals in soil matrix.

The above observations indicated that the uptake of heavy metals such as cadmium, nickel and lead was comparatively low in organic farming treatments followed by integrated nutrient management as compared to their values in chemical treatments with comparable yields of the crops in both cases.

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