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Conjoint application of organic and inorganic sources of nutrients on uptake of heavy metals (Cd, Cr, Ni, Pb) in straw and grain of rice and wheat

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Abstract
Field experiments were conducted for two years in sandy loam soil to study the direct effect of organic (sewage sludge, vermicompost and sesbania) and inorganic (chemical fertilizers) source of nutrients on rice (*Oryza sativa*) and their residual effect on wheat (*Triticum aestivum*) grown in sequence 2015-16 to 2016-17 at Varanasi, Uttar Pradesh. The present study was taken up to evaluate the effect of organic amendments on heavy metals accumulation in grain and straw of rice. In the experiment, 75% recommended dose of fertilizer were applied along with quantities of the organic sources calculated on the basis of 25% N equivalent. The applied treatments effect were compared with the absolute control (N: P_2O_5: K_2O: 00:00: 00) and recommended dose of fertilizers i.e. 150, 60 and 60 kg N, P_2O_5 and K_2O ha^{-1}. Application of organics amendments increased the uptake of heavy metals in grain and straw. The highest (2.91 g ha^{-1}) total uptake of cadmium in rice was recorded in customized fertilizer (T_4) followed by T_5 sewage sludge (2.81 g ha^{-1}) with a respective increase of 1.69 and 1.60 times over 100% RDF. During second year (2016-17) the highest total uptake (2.07 g ha^{-1}) of Cd was recorded in 75% RDF + 25% N through sewage sludge followed by customized fertilizer (1.73 g ha^{-1}) which was 1.2 and 0.8 times higher over 100% RDF and 2.8 and 2.2 times higher over control, respectively in II rice. The maximum (7.08 g ha^{-1}) total chromium uptake of I rice was recorded in 75% RDF + 25% N through sesbania and minimum in control (T_1). The treatments which received 100% RDF, customized fertilizer, 75% RDF + 25% N through sewage sludge and 75% RDF + 25% N through vermicompost did not significantly differ to each other. The total uptake of chromium varied from 0.20 to 2.63 g ha^{-1} in I wheat. Treatment T_2, T_3, T_4, T_6 and T_7 were significantly at par with each other. The total nickel uptake of I rice varied from 0.38 to 2.01 g ha^{-1}. The highest (7.54 g ah^{-1}) total uptake of nickel was recorded in 100% RDF + S_{40}, Zn_5, $B_{1.5}$ followed by 75% RDF + 25% N through sesbania (7.08 g ha^{-1}) which was 59 and 49% higher over 100% RDF (T_2), respectively. The total uptake of nickel in I wheat varied from 4.87 to 23.11 g ha^{-1}. The total uptake of lead varied from 0.24 to 0.71 g ha^{-1} in I rice. The highest (0.71 g ha^{-1}) total uptake of lead was recorded in 75% RDF + 25% N through sewage sludge and minimum was recorded in control in I rice. The highest total uptake of I wheat was recorded in treatment (T_5) in which sewage sludge was applied in I rice. During second year, the highest total uptake of lead was recorded in 75% RDF + 25% N through sewage sludge and minimum was recorded in control in II rice. The total uptake of lead varied from 0.018 to 0.179 g ha^{-1} in II wheat. The treatment T_3, T_4 and T_6, T_7 were statistically at par with each other in II wheat.

Keywords: Organic and inorganic source of nutrients, customized fertilizer, heavy metals, sewage sluge, vermicompost, *sesbania*, rice- wheat

Introduction

Organic amendments as sewage sludge, vermicompost and sesbania invariably contain all essential plant nutrients, which are released into the soil solution upon their decomposition by microorganisms. Green manuring before transplanting of rice has been advocated to improve yields and to partially substitute for nitrogen requirement of the crop (Singh 1984). Addition of organic manures with inorganic fertilizers to soil has been reported to increase the efficiency of applied fertilizers (Ahmad *et al.* 1998) [1]. Residual effect of green manuring plus 100% recommended dose of NPK significantly increased the yield of wheat over 100% recommended dose of NPK (Majumdar *et al.*, 2014) [8, 9]. Additions of green manure resulted in higher removal of nutrients by the crops as compared to chemical fertilizers and buildup of soil N, P, K, Zn and organic carbon while reducing the soil pH (Sharma *et al.* 2001) [18]. that of water. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment; raising concerns over their potential effects on human health and the environment. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. Heavy metal contents of agricultural soils can affect human health directly through consumption of crops grown in contaminated soils. Rice is the staple food of 90% of people of Asia and it is one of the major sources of Cd and Pb intakes for humans. Plants absorb heavy metals from the soil, the surface 25 cm depth zone of soil is the most affected by such pollutants resulting from anthropogenic activities. Application of high amount of sewage sludge and industrial effluents in agriculture also supply the undesirable levels of heavy metals which influence the physical chemical and biological properties of soils. Metals such as Cr, Cu and Co etc. are essential for plant metabolism, but at levels exceeding food and fodder safety levels, they pose sever health risk (Wang *et al*., 2012; Katnoria *et al*., 2011) [6]. Heavy metal contents in soils and crops are dependent on the soil physico-chemical properties, cropping practices, availability and species of metal in soil, solubility of metals in soil and type of plant (Sinha *et al*., 2006; Dheri *et al*., 2007) [4]. Heavy metals accumulate in this soil layer due to the relatively high organic matter content (Zang and ke, 2004 and Fangmin *et al*., 2006) [5]. This depth zone is also where roots of most cereal crops are located (Ross, 1994 and Mico *et al*., 2007) [10]. A number of chemicals are applied in soil as a source of plant nutrients, mitigation of insect pest infestation and disease control. On the other hand, application of high amount of sewage sludge and industrial effluents in agriculture also supply the undesirable levels of heavy metals which influence the physical chemical and biological properties of soils.

In the backdrop of the above facts, heavy metals uptake were asses in the experiment having substitution of a part of chemical fertilizers through organic sources (sewage sludge, vermicompost and sesbania) of nutrients.

Materials and Methods

The experiment was laid out in a randomized block design in 8.0 × 3.2 m net plot size with three replications and eventreatments as per details presented in Table 1. The N, P, K, S, Zn, and B were applied through urea, DAP, MOP, gypsum, zinc sulfate and borax, respectively. The recommended dose of fertilizer (RDF) was N, P_2O_5 and K_2O @ 150, 60 and 60 kg ha^{-1}, respectively. The S, Zn and B were applied @ 40:05:1.5 kg ha^{-1} in T_3 where as in T_4 a customized fertilizer developed by Tata Chemical with composition N: P_2O_5: K_2O: S: Zn: 10:26:17:1.0:0.3 was used in rice and 10:18:25:4:0.5:0.2 N: P_2O_5: K_2O: S: Zn: B in wheat as basal treatment @ 250 kg ha^{-1}. Half dose of N and full dose of P_2O_5 and K_2O was applied as basal. Remaining half dose of N was applied in two equal splits at 30 and 60 days after sowing in each plot. The amount of vermicompost, sewage sludge ans Sesbania were calculated on the basis of their N content to suppliment 25% of nitrogen and incorporated in plots on 10 days before of transplanting of rice. Twenty five days old seedlings of rice were transplanted keeping a distance of 20 cm from row to row and 15 cm from plant to plant. Intercultural operations were done to ensure normal growth of the crop. Straw and grain samples were collected after harvest of each crop, from each plot and processed.

Agriculture Research Farm, BHU, Varanasi lies in the Northern Gangetic Alluvial plain (25°18' N, 83°03' E at 129 m above the mean sea-level). Varanasi falls in a semi-arid to sub humid climate with moisture deficit index between 20-40. The normal period for onset of monsoon in this region is the 3rd week of June which lasts up to end of September or sometimes extends up to the first week of October. Showers of rain are often experienced during winter season. The annual rainfall of this region is about 1100 mm. Generally, the maximum and the minimum temperature ranged between 20^0 – 42 ^{0}C and 9^0 - 28 ^{0}C, respectively. May and June are the hottest months with maximum temperature ranging from 39^0 to 42 ^{0}C. The cold period lies between November and January with the minimum temperature varying between 9^0-10^0C. The mean relative humidity is about 68% which rise to 82% during wet season and goes down to 30% during dry season.

Grain and straw samples were digested in di-acid mixture (4:1 v/v HNO3: HClO4) (Tandon, 2001) [21]. Heavy metals (Cd, Cr, Ni, Pb) in the digest were estimated using atomic absorption spectrophotometer (Model. Agilent FS- 240).

Results and Discussion

Uptake of heavy metals in straw and grain of rice and wheat Cadmium

The data (Table 2) revealed that the Cd uptake in grain of 1st rice varied from 0.09 to 0.75 g ha^{-1}, whereas, in I wheat, it ranged between 0.02 to 0.08 g ha^{-1}. The maximum Cd uptake in I rice (0.75 g ha^{-1}) and in 1st wheat (0.08 g ha^{-1}) was recorded in treatment T_5 (75% RDF + 25% N through sewage sludge), whereas, the minimum was recorded in control (T_1). The application of 75% RDF + 25% N through sewage sludge, 75% RDF + 25% N through sesbania (T_5 and T_7) significantly increased the Cd uptake in grain by 97 and 84% over 100% RDF in 1st rice and and residual effect on wheat was recorded in T_5 (100% RDF) and T_4 (customized fertilize) which was 33 and 16% higher over T_2 (100% RDF), respectively in I wheat. The Cd uptake in straw varied from 0.50 to 2.41 g ha^{-1} in I rice and 0.03 to 0.14 g ha^{-1} in I wheat. During II year, the maximum Cd uptake of grain and straw was recorded in 75% RDF + 25 % N through sewage sludge in II rice and II wheat and minimum was recorded in control (T_1). This may be attributed to the Cd content of the sewage sludge.

The total uptake of Cd ranged between 0.59 to 2.91 and 0.05 to 0.22 in 1st rice and 1st wheat, respectively (Table 1). During two years of crop cycle, the highest total uptake of Cd was recorded in I rice (2.91 g ha^{-1}) with customized fertilizer followed by 75% RDF +25% N through sewage sludge (2.81 g ha^{-1}) and 100% RDF (2.30 g ha^{-1}) which was 1.7, 1.6, 1.1 times and 4, 3.7 and 2.8 times higher, over 100% RDF (1.08 g ha^{-1}) and control (0.59 g ha^{-1}). The total uptake of Cd in 1st wheat ranged between 0.05 to 0.22 g ha^{-1}. During II year (2016- 17), the data indicated that highest total uptake of Cd (2.07 g ha^{-1}) at 75% RDF + 25% N through sewage sludge plot in II rice. The result are in agreement with cadmium uptakes by rice, soybean and maize that were grown in soil contaminated by cadmium (Murakami *et al*., 2007 and Sampanpanish and Pongpaladisai 2011) [17]. Similar results of increase in uptake pattern of Cd were also reported by Ramachandran D'souza (1999) and Oliveira *et al.* (2006) [12, 15].

Chromium

The data (Table 2) showed that the Cr uptake in I rice varied from to 0.38 to 2.00 g ha^{-1}, whereas, in I wheat it ranged between 0.05 to 0.89 g ha^{-1}. The maximum Cr uptake in grain of I rice (2.00 g ha^{-1}) and in I wheat (0.89 g ha^{-1}) was recorded in treatment T_3 (100% RDF + $S4_0$, Zn_5, $B_{1.5}$) and T_5 (RDF + 25% N with sewage sludge). The graded application of 100% RDF + S_{40}, Zn_5, $B_{1.5}$, customized fertilizer and 75% RDF + 25% N through sesbania (T_3, T_4 and T_7) significantly increased the Cr uptake in grain by 2.2, 2.1, 1.7 times an 4.2, 4.0 and 3.3 times over 100% RDF and control in I rice. During the second year of the experiment, the Cr uptake in straw ranged between 2.28 to 5.53 and 0.15 to 1.74 g ha^{-1} in I rice and I wheat, respectively. The treatment 100% RDF with S, Zn, B and 75% RDF with 25% N through sesbania treated plot had statistically similar results because no significantly changed in Cr uptake of II rice grain was noted. The treatments (T_3 to T_7) were significantly increased in Cr uptake over 100% RDF. The similar trends was also found for Cr uptake of II wheat grain. The Cr uptake of II rice straw varied from 1.73 to 4.30 g ha^{-1} and the treatment T_6 and T_7 was statistically at par with each other.
Total Cr uptake of varied from 2.67 to 7.53 g ha^{-1} in I rice and 0.20 to 2.63 g ha^{-1} in I wheat (Table 1). The highest total uptake of Cr in I rice was found in 100% RDF + S_{40}, Zn_5, $B_{1.5}$, followed by 75% RDF + 25% N through sesbania and the lowest in control plot in both the crop. In I wheat, the highest total uptake of Cr was found in T_5 in which sewage sludge was applied followed by treatment T_3 (1.63 g ha^{-1}) and minimum was in control. During II year (2016- 17), vermicompost treated plots resulted in higher total uptake of Cr in II rice by 1.59 and 0.7 times over control and 100% RDF, respectivelly. The total uptake of Cr varied from 0.11 to 2.02 g ha^{-1} and the minimum was obtained in control in II wheat. Similar result was also found by Latare *et al*., 2014. Significant Cr increase in maize roots by increasing sludge application was noticed by Rabie *et al*., 1997 [14].

Nickel

The data (Table 3) showed that the Ni uptake of grain in I rice varied from 0.38 to 2.01 g ha^{-1}, whereas, in I wheat it ranged between 1.56 to 10.52 g ha^{-1}. The application of 100% RDF + S_{40}, Zn_5, $B_{1.5}$ (T_3) significantly increased the Ni uptake in grain of I rice by 2.2 and 4.2 times over 100% RDF and control and in I wheat, the highest uptake of Ni in grain was recorded in customized fertilizer (T_4) which was 5.7 times higher over control.
During second year of the experiment, the Ni uptake in grain ranged between 0.52 to 2.04 g ha^{-1} and 0.81 to 7.80 g ha^{-1} in II rice and II wheat, respectively. The maximum Ni uptake in II rice (2.04 g ha^{-1}) and II wheat (7.80 g ha^{-1}) was recorded in T_4 (customized fertilizer). Silmilar result was also found with respect to the uptake of Ni in straw of rice and wheat during the course of study.
The total Ni uptake by I rice varied from 2.67 to 7.08 g ha^{-1} (Table 3). Total Ni uptake under 100% RDF with S_{40}, Zn_5, $B_{1.5}$ was significantly greater than that in other treatments. The highest total Ni uptake was observed in 100% RDF with S_{40}, Zn_5, $B_{1.5}$ though it remained at par with treatment 75% RDF + 25% N through sesbania, but found significantly superior to 100% RDF and other treatments in I rice.

Lead

The data pertaining to Pb uptake in rice and wheat grain has been presented in Table 3. The Pb uptake in I rice varied from 0.09 to 0.36 g ha^{-1}, whereas, in I wheat, it ranged between 0.004 to 0.042 g ha^{-1}. The maximum Pb uptake in I rice (0.36 g ha^{-1}) and in I wheat (0.042 g ha^{-1}) was recorded in treatment which received 75% RDF + 25% N through sewage sludge for rice and its residual effect on wheat. Similar trend was recorded in grain and straw of both the crop during study.
The total uptake of Pb varied from 0.24 to 0.71 and 0.009 to 0.089 in I rice and I wheat the maximum being in 75% RDF + 25% N through sewage sludge and 100% RDF (T_5), respectively and the minimum in control (Table 3). In I rice, treatments 75% RDF + 25% N through sewage sludge and 75% RDF + 25% N through vermicopost recorded 1.9 and 1.7 times increase in Pb content over 100% RDF (T_2). The highest Pb uptake (0.089 g ha^{-1}) in 1st wheat was recorded in treatment T_5 which received 75% RDF + 25% N through sewage sludge in preceding rice and 100% RDF in wheat crop. During 2nd year, the highest total Pb uptake was recorded in 75% RDF + 25% N through sewage sludge (T_5) and 100% RDF in rice and wheat, respectively and the minimum was recorded in control. If exceed the maximum permissible limit (0.2 mg/kg), Pb in leafy vegetables may affect the nervous system, bones, liver, pancreases, teeth, and gum and causes blood disorders, when are consumed by human (Page *et al*., 1996 and Cheraghi *et al*., 2015) [13, 3]. Organic amendments increased soil DTPA- extractable heavy metals (Cd, Cr, Ni, Pb) this would have been responsible for increased uptake of these elements by rice and wheat. Increase in uptake of Cd, Cu and Zn by Barley plants and grains due to cumulative addition of sewage sludge was also reported by Antolin *et al*. (2005).

Table 1: Treatment schedule followed during the course of the investigation

Treatment symbols	Year of experimentation			
	2015-16		2016-17	
	I Rice	I Wheat	II Rice	II Wheat
T_1	Control-NPK (00-00-00)	Control-NPK (00-00-00)	Control-NPK (00-00-00)	Control-NPK (00-00-00)
T_2	RDF* - NPK (150-60-60) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}
T_3	RDF + S, Zn, B (40-05-1.5) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	RDF + S, Zn, B (40-05-1.5) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}
T_4	CF# [10:26:17:1.0:0.3] ($N:P_2O_5:K_2O:S:Zn$)	CF [10:18:25:4:0.5:0.2] ($N: P_2O_5: K_2O : S :Zn: B$)	CF [10:26:17:1.0:0.3] ($N:P_2O_5:K_2O:S:Zn$)	CF [10:18:25:4:0.5:0.2] ($N: P_2O_5: K_2O : S :Zn: B$)
T_5	75% RDF + 25% N through sewage sludge ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	75% RDF + 25% N through sewage sludge ha^{-1}	RDF- NPK (150-60-60) ha^{-1}
T_6	75% RDF + 25% N through Vermicompost ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	75% RDF + 25% N through Vermicompost ha^{-1}	RDF- NPK (150-60-60) ha^{-1}
T_7	75% RDF + 25% N through *Sesbania* (GM) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}	75% RDF + 25% N through *Sesbania* (GM) ha^{-1}	RDF- NPK (150-60-60) ha^{-1}

*Recommended dose of fertilizer (150 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1}) #CF – Customised fertilizer

Table 2: Effect of organic and inorganic sources of nutrients on uptake of cadmium and chromium (g ha^{-1}) in rice and wheat

Treatment	Grain				Straw				Total uptake (grain + Straw)			
	2015-16		2016-17		2015-16		2016-17		2015-16		2016-17	
	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat
	Cadmium											
T_1	0.09±0.03a	0.02±0.01a	0.13±0.01a	0.02±0.00a	0.50±0.05a	0.03±0.01a	0.41±0.04a	0.03±0.01a	0.59±0.07a	0.05±0.00a	0.54±0.05a	0.05±0.00a
T_2	0.38±0.01b	0.06±0.01b	0.39±0.02b	0.06±0.01b	0.70±0.04ab	0.10±0.01b	0.55±0.04ab	0.12±0.02b	1.08±0.05b	0.16±0.01b	0.94±0.05b	0.18±0.01b
T_3	0.47±0.02b	0.06±0.01b	0.49±0.03c	0.08±0.02b	1.83±0.23c	0.14±0.02b	1.13±0.01d	0.18±0.03bc	2.30±0.21d	0.20±0.02b	1.62±0.03d	0.25±0.04bc
T_4	0.50±0.05b	0.07±0.02b	0.47±0.02c	0.08±0.01b	2.41±0.09d	0.12±0.02b	1.26±0.13d	0.15±0.02bc	2.91±0.07e	0.19±0.02b	1.73±0.14d	0.23±0.02bc
T_5	0.75±0.08c	0.08±0.01b	0.73±0.05d	0.09±0.01c	2.06±0.25cd	0.14±0.02b	1.34±0.11d	0.20±0.02c	2.81±0.19e	0.22±0.03b	2.07±0.08e	0.29±0.03c
T_6	0.49±0.02b	0.05±0.01b	0.51±0.03c	0.06±0.01b	0.80±0.08ab	0.11±0.02b	0.79±0.10bc	0.15±0.02bc	1.28±0.08b	0.16±0.03b	1.30±0.12c	0.21±0.03b
T_7	0.70±0.10c	0.05±0.00a	0.66±0.02d	0.06±0.01b	1.16±0.14b	0.12±0.01b	1.04±0.13cd	0.15±0.01bc	1.86±0.22c	0.17±0.01b	1.71±0.13d	0.22±0.01bc
	Chromium											
T_1	0.38±0.10a	0.05±0.03a	0.53±0.14a	0.04±0.01a	2.28±1.14a	0.15±0.01a	1.73±0.49a	0.07±0.02a	2.67±1.06a	0.20±0.03a	2.26±0.36a	0.11±0.02a
T_2	0.61±0.11a	0.41±0.02b	0.61±0.10a	0.21±0.05b	4.11±1.32a	0.56±0.10ab	2.80±0.89ab	0.31±0.08ab	4.73±1.38ab	0.97±0.12b	3.41±0.97ab	0.53±0.09ab
T_3	2.00±0.46b	0.58±0.14bc	1.52±0.29b	0.30±0.07b	5.53±1.85a	1.05±0.10bc	4.05±0.98b	0.72±0.43ab	7.53±2.27b	1.63±0.18b	5.57±1.26b	1.02±0.50ab
T_4	1.91±0.17b	0.40±0.15b	1.52±0.12b	0.22±0.03b	4.76±1.39a	1.18±0.04c	3.32±0.80ab	1.34±0.53ab	6.67±1.27ab	1.59±0.17b	4.84±0.83b	1.57±0.50ab
T_5	1.54±0.32b	0.89±0.12c	1.79±0.23b	0.23±0.04b	4.13±0.06a	1.74±0.33d	2.77±0.21ab	1.79±0.64b	5.68±0.25ab	2.63±0.43c	4.56±0.18ab	2.02±0.65b
T_6	1.62±0.35b	0.60±0.12bc	1.55±0.19b	0.24±0.02b	5.04±0.38a	0.97±0.09bc	4.30±0.10b	1.22±0.43ab	6.65±0.22ab	1.57±0.21b	5.86±0.15b	1.47±0.44ab
T_7	1.65±0.23b	0.71±0.12bc	1.65±0.36b	0.24±0.09b	5.43±0.48a	0.92±0.14bc	3.96±0.47b	0.91±0.59ab	7.08±0.56b	1.62±0.25b	5.62±0.72b	1.15±0.54ab

*Treatment details Rice- T_1 Control N,P,K (00,00,00), T_2- 100 %RDF, T_3- RDF+ S, Zn, B (40-05-1.5), T_4- *CF ($N:P_2O_5:K_2O:S:Zn:B$: 10:18:25:04:0.5:0.2), T_5- 75% RDF+ 25% N through Sludge, T_6- 75% RDF+ 25% N through Vermicompost, T_7- 75% RDF+ 25% N through *Sesbania*
Wheat- T_1 Control N,P,K (00,00,00), T_2, T_3, T_5, T_6 and T_7- 100 %RDF, T_4- CF($N:P_2O_5:K_2O:S:Zn:B$:10:18:25:04:0.5:0.2)

Table3: Effect of organic and inorganic sources of nutrients on uptake of nickel and lead (g ha^{-1}) in rice and wheat

Treatment	Grain				Straw				Total uptake (grain + Straw)			
	2015-16		2016-17		2015-16		2016-17		2015-16		2016-17	
	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat
	Nickel											
T_1	0.38±0.10a	1.56±0.24a	0.52±0.14a	0.81±0.12a	2.28±1.14a	3.31±0.13a	2.46±0.59a	1.20±0.32a	2.67±1.06a	4.87±0.34a	2.99±0.50a	2.01±0.44a
T_2	0.62±0.11a	7.87±1.66b	0.63±0.06a	5.32±0.61b	4.11±1.32a	9.58±1.00b	3.67±0.63ab	4.71±0.25b	4.73±1.38ab	17.45±2.64b	4.30±0.68ab	10.03±0.46b
T_3	2.01±0.47b	8.67±1.36b	1.76±0.38b	7.51±0.92bc	5.53±1.85a	13.37±1.86b	4.11±0.82ab	6.92±0.49c	7.54±2.27b	22.04±2.94b	5.87±1.15b	14.44±1.11c
T_4	1.91±0.17b	10.52±0.89b	2.04±0.32b	7.80±0.86c	4.76±1.39a	12.59±1.54b	4.16±0.70ab	8.43±0.64c	6.67±1.27ab	23.11±2.10b	6.19±0.47b	16.23±1.08c
T_5	1.55±0.31b	7.67±0.80b	1.94±0.25b	7.27±0.73bc	4.13±0.06a	12.54±1.21b	3.59±0.33ab	6.81±0.41c	5.69±0.25ab	20.21±2.01b	5.53±0.31b	14.08±1.13c
T_6	1.62±0.35b	6.99±0.56b	1.78±0.14b	6.57±0.67bc	5.04±0.38a	10.10±1.00b	4.20±0.23ab	6.77±0.55c	6.66±0.22ab	17.09±1.32b	5.98±0.13b	13.34±1.09c
T_7	1.65±0.23b	7.73±1.70b	1.75±0.21b	6.55±0.75bc	5.43±0.48a	10.85±0.73b	4.59±0.59b	7.71±0.82c	7.08±0.56b	18.58±1.02b	6.33±0.77b	14.26±0.91c
	Lead											
T_1	0.09±0.03a	0.004±0.002a	0.13±0.04a	0.003±0.001a	0.15±0.04a	0.005±0.003a	0.13±0.03a	0.016±0.003a	0.24±0.07a	0.009±0.002a	0.26±0.07a	0.018±0.004a
T_2	0.20±0.05ab	0.013±0.003ab	0.22±0.02ab	0.041±0.002b	0.18±0.01ab	0.018±0.005ab	0.15±0.01ab	0.065±0.011b	0.39±0.05ab	0.031±0.003ab	0.38±0.01b	0.105±0.010b
T_3	0.27±0.02bc	0.019±0.003ab	0.27±0.02bc	0.059±0.010b	0.26±0.03ab	0.018±0.007ab	0.20±0.01b	0.097±0.021bc	0.53±0.02bc	0.038±0.006ab	0.47±0.01b	0.156±0.014bc
T_4	0.30±0.03bc	0.036±0.004c	0.32±0.05bcd	0.049±0.015b	0.33±0.06b	0.019±0.010ab	0.31±0.03c	0.102±0.010bc	0.63±0.04cd	0.055±0.012b	0.64±0.03c	0.152±0.006bc
T_5	0.36±0.01c	0.042±0.004c	0.41±0.01d	0.055±0.014b	0.34±0.04b	0.047±0.003c	0.31±0.03c	0.124±0.013c	0.71±0.03d	0.089±0.006c	0.72±0.02c	0.179±0.027c
T_6	0.33±0.04c	0.016±0.010ab	0.36±0.05cd	0.042±0.010b	0.32±0.07b	0.030±0.007bc	0.32±0.03c	0.063±0.015b	0.65±0.08cd	0.047±0.016b	0.67±0.06c	0.105±0.025b
T_7	0.34±0.05c	0.027±0.006bc	0.37±0.02cd	0.033±0.008ab	0.30±0.07ab	0.026±0.010abc	0.28±0.02c	0.070±0.015b	0.64±0.02cd	0.053±0.013b	0.65±0.01c	0.103±0.023b

*Treatment details Rice- T_1 Control N,P,K (00,00,00), T_2- 100 %RDF, T_3- RDF+ S, Zn, B (40-05-1.5), T_4- *CF ($N:P_2O_5:K_2O:S:Zn:B$: 10:18:25:04:0.5:0.2), T_5- 75% RDF+ 25% N through Sludge, T_6- 75% RDF+ 25% N through Vermicompost, T_7- 75% RDF+ 25% N through *Sesbania*
Wheat- T_1 Control N,P,K (00,00,00), T_2, T_3, T_5, T_6 and T_7- 100 %RDF, T_4- CF($N:P_2O_5:K_2O:S:Zn:B$:10:18:25:04:0.5:0.2)

Conclusion

The results of this study demonstrate that by using sludge, vermicompost and sesbania to supplement a part of chemical fertilizers higher uptake of Cd, Cr, Ni and Pb has been observed. The sewage sludge should be applied under strict scientific monitoring to avoid the heavy metals contamination of rice and wheat grain.

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