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Direct and residual effect of organic amendments (sewage sludge, vermicompost, sesbania) with chemical fertilizers on heavy metals (Cd, Cr, Ni and Pb) content under rice–wheat system

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Abstract

Field experiments were conducted for three years in sandy loam soil to study the direct effect of organic manures i.e. sewage sludge (SS), vermicompos (VC) and sesbania (SB) with chemical fertilizers on rice (*Oryza sativa*) and their residual effect on wheat (*Triticum aestivum*) grown in sequence in winter (*Rabi*) and summer (Kharif) season during 2015-16 and 2016-17 at Varanasi, Uttar Pradesh. Twenty five percent nitrogen through supplement organic sources with 75% recommended dose of fertilizers, customized fertilizer, 100% RDF with S, Zn, B applied to rice and their effects were compared with the recommended dose of fertilizers i.e., 150, 60 and 60 kg N, P_2O_5 and K_2O ha^{-1} and control, respectively. There was significant increase the concentration of Cd and Pb (straw and grain) of both the crops (grain and straw) with application of 75% RDF + 25% N through sewage sludge. The highest concentration of Cr in I rice grain was recorded in customized fertilizer and in I rice straw was highest in 75% RDF + 25% N through sesbania and minimum in control. The highest Cr concentration of I wheat grain increased 78% at residual effect of sludge application of previous rice over 100% RDF (T_2) similar trend was recorded in concentration of Cr in I wheat straw. During second year the highest Cr content in II rice grain and straw was varied between 1.49 to 4.03 mg kg^{-1} and 3.82 to 7.93 mg kg^{-1}. The highest (4.03 mg kg^{-1}) content of Cr in II rice grain was recorded in 75% RDF with 25% N through sewage sludge which was 1.7 times increased respectively, over 100% RDF. The treatment T_5, T_6 and T_7 which receive 25% N supplement through organic sources were statistically at par with each other in II rice grain. Application of 75% RDF + 25% N through vermicompost increased the Cr content in II rice straw followed by 100% RDF + S, Zn, B which was 28 and 18% respectively, over 100% RDF. All the treatment of statistically at par with each other in II rice Cr content of straw. The Cr content in II wheat (grain and straw) which was statistically at par with each other. The Ni content in I rice grain was highest (4.32 mg kg^{-1}) in customized fertilizer and minimum in control. The treatment T_2 to T_7 show no significantly change from one other but increased in 100% RDF. Similar result was found in I rice straw content of Ni. The similar result was found that no significantly change with all seven treatment in Ni content of I wheat (grain and straw). The highest (4.49 mg kg^{-1}) content of Ni grain in II rice was recorded in customized fertilizer followed by sewage sludge treated plot and then vermicompost which was 1.9, 1.8 and 1.6 times increased respectively, over 100% RDF and control was 0.65% decreased over control. The Ni content of II rice straw was recorded no significant changes in all the seven treatments. The highest (17.21 mg kg^{-1}) Ni content in II wheat grain was recorded in residual effect of supplement through sewage sludge and minimum was in control. Treatment T_3 to T_7 was recorded in no significant changes one other in II wheat Ni grain content. The highest Ni content in II straw was recorded in 25% N supplement through sesbania with RDF and minimum was recorded in control. The minimum Ni content in II wheat straw was recorded in control which was 31% decreased over 100% RDF.

Keywords: organic and inorganic sources of nutrients, chemical fertilizers, customized fertilizers, sewage sludge, vermicompost, sesbania, rice- wheat

1. Introduction

Rice (*Oryza sativa* L.) wheat (*Tritcum aestivum* L.) (RW) cropping system has been developed through the introduction of rice in the traditional wheat-growing areas and vice versa in India (Paroda *et al.,* 1994) [14]. In the mid-1960s, Green Revolution technologies led to the emergence of RW as the major production system covering an area of 10 million hectares spread over the Indo-Gangetic Plains (IGP) of India (Singh and Sidhu 2013). About one-third of the total cereals of India are produced in this region. It is the most important cropping system and stands first in coverage. The system covers an area of about 23% of rice and 40% of wheat, and both crops together contribute 85% of the total cereal production contributing substantially to national food basket (Katyal *et al.*, 1998) [5].

The high input agriculture has led to self-sufficiency in food-grains but it has posed several new challenges.

The conversion of modern agriculture into organic agriculture is now widely debated. Growing of high yielding varieties with indiscriminate use of fertilizers, poor water management practices and inefficient plant-protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce (Pradhan and Mondal, 1997) [15]. The productivity of most of the crops is declining. Hence, conversion of modern chemical intensive agriculture to a more sustainable form of agriculture appears to be an option for maintaining the desirable agricultural production in future (Modgal *et al*., 1995) [10].

Heavy metal contents of agricultural soils can affect human health directly through consumption of crops grown in contaminated soils. A clear evidence linking human renal tubular dysfunction with contamination of rice with Cd in subsistence farms in Asia. Indeed, rice is the staple food of 90% of people of Asia and it is one of the major sources of Ca and Pb intakes for humans (Chaney *et al*., 2005) [2]. 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 (Moon *et al*., 1995 and Simbo *et al*., 2001) [11] Heavy metals accumulate in this soil layer due to the relatively high organic matter content (Zhang and Ke 2004) [22]. This depth zone is also where roots of most cereal crops are located (Ross 1994 and Mico *et al*., 2007) [12].

Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are cadmium (Cd), chromium (Cr), nickel (Ni) and lead (Pb) (Gwrtac 1997). Soils are the major sinks for heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation (Kirpichtchikova *et al*. 2006) [21], and their total concentration in soils persists for a long time after their introduction (Adriano, 2003) [3]. The critical values for Cd, Ni and Pb are 3–6, 75–150, and 250–500 µg g^{-1}, respectively (Nagajyoti *et al*., 2010). The presence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants (Maslin and Maier 2000) [13].

2. Materials and Methods

The field experimental was conducted at the Agricultural Research Farm, Banaras Hindu University, Varanasi (UP) India during *kharis* and *Rabi* from 2015-16 and 2016-17 with rice and wheat system. The research farm lies in the Northern Gangetic Alluvial plain at 25o18´ North latitudes, 83º03´ East longitude and at an altitude of 128.93 meters above the mean sea level. The applied organic sources of plant nutrients were sewage sludge, vermicompost and *Sesbania* that had 1.3, 0.8 and 2.1% N, respectively. The dried sewage sludge collected from Sewage Treatment Plant, Bhagwanpur, Varanasi (UP), vermicompost and sesbania are collected from Agriculture Research farm, Institute of Agricultural Sciences, BHU, Varanasi. The experiment was laid ut in a randomized block design in 8.0 × 3.2 m net plot size with three replications and seven treatments 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) were N, P_2O_5 and K_2O @ 150, 60 and 60 kg ha^{-1}, respectively. The Zn, B and S 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} as basal treatment. 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. The content of Cd, Cr, Ni and Pb in the diacid digest mixture (3:1 v/v HNO_3: $HClO_4$) was determined using atomic absorption spectrophotometer (Agilent FS- 240). The DTPA extractable Cd, Cr, Ni and Pb (Lindsay and Norwell, 1978) by atomic absorption spectrophotometer (Agilent FS- 240) following the procedure outline in Sparks (1996) [20].

Table 1: The treatment schedule followed during the course of the investigation is as under:

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^{-}	RDF- NPK (150-60-60) ha^{-1}	RDF + S, Zn, B (40-05-1.5) ha^{-}	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, Field operations conducted during the course of the study is presented in table 3.5

2.1 Statistical analysis

The data of three years of study were pooled and subjected to one-way analysis of variance (ANOVA) using SPSS version 16 software. Duncan's multiple range test (DMRT) was performed to test the significance of difference between the treatments.

3. Results and Discussion

3.1 Heavy metals content in rice and wheat

3.1.1 Cadmium

The Cd contents in grain (Table 2) varied from 0.34 to 1.86 mg kg^{-1} in I rice and 0.12 0.21 mg kg^{-1}, respectively in I wheat. The Cd content in I rice grain at 100% RDF, 100% RDF + S, Zn, B, customized fertilizer and 75% RDF + 25% N through sewage sludge statistically at par with each other because no significantly different from one other. The Cd content of I wheat grain found that all the seven treatment are showing similar result were found no significantly different one other. The treatment 100% RDF (T_2) was increased over control. The straw Cd content of I rice was varied from 0.93 to 3.27 mg kg^{-1}. The application of 75% RDF with 25% N though sewage sludge observed highest Cd content in I rice straw followed by customized fertilizer and RDF with S, Zn, B which was 1.8, 2.3 and 1.0 times increased respectively, over 100% RDF. The treatment which received 100% RDF with S, Zn, B and significantly change over 100% RDF. The Cd content of I wheat straw were no significant change in all the treatment because all the treatments showing similar affect. During second year II rice and II wheat Cd content in grain was recorded the treatment T_2, T_3 and T_4 was statistically at par with each other, no significantly changed all the three treatment for both crop. The highest Cd content in straw was recorded in sewage sludge treated plot which was 72 and 37.5% increased respectively, over 100% RDF in II rice and II wheat. Sewage sludge contains nutrients, therefore, the concentration of Cd in II rice and wheat straw of both crops increased with the increase in application of 75% RDF with 25% N through sewage sludge.

Latare *et al*. (2014) [6] found that the maximum concentration of Cd was observed in treatment which received 40 t ha^{-1} sludge with 100% RDF with respective increase over 100% RDF by 83%. The residual effect of sludge on Cd accumulation in wheat straw was only effective at higher levels. Application of 40 t ha^{-1} sludge increased 45% of Cd content in wheat straw over 100% RDF.

3.1.2 Chromium

There was significantly increased in Cr content with application of 25% N through sewage sludge, vermicompost, sesbania along with 75% RDF. The grain content of Cr varied from 1.51 to 4.32 mg kg^{-1} and 0.46 to 2.11 mg kg^{-1}, respectively in I rice and I wheat. The maximum content was observed with application of customized fertilizer followed by 100% RDF with S, Zn, B and 75% RDF with 25% N through sewage sludge which were 1.7, 1.6 and 1.4 times increased over 100% RDF alone (T_2). The residual effect of sewage sludge observed maximum Cr content in I wheat and minimum was recorded in control (T_1). The residual effect of organic treated plots (T_5, T_6, T_7) were statistically at par with each other i.e. similar result were found in all organics treated plots in Cr content of I wheat grain. The lowest value of Cr in I wheat grain was recorded in control (T_1).

During II year the maximum Cr content of II rice was recorded in supplement a part of N through sewage sludge (T_5) followed by 25% N through vermicompost and sesbania along with 75% RDF (T_6 and T_7) which was 1.7, 1.3 and 1.4 times increased over 100% RDF (T_2).The minimum Cr content was recorded in 100% RDF (T_2) which was 4% decreased over control (T_1). In II wheat, Cr content of grain was statistically at par with all the seven treatment with each other no significantly changed one other.

The Cr concentration varied from 4.07 to 7.93 mg kg^{-1} and 1.06 to 3.95 mg kg^{-1} in I rice and wheat straw. The Cr content in I rice straw were statistically at par with all the treatments with each other, however no significantly change with one other. The residual effect of sewage sludge treated plots recorded maximum Cr content in I wheat followed by customized fertilizer and then treatment which received vermicompost and sesbania (T_6 and T_7) which were 1.5, 0.62 and 0.51 times increased respectively, over 100% RDF (T_2).

During second year Cr content range from 3.82 to 7.93 and 0.51 to 3.18 mg kg^{-1} in II rice and wheat straw. The application of 25% N through vermicompost along with 75% RDF was maximum Cr content in II rice straw. The content of Cr in II rice and II wheat straw were statistically at par with all treatment with each other in both the crop because similar result was found in all the treatments.

The normal range of Cr in plants is considered 0.03-14.00 mg kg^{-1}, while the toxic concentrations fall between 5-30 mg kg^{-1} (Alloway and Ayers, 1997) [1]. This suggests that plant Cr in this study was in the normal range.

3.1.3 Nickel

The Ni content (Table 3) showed a significant effect with graded application of 100% RDF with S, Zn, B and customized fertilizer in I rice grain. Its content in I rice grain varied between 0.38 to 2.01 g ha^{-1}, maximum was recorded in 100% RDF with S, Zn, B and minimum in control (T_1). Treatments 100% RDF with S, Zn, B and customized fertilizer recorded 2.2 and 2.0 times increase in Ni content over 100% RDF (T_2) in I rice grain. The Ni content in rice plant and grain was well within the critical levels for its toxicity (10-100 mg kg^{-1}) as reported by Alloway and Ayers (1997) [1]. The treatment which received sewage sludge, vermicompost and sesbania was statistically at par with each other in I rice grain. The Ni content on I wheat grain varied from 1.56 to 10.52 g ha^{-1}. The maximum was recorded in customized fertilizer and minimum in control in I wheat grain. The Ni content which received residual effect of organic amendments treatments along with 75% RDF (T_5, T_6 and T_7) were found statistically at par with 100% RDF (T_2) in I wheat grain.

During II year Ni content varied from 0.52 to 2.04 g ha^{-1} and 0.81 to 7.80 g ha^{-1} II rice and II wheat grain. The maximum Ni content of grain was recorded in customized fertilizer followed by sewage sludge and vermicompost treated plots which was 1.2, 2.0 and 1.8 times increased over 100% RDF (T_2) in II rice. The organic treatments (T_5, T_6, T_7) were statistically at par with each other in II rice and II wheat grain. The maximum Ni content was recorded in customized fertilizer and minimum in control in II wheat grain.

A significant increase in Ni content of rice and wheat straw was recorded with application of 100% RDF with S, Zn, B and customized fertilizer (Table 2). The K content in straw significantly ranged between 2.28 to 5.53% in I rice and 3.31 to 13.27% in I wheat. The Ni content of straw was significantly similar result were found with application of organics treated plots (T_5, T_6 and T_7) in I rice and I wheat straw. The treatment which received 25% N through sewage sludge, vermicompost and sesbania with 75% RDF (T_5, T_6 and T_7) was significantly increased by 0.4, 22 and 32% over 100% RDF in I rice and 30, 5 and 13% Ni content in I wheat straw. During second year the Ni content in straw was found in similar trend was recorded in both crop.

3.1.4 Lead

Lead content in grain (Table 3) varied between 0.09 to 0.36 mg kg^{-1} and 0.004 to 0.042 mg kg^{-1} maximum being in sewage treated plots (T_5) and minimum in absolute control (T_1) in I rice and I wheat. Treatments which received 25% N through sewage sludge, vermicompost and sesbania along with 75% RDF (T_5, T_6 and T_7) increased Pb content in grain by 80, 65, 70%, and 223, 23 and 1.7% respectively, over 100% RDF in I rice and I wheat. A significant increase in Pb content in I rice and I wheat grain was observed with application of sewage sludge. Application of 100% RDF with S, Zn, B (T_3) was significantly 27 and 46% increased over 100% RDF (T_2) in I rice and I wheat Pb content of grain.

During second year the application of 25% N through sewage sludge significantly increased by 85 and 34% in II rice and II wheat Ni content of grain. Sole application of 100% RDF (T_2) was significantly decreased over 100% RDF with S, Zn, B and customized fertilizer. The treatments T_2, T_3, T_4, T_5, T_6 and T_7 were similar result found no significantly change with each other in Pb content of II wheat grain.

A significantly increased in Pb content in straw with the application of 25% N through sewage sludge with 75% RFF followed by customized fertilizer and 25% N through vermicompost along with 75% RDF which was 88, 83 and 77% over 100% RDF (T_2). Treatment with the application of 25% N through sewage sludge and vermicompost along with 75% RDF (T_5 and T_6) in I rice and I wheat, were found statistically at par with T_2 (100% RDF) in straw content of Pb. Similar trend were found in II rice and II wheat Pb content of straw.

The concentrations of heavy metals were higher in straw and grain of rice as compared to wheat. This might be due to the direct application of sewage sludge in rice. Singh and Agrawal (2010a, b) [18] also reported increase in heavy metal concentration in the above ground parts of rice with application of sewage sludge. Dar *et al*. (2012) found that the increase in content of Cd, Ni and Zn ranged from 0.074-0.149, 1.37-2.69 and 26.60-40.40 mg kg^{-1} respectively in grain and 0.123-0.199, 0.61-2.16 and 35.00-45.20 mg kg^{-1} respectively in straw. Concentration of Cd, Ni and Zn in rice grain and straw were highest in the treatment comprising application of fertilizer nitrogen with fly ash and organic compost (Lee *et al*. 2006) [7].

Application of sewage sludge along with chemical fertilizers increased Ni, Cr, Cd and Pb content in rice straw and grain. There was about 7, 5, 5 and 10 times increase in Cd, Cr, Ni and Pb concentration, respectively, in rice grain and about 7, 3, 7 and 2 times increase in rice straw over control (Latare *et al*. 2014) [6].

Table 2: Effect of organic and inorganic sources of nutrients on concentration of cadmium and chromium (mg kg^{-1}) in rice wheat

Treatment			Grain				Straw			
			2015-16		2016-17		2015-16		2016-17	
	Rice	Wheat	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat
	Cadmium									
T_1	Control N,P,K (00,00,00)	Control N,P,K (00,00,00)	0.34±0.10a	0.21±0.05 a	0.38±0.05a	0.18±0.03a	0.93±0.05a	0.22±0.05 a	0.92±0.05a	0.23±0.05a
T_2	100 %RDF	100 %RDF	0.96±0.04b	0.19±0.04 a	0.95±0.05b	0.16±0.02ab	1.15±0.05ab	0.27±0.03 a	1.20±0.03ab	0.25±0.03a
T_3	RDF+ S, Zn, B (40-05-1.5)	100 %RDF	0.96±0.06b	0.14±0.01 a	1.08±0.06b	0.17±0.03ab	2.40±0.24c	0.30±0.05 a	2.02±0.02cd	0.29±0.05a
T_4	*CF ($N:P_2O_5:K_2O$:S:Zn: 10:26:17:01.0:0.3)	*CF($N:P_2O_5:K_2O$:S:Zn:B: 10:18:25:04:0.5:0.2)	1.13±0.06b	0.15±0.03 a	1.05±0.05b	0.17±0.02ab	3.19±0.19d	0.26±0.04 a	2.26±0.18d	0.25±0.03a
T_5	75% RDF+ 25% N through Sludge	100 %RDF	1.86±0.18c	0.18±0.01 a	1.64±0.11c	0.22±0.02b	3.27±0.43d	0.32±0.05 a	2.72±0.13e	0.34±0.04a
T_6	75% RDF+ 25% N through Vermicompost	100 %RDF	1.13±0.04b	0.13±0.02 a	1.15±0.03b	0.13±0.02ab	1.23±0.15ab	0.26±0.05 a	1.46±0.18b	0.27±0.04a
T_7	75% RDF+ 25% N through *Sesbania*	100 %RDF	1.60±0.23c	0.12±0.01 a	1.48±0.06c	0.15±0.02ab	1.69±0.25b	0.30±0.02 a	1.88±0.11c	0.28±0.01a
	Chromium									
T_1	Control N,P,K (00,00,00)	Control N,P,K (00,00,00)	1.51±0.42a	0.46±0.28a	1.55±0.41a	0.48±0.12a	4.07±1.90a	1.06±0.09a	3.82±0.95a	0.51±0.19a
T_2	100 %RDF	100 %RDF	1.55±0.33a	1.18±0.08ab	1.49±0.26a	0.57±0.12a	6.86±2.27a	1.54±0.26ab	6.18±1.94a	0.65±0.14a
T_3	RDF+ S, Zn, B (40-05-1.5)	100 %RDF	4.06±0.86b	1.34±0.34abc	3.37±0.67b	0.68±0.16a	7.16±2.31a	2.26±0.17ab	7.29±1.84a	1.19±0.70a
T_4	*CF ($N:P_2O_5:K_2O$:S:Zn: 10:26:17:01.0:0.3)	*CF($N:P_2O_5:K_2O$:S:Zn:B: 10:18:25:04:0.5:0.2)	4.32±0.44b	0.86±0.33ab	3.38±0.32b	0.49±0.07a	6.25±1.80a	2.51±0.08b	5.94±1.42a	2.24±0.88a
T_5	75% RDF+ 25% N through Sludge	100 %RDF	3.85±0.81b	2.11±0.24c	4.03±0.57b	0.54±0.10a	6.54±0.02a	3.95±0.84c	5.63±0.19a	3.18±1.18a
T_6	75% RDF+ 25% N through Vermicompost	100 %RDF	3.78±0.78b	1.46±0.32bc	3.49±0.49b	0.59±0.04a	7.73±0.37a	2.33±0.19b	7.93±0.17a	2.22±0.80a
T_7	75% RDF+ 25% N through *Sesbania*	100 %RDF	3.77±0.54b	1.77±0.27bc	3.72±0.87b	0.60±0.24a	7.93±0.83a	2.33±0.37b	7.15±0.45a	1.68±1.08a

*CF (Customized fertilizer) = two equal split of N @ 125kg ha^{-1} was applied through urea; *RDF- Recommended dose of fertilizers

Table 3: Effect of organic and inorganic sources of nutrients on concentration of nickel and lead (mg kg^{-1}) in rice and wheat

Treatment			Grain				Straw			
			2015-16		2016-17		2015-16		2016-17	
	Rice	Wheat	I Rice	I Wheat	II Rice	II Wheat	I Rice	I Wheat	II Rice	II Wheat
	Nickel									
T_1	Control N,P,K (00,00,00)	Control N,P,K (00,00,00)	1.51±0.42a	14.94±1.99 a	1.53±0.41a	9.90±0.79a	4.07±1.90a	23.81±4.25 a	5.49±1.10a	7.61±1.03a
T_2	100 %RDF	100 %RDF	1.55±0.33a	22.00±3.17 a	1.54±0.18a	14.62±1.13ab	6.86±2.27a	26.89±3.33 a	8.10±1.42a	9.97±0.13ab
T_3	RDF+ S, Zn, B (40-05-1.5)	100 %RDF	4.06±0.86b	19.77±2.77 a	3.90±0.86b	16.96±2.13b	7.16±2.31a	28.98±3.99 a	7.40±1.59a	11.52±0.67bc
T_4	*CF ($N:P_2O_5:K_2O$:S:Zn: 10:26:17:01.0:0.3)	*CF($N:P_2O_5:K_2O$:S:Zn:B: 10:18:25:04:0.5:0.2)	4.32±0.44b	22.58±2.22 a	4.49±0.61b	17.04±2.08b	6.25±1.80a	26.74±3.56 a	7.46±1.23a	13.96±0.90c
T_5	75% RDF+ 25% N through Sludge	100 %RDF	3.85±0.81b	18.24±1.58 a	4.35±0.60b	17.21±1.55b	6.54±0.02a	28.39±3.82 a	7.30±0.43a	11.70±0.85bc
T_6	75% RDF+ 25% N through	100 %RDF	3.78±0.78b	16.97±1.48	4.01±0.39b	15.85±1.94b	7.73±0.37a	24.13±2.25	7.73±0.37a	12.08±0.76bc

	Vermicompost			a				a		
T_7	75% RDF+ 25% N through *Sesbania*	100 %RDF	3.77±0.54b	19.16±3.41 a	3.92±0.52b	16.15±1.45b	7.93±0.83a	27.66±2.17 a	8.26±0.52a	14.39±1.67c
	Lead									
T_1	Control N,P,K (00,00,00)	Control N,P,K (00,00,00)	0.37±0.13a	0.04±0.02 a	0.38±0.11a	0.03±0.01a	0.28±0.07a	0.03±0.01 a	0.29±0.05a	0.10±0.01a
T_2	100 %RDF	100 %RDF	0.49±0.12ab	0.04±0.01 a	0.54±0.04ab	0.11±0.01b	0.30±0.03ab	0.05±0.01 ab	0.32±0.02a	0.14±0.02ab
T_3	RDF+ S, Zn, B (40-05-1.5)	100 %RDF	0.55±0.04ab	0.05±0.01 a	0.59±0.04abc	0.13±0.02b	0.34±0.03ab	0.04±0.01 a	0.36±0.03a	0.16±0.03ab
T_4	*CF ($N:P_2O_5:K_2O:S:Zn$: 10:26:17:01.0:0.3)	*CF($N:P_2O_5:K_2O:S:Zn:B$: 10:18:25:04:0.5:0.2)	0.67±0.09abc	0.08±0.01 ab	0.71±0.10bcd	0.11±0.03b	0.44±0.09ab	0.04±0.02 a	0.56±0.04b	0.17±0.02ab
T_5	75% RDF+ 25% N through Sludge	100 %RDF	0.90±0.04bc	0.10±0.01 b	0.92±0.03d	0.13±0.03b	0.55±0.07b	0.10±0.00 b	0.63±0.03b	0.21±0.03b
T_6	75% RDF+ 25% N through Vermicompost	100 %RDF	0.77±0.10bc	0.04±0.03 a	0.79±0.10cd	0.10±0.03ab	0.50±0.11ab	0.07±0.01 ab	0.59±0.05b	0.11±0.03a
T_7	75% RDF+ 25% N through *Sesbania*	100 %RDF	0.77±0.12bc	0.07±0.01 ab	0.82±0.04cd	0.08±0.02ab	0.44±0.09ab	0.06±0.02 ab	0.51±0.05b	0.13±0.03a

*CF (Customized fertilizer) = two equal split of N @ 125kg ha^{-1} was applied through urea; *RDF- Recommended dose of fertilizers

4. Conclusion

It may be concluded that the results of this study demonstrate that by using sludge, vermicompost and sesbania to supplement a part of chemical fertilizers higher content 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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