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Research Article

# TRACE METALS ACCUMULATION IN VEGETABLES GROWN IN PRESENCE OF PESTICIDE CARBOFURAN, SEWAGE SLUDGE, NITROGEN FERTILIZER AND THEIR MIXTURES

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### ABSTRACT

A pot study was performed to study the growth and concentration of heavy metals Zn, Cu, Mn, Fe, Cr, Ni and Pb in tomato, brinjal, corn and carrot grown in presence of different doses of carbofuran, sewage-sludge, nitrogen fertilizer and their mixtures. We determined that in presence of lower doses of carbofuran the concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb in root, stem, and edible part increased significantly, while higher doses of carbofuran caused negative influence. The change in concentration of micronutrients may be due to active role played by pesticides on soil microbial status, soil pH and adsorption by soil minerals. The concentration of metals in different parts of crops increased initially (20-25%) with addition of sewage-sludge which may be due to more availability of micronutrients to plants. The concentration was more in sewage-sludge treated samples than carbofuran treated soils. The concentration of metals in presence of both carbofuran and sewage-sludge decreased significantly except in tomato plants. The concentration of metals increased in the presence of lower doses of nitrogen fertilizer which may be due to solubilising effects and decrease in pH. In presence of carbofuran and different doses of nitrogen fertilizer the metal concentration in different parts of crops was more than in presence of nitrogen fertilizer alone except in case of tomato. In presence of carbofuran, sewage-sludge and different doses of fertilizer the concentration of metals in different parts of crops increased initially and then decreased.

**Keywords:** Carbofuran, Sewage Sludge, Nitrogen Fertilizer, Trace Metals, Crops.

### INTRODUCTION

Soil pesticides are being extensively used to control a wide range of pests of crop plants. The soil microbial populations are involved in numerous decomposition and mineralization process in soil, which ultimately affects the availability of nutrients in soil and these are likely to be influenced by soil pesticide<sup>1</sup>. Sewage-sludge has been used as an amendment to agricultural soils mostly for the cultivation of vegetables. This leads to the accumulation of micronutrients in the soil resulting in their enhanced uptake by plants<sup>2</sup>. The uptake of micronutrients present in sewage-sludge by plants is important as: (i) Sewage sludge is the source of micro-nutrients to the plants, (ii) Excessive amount of micro-nutrient absorbed by plants causes phytotoxicity<sup>3,4</sup>, (iii) Higher level of micronutrients in crop-produce causes human and animal health hazard. Heavy-metal-toxicity in different plant species grown on the same substrate may vary according to plant species, concentration of metals in the substrate and the metal considered e.g. toxicity of Cd causes hypertension,

euphyxema and chronic bronchitis and itai-itai in human beings<sup>5</sup>.

Soil microbial biomass which is the index of soil fertility is increased by addition of nitrogen fertilizers. There are certain claims that there exists some synergistic effect between pesticides and nitrogen fertilizer on the growth and yield of crops<sup>6</sup>.

The purpose of present study was to study the effect of carbofuran, sewage-sludge, nitrogen fertilizer, and their mixtures, on the concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb, in vegetable parts of tomato, brinjal, corn and carrot.

### MATERIALS AND METHODS

The soil used in this study was alluvial from Aligarh. The surface soil (0-25 cm depth) was air dried, crushed and grounded to pass through <70 mesh sieve before use. The physico-chemical properties along with sewage sludge were determined by usual methods<sup>7</sup> and values are given in Table 1. Greenhouse experiments were conducted in glazed earthenware pots filled with 10 kg of the soil in six sets of

experiments. (i) In the first set of experiment the pots were treated with 0 to 0.5 g carbofuran @  $\text{kg}^{-1}$  of soil, (ii) In the second set of experiment the pots were treated with 0-10 g of dried and grounded sewage-sludge @  $\text{kg}^{-1}$  soil, (iii) In the third set of experiments the pots were treated with 0-0.5 g of nitrogen fertilizer @  $\text{kg}^{-1}$  soil, (iv) In the fourth set of experiment the pots were treated with 0-10 g of dried grounded sewage-sludge in presence of 0.4 g of carbofuran @  $\text{kg}^{-1}$  soil, (v) In the fifth set of experiment the pots were treated with 0-0.5 g of urea @  $\text{kg}^{-1}$  soil in presence of 0.4 g of carbofuran, (vi) In the sixth and last experiment the pots were treated with 0-0.5 g of urea @  $\text{kg}^{-1}$  soil in presence of 0.4 g of carbofuran and 5 g of sewage-sludge. Four pregerminated seedlings of tomato (*Lycopersicon esculentum*), brinjal (*Solanum melongena*), corn (*Zea mays*) and carrot (*Daucus carota*) were planted in each pot in all the six experiments. The plants were watered daily to maintain the water holding capacity of the soil. These pots including blanks were also amended with  $\text{NH}_4\text{NO}_3$ , superphosphate and KCl. The concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb in root, stem and edible parts of these six experiments, conducted in triplicate, were estimated by atomic absorption spectrophotometer after digesting with  $\text{HClO}_3$  :  $\text{HClO}_4$  (1:4 mixture).

The values are given in Table 2-5.

## RESULTS AND DISCUSSION

The results of studies denoted (Table 2) that concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb in root, stem and edible parts of tomato plant in presence of different doses of carbofuran followed the order:  $0.3 > 0.2 > 0.4 > 0.1 > 0.5 > 0.0 \text{ g kg}^{-1}$  soil. In presence of sewage-sludge the concentration of metals in different parts of crop was in the order:  $3 > 5 > 2 > 7.5 > 1 > 10 > 0 \text{ g of sewage-sludge kg}^{-1}$  soil. The metal concentration of root, stem and edible parts of tomato plant in presence of 0.4 g of carbofuran and different doses of sewage-sludge increased with addition of sewage-sludge upto 5 g of sewage-sludge. The metal concentration in different parts of tomato plants, in presence of different concentration of urea, followed the order:  $0.3 > 0.2 > 0.4 > 0.1 > 0.5 > 0.0 \text{ g of urea kg}^{-1}$  soil. The concentration of studied metals in different parts of tomato plant, in presence of 0.4 g of carbofuran and different concentration of urea was in the order:  $0.4 > 0.5 > 0.3 > 0.2 > 0.1 > 0.0 \text{ g of urea kg}^{-1}$  soil. The metal concentration in root, stem and edible part was more in presence of both urea and carbofuran than urea alone. The metal concentration in presence of 0.4 g of carbofuran, 5 g of sewage-sludge and different doses of urea followed the order:  $0.3 > 0.2 > 0.4 > 0.1 > 0.0 > 0.5 \text{ g of urea kg}^{-1}$  soil.

The concentration of metals in different parts of brinjal plant (Table 3) in presence of carbofuran increased upto 0.2 g carbofuran  $\text{kg}^{-1}$  soil and then declined. The concentration of metals was maximum in root-part and followed the order:  $0.2 > 0.3 > 0.1 > 0.0 > 0.4 > 0.5 \text{ g of carbofuran kg}^{-1}$  soil. In presence of sewage-sludge, the concentration of metals increased upto 3 g of sewage-sludge and then declined. The concentration of metals was in the order:  $3 > 5 > 2 > 7.5 > 1 > 10 > 0 \text{ g of sewage-sludge kg}^{-1}$  soil. The concentration of

metals in crop parts in presence of sewage-sludge was more than in presence of carbofuran alone. The nitrogen fertilizer had no appreciable effect on metal concentration in different part of plants. Metal concentration in presence of 0.4 g carbofuran and different amounts of sewage-sludge was in the order:  $3 > 5 > 2 > 7.5 > 1 > 10 > 0 \text{ g of sewage-sludge kg}^{-1}$  soil. The concentration of metals in presence of mixture of carbofuran and sewage-sludge was found lower than that of sewage-sludge alone. In presence of 0.4 g of carbofuran and different doses of urea the metal concentration in different parts of brinjal plants increased upto 0.2 g of urea and then decreased. The metal concentration in different parts of plant was found more in presence of both carbofuran and urea than urea alone. The concentration of metals in root, stem and edible parts in presence of 0.4 g carbofuran, 0.5 g sewage-sludge and different doses of nitrogen fertilizer was in the order:  $0.4 > 0.3 > 0.2 > 0.5 > 0.1 > 0.0 \text{ urea kg}^{-1}$  soil.

The metal concentration in root, stem and edible part of corn plants in presence of different amount of carbofuran (Table 4) was in order:  $0.3 > 0.4 > 0.2 > 0.1 > 0.5 > 0.0 \text{ g carbofuran kg}^{-1}$  soil. The concentration of metals in presence of different doses of sewage-sludge increased upto 5 g of sewage-sludge and then decreased. The concentration of metals in crop yield followed the order:  $5 > 3 > 7.5 > 2 > 1 > 10 > 0 \text{ g of sewage-sludge kg}^{-1}$  soil. The concentration of metals in presence of nitrogen fertilizer increased with different amounts of fertilizer. In presence of carbofuran and nitrogen fertilizer the concentration of metals was in the order:  $0.4 > 0.5 > 0.3 > 0.2 > 0.1 > 0.0 \text{ g of nitrogen fertilizer kg}^{-1}$  soil. The concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb in presence of 0.4 g of carbofuran and 5 g sewage-sludge and different concentration of nitrogen fertilizer followed the order:  $0.4 > 0.3 > 0.5 > 0.2 > 0.1 > 0.0 \text{ g of urea kg}^{-1}$  soil.

The concentration of metals in root and stem part of carrot plant, in presence of different concentration of carbofuran (Table 5), increased upto 0.3g of carbofuran and thereafter decreased, followed the order:  $0.3 > 0.4 > 0.2 > 0.5 > 0.1 > 0.0 \text{ g of carbofuran kg}^{-1}$  soil. The metal concentration in root and stem part of carrot plant, in presence of different concentration of sewage-sludge increased with the amount of sewage-sludge. In presence of 0.4 g of carbofuran and different doses of sewage-sludge the metal concentration increased upto 5 g of sewage-sludge and then decreased, followed the order:  $5 > 3 > 7.5 > 2 > 10 > 1 > 0 \text{ g of sewage-sludge kg}^{-1}$  soil. The metal concentration in root and stem part was more in presence of both carbofuran and sewage-sludge than sewage-sludge alone. The accumulation of metals in root and stem part of carrot plant in presence of different amount of nitrogen fertilizer was in order:  $0.3 > 0.4 > 0.2 > 0.1 > 0.5 > 0.0 \text{ g of urea kg}^{-1}$  soil. In presence of 0.4 g of carbofuran and different amount of nitrogen fertilizer the accumulation of metals was more than nitrogen fertilizer only and followed the order:  $0.3 > 0.2 > 0.4 > 0.1 > 0.5 > 0.0 \text{ g of urea kg}^{-1}$  soil. There was appreciable change in metal accumulation in presence of 0.4 g of carbofuran and 5 g sewage-sludge and different amount of nitrogen fertilizer and followed the order :  $0.3 > 0.2 > 0.4 > 0.1 > 0.5 > 0.0 \text{ g of fertilizer kg}^{-1}$  soil.

These results indicated that in presence of carbofuran the concentration of Zn, Cu, Mn, Fe, Cr, Ni and Pb increased

significantly in roots stem and edible parts. The concentration of metals in studied crops (Tables 2-5) was found in the range: Zn 52-128, 34-74, 8-14; Cu 15-46, 10-25, 1.8-2.7; Mn 30-50, 25-36, 12-20; Fe – 520-736, 386-542, 210-252; Cr – 1.0-1.8, 1.1-1.5, 0.3-0.4; Ni – 2.2-3.6, 1.3-2.0, 0.3-0.6 and Pb 1.7-3.7, 1.1-2.1, 0.3-0.7 mg kg<sup>-1</sup> on dry basis in root, stem and edible part respectively. The change in micronutrients concentration in root, stem and edible part with different doses of carbofuran pesticide may be due to active role played by pesticides on soil microbial status. The preliminary studies of Bansal<sup>8</sup> have showed that in presence of lower doses of carbamate pesticides the microbial population increased. The increase and thereafter decrease in micronutrient concentration in presence of different doses may be due to solubilising effects<sup>9</sup> by *Aspergillusniger*, *Thiobacillus*, *Rhizobium* etc. (which converts unavailable nutrients into available nutrients), accompanied with decrease in soil pH with the release of soil humic acid<sup>10</sup>. Higher doses of carbofuran caused negative influence which may be due to reduction of biological activity and adsorption by soil minerals.

The concentration of metals in different parts of crops increased initially with addition of sewage-sludge which may be due to more availability of micro-nutrients to plants. The metal concentration enhanced 20-50% in root, stem and edible parts of different crops in comparison to blank. At higher concentration of sewage-sludge the concentration of metals in crops decreased which may be due to the formation of metal complexes with soil<sup>11, 12</sup>. The concentration was more in sewage-sludge treated samples than carbofuran treated soil. The concentration of metals in presence of both carbofuran and sewage-sludge decreased significantly except in tomato plant which may be due to formation of complex between pesticide and metals and/or nitrogen fixation by microbial activity.

The concentration of metals increased in the presence of nitrogen fertilizer at lower doses which may be due to solubilization effects and decrease in pH<sup>13</sup>. The reduction in availability of micronutrients at higher doses of nitrogen fertilizer may be due to reduction in enzymatic activity like urease<sup>14</sup>. In presence of carbofuran and different amount of nitrogen fertilizer the metal concentration in different part of crops was more than in presence of nitrogen fertilizer alone except in tomato, suggesting that nitrogen mineralization<sup>15</sup> in presence of pesticide carbofuran was more than urea alone. In presence of carbofuran, sewage-sludge and different doses of fertilizer the concentration of metals in different parts of crops increased and then decreased suggesting that in presence of sewage-sludge higher concentration of nitrogen caused immobilization/fixation of metals. So, lesser amount of metals became available to plants.

## CONCLUSION

From these results it may be inferred that the different concentration of carbofuran, sewage-sludge, nitrogen fertilizer and their mixtures influenced the concentration of metals viz. Zn, Cu, Mn, Fe, Cr, Ni and Pb in different parts of brinjal, tomato, and corn and carrot plants. In presence of lower doses of carbofuran and/or sewage sludge the metal concentration in

different parts of crops increased which might be due to increase in microbial population and/or due to more availability of micronutrients to plants.

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**Table 1: Physico-chemical properties of the soils and anaerobically digested sewage sludge**

Properties	Soils			Sewage-sludge
	Black (Vertisol)	Red (Alfisol)	Alluvial (Inceptisol)	
Silt %	3.0	33.9	54.4	-----
Clay %	16.0	47.7	42.6	-----
EC (1:2.5) (dSm <sup>-1</sup> )	1.94	0.46	0.56	16.8
pH (1:2.5)	7.6	7.2	8.1	7.6
Organic Carbon %	1.88	0.81	0.86	18.6
CEC [C mol(P <sup>+</sup> ) kg <sup>-1</sup> ]	9.75	6.07	6.0	14.5
Water holding Capacity (%)	70	42	36	-----
<b>Total heavy metals (mg kg<sup>-1</sup>)</b>				
Cu	1.8	1.4	1.4	306
Cd	0.12	Traces	Traces	3.0
Ni	0.6	0.4	0.5	24.0
Zn	6.8	6.3	6.2	240
Mn	32	30	32	600
Fe	2100	2600	2000	2010
Pb	1.6	1.6	1.7	76
Cr	4.6	3.6	4.0	42
<b>DTPA extractable (mg kg<sup>-1</sup>)</b>				
Cu	0.52	0.60	0.64	
Cd	0.02	Traces	Traces	
Ni	0.04	0.02	0.04	
Zn	0.72	0.66	0.42	
Mn	3.2	2.8	3.0	
Fe	9.2	16.8	5.6	
Pb	0.06	0.08	0.10	
Cr	0.22	0.18	0.34	

**Table 2: Concentration of heavy metals in various parts of tomato plant (mg kg<sup>-1</sup> dry weight) in presence of different concentration of carbofuran, sewage sludge, nitrogen fertilizer and their mixture**

Metals		Carbofuran	Sewage -sludge	Nitrogen fertilizer	Carbofuran+ sewage sludge	Carbofuran+ Nitrogen fertilizer	Carbofuran+ sewage sludge +Nitrogen fertilizer
Zn	R	78.7±1.5 (74-84)	91±3.8 (74-106)	82±2.5 (74-88)	109±6.3 (80-128)	93±5 (82-108)	126±2(120-132)
	S	54.3±1.2 (50-58)	57±1.9 (50-64)	55±1.6 (50-60)	67±3.1(56-78)	63±4.8 (54-68)	80±2.1(76-88)
	E	10.8±0.05 (10-12)	10.7±0.3(10-12)	10.3±0.2 (10-11)	13±0.6 (11-15)	13±1.1 (11-16)	18.3±1.1 (15-23)
Cu	R	20.2±0.7 (18-22)	21.2±0.8 (18-23)	18.7±0.5 (17-20)	27±1.5 (22-32)	26±1 (23-28)	38.4±2.1 (34-42)
	S	12.0±0.5 (10-13)	11±0.3 (10-13)	11.4±0.4 (10-12)	16±0.8 (13-18)	16.1±0.7 (14-18)	21.1±0.5 (20-22)
	E	2.25±0.05 (2.0-2.3)	2.1±0.06 (2-2.3)	2.15±0.04(2.0-2.2)	2.7±0.09(2.4-3.0)	2.7±0.08(2.5-2.9)	3.23±0.05(3.1-3.4)
Mn	R	35.7±1.3 (32-38)	41±1.9 (32-47)	36.4±1.2 (32-40)	42.1±1.4 (36-47)	38±1.4 (33-41)	47.5±0.9 (45-50)
	S	30.2±1.1 (26-34)	30±1 (26-34)	30±1.1(26-34)	33.3±0.7 (30-36)	32.1±1.1 (29-35)	34±0.9 (32-37)
	E	13.7±0.4 (13-15)	14±0.4 (13-15)	14.4±0.6 (13-16)	16.0±0.4 (15-17)	16±0.5 (14-17)	17±0.4 (16-18)
Fe	R	633±15 (612-700)	683±18.4 (612-742)	657±16 (612-694)	713±14 (666-766)	688±15 (636-724)	743±11 (710-777)
	S	444±9 (418-472)	459±9.8 (426-501)	457±9 (426-486)	500±11 (458-536)	467±13 (420-502)	519±7 (506-538)
	E	213±4 (202-233)	216±5.2 (202-236)	221±6 (202-236)	234± 6(220-256)	229±9 (204-256)	265±7 (246-288)
Cr	R	1.92±0.04 (1.8-2.0)	1.87 ±0.04 (1.8-2.0)	1.91 ±0.04 (1.8-2.0)	2.2±0.04 (2.1-2.4)	2.1±0.06 (2.0-2.3)	2.55±0.05 (2.5-2.7)
	S	1.41±0.03(1.3-1.5)	1.4±0.03 (1.3-1.5)	1.35±0.03 (1.3-1.4)	1.64±0.03 (1.5-1.7)	1.6±0.04(1.5-1.7)	1.75±0.03 (1.7-1.8)
	E	0.35±0.02 (0.3-0.4)	0.33±0.02 (0.3-0.4)	0.32±0.01 (0.3-0.4)	0.46±0.02 (0.4-0.5)	0.45±0.02 (0.4-0.5)	0.56±0.02 (0.5-0.6)
Ni	R	2.91±0.09 (2.6-3.2)	2.7±0.04(2.6-2.8)	2.7±0.03 (2.6-2.8)	3.4±0.1 (3.1-3.7)	3.0±0.05 (2.9-3.2)	3.6±0.05 (3.5-3.7)
	S	1.65±0.05 (1.5-1.8)	1.62±0.03 (1.5-1.7)	1.53±0.03 (1.5-1.6)	2.1±0.08 (1.8-2.3)	1.7±0.04 (1.6-1.8)	2.3±0.04 (2.2-2.4)
	E	0.33±0.03 (0.3-0.4)	0.33±0.02 (0.3-0.4)	0.32±0.01 (0.3-0.4)	0.53±0.02 (0.4-0.6)	0.36±0.02 (0.3-0.4)	0.67±0.02 (0.6-0.8)
Pb	R	3.43±0.09 (3.2-3.7)	3.4±0.06 (3.2-3.6)	3.3±0.09 (3.2-3.6)	3.7±0.05 (3.6-3.8)	3.7±0.06 (3.5-3.9)	3.9±0.05 (3.8-4.0)
	S	2.02±0.05 (1.8-2.1)	1.87±0.04 (1.8-2.0)	1.87±0.03 (1.8-2.0)	2.47±0.04 (2.2-2.5)	2.37±0.04 (2.2-2.5)	2.57±0.03 (2.5-2.6)
	E	0.63±0.03 (0.5-0.7)	0.53±0.02 (0.5-0.6)	0.53±0.01 (0.5-0.6)	0.80±0.02 (0.7-0.9)	0.63±0.02 (0.6-0.7)	0.86±0.02 (0.8-0.9)

R= Root; S= Stem; E= Edible part; ± values are SD; values in bracket denote range

**Table 3: Concentration of heavy metals in various parts of brinjal plant (mg kg<sup>-1</sup> dry weight) in presence of different concentration of carbofuran, sewage sludge, nitrogen fertilizer and their mixture**

Metals		Carbofuran	Sewage -sludge	Nitrogen fertilizer	Carbofuran+ sewage sludge	Carbofuran+ Nitrogen fertilizer	Carbofuran+ sewage sludge +Nitrogen fertilizer
Zn	R	109±5.4 (93-125)	144±9 (106-166)	109±1.2 (106-112)	131±6.8 (102-154)	105±3.6 (94-116)	153±4.5 (138-166)
	S	64±2.4 (58-72)	80±3.9 (60-89)	62.5±1 (60-65)	72±2.2(63-80)	70±2.1 (62-76)	88±2.1(78-96)
	E	13±0.5 (11-14)	14.6±0.8(12-17)	12.7±0.5 (11-14)	15.3±0.7 (13-18)	14.7±0.5 (13-16)	18.3±0.7 (16-20)
Cu	R	21.5±0.8 (19-24)	23.3±1.0 (20-27)	21.7±0.5 (20-23)	22±0.7 (20-24)	25±1 (21-28)	26.7±1.1 (24-30)
	S	12.5±0.6 (11-14)	14.3±0.7 (12-17)	13±0.5 (11-14)	13±0.6 (11-15)	12.7±0.6 (11-14)	17.7±0.7 (16-20)
	E	2.3±0.15 (2.0-2.7)	2.46±0.06 (2-2.9)	2.2±0.05(2.2-2.3)	2.5±0.09(2.2-2.8)	2.5±0.07(2.3-2.7)	3.13±0.05(3.0-3.3)
Mn	R	44±1.8 (40-50)	48.4±1.8 (42-51)	46±1.6 (42-52)	46.1±1.2 (42-50)	48±1.1 (44-51)	49±1.9 (42-55)
	S	33±1.6 (29-38)	34±1.1 (30-37)	36±1.1(30-36)	33.3±0.8 (30-36)	34.1±0.7 (32-36)	37±1.4 (33-42)
	E	17±0.9 (15-20)	16±0.5 (15-17)	16±0.8 (15-18)	16.3±0.8 (13-18)	18±0.5 (17-19)	17.6±0.5 (16-19)
Fe	R	572±17(520-620)	586±21.4 (514-666)	582±17 (520-612)	598±11 (562-636)	608±9 (570-626)	697±21 (624-736)
	S	414±13 (376-452)	425±16 (378-472)	400±7 (378-420)	428±7 (400-452)	465±11 (420-502)	476±12 (440-512)
	E	224±8.4(204-252)	221±4.5 (206-238)	208±7 (178-222)	221± 9(190-252)	235±4 (228-242)	255±9 (222-288)
Cr	R	1.94±0.04 (1.8-2.1)	2.0±0.04 (1.9-2.1)	2.0±0.05 (1.9-2.2)	1.9±0.04 (1.8-2.0)	1.9±0.03 (1.8-2.0)	2.1±0.03 (2.0-2.2)
	S	1.41±0.04(1.2-1.5)	1.4±0.05 (1.3-1.6)	1.4±0.04 (1.3-1.5)	1.47±0.04 (1.4-1.6)	1.45±0.02(1.4-1.5)	1.55±0.04 (1.5-1.6)
	E	0.33±0.02 (0.3-0.4)	0.34±0.02 (0.3-0.4)	0.37±0.03 (0.3-0.4)	0.33±0.02 (0.3-0.5)	0.35±0.02 (0.3-0.4)	0.33±0.02 (0.3-0.4)
Ni	R	3.15±0.15 (2.7-3.6)	3.36±0.12(3.1-3.7)	3.35±0.08(3.1-3.6)	3.2±0.07 (3 -3.4)	3.15±0.04 (3.0-3.3)	3.35±0.04 (3.2-3.5)
	S	1.9±0.08(1.7-2.1)	1.82±0.06 (1.7-2.1)	1.8±0.04 (1.7-2.0)	1.9±0.04 (1.8-2.0)	1.95±0.04 (1.8-2.1)	2.08±0.04 (2.0-2.2)
	E	0.53±0.04 (0.4-0.6)	0.5±0.03 (0.4-0.6)	0.47±0.03 (0.4-0.6)	0.6±0.05 (0.5-0.8)	0.53±0.02 (0.5-0.6)	0.77±0.02 (0.7-0.8)
Pb	R	2.7±0.05(2.5-2.8)	2.9±0.07 (2.6-3.1)	2.63±0.04 (2.4-2.8)	2.76±0.04 (2.6-3.0)	2.67±0.02 (2.6-2.8)	3.07±0.05 (2.9-3.2)
	S	1.5±0.05 (1.3-1.7)	1.72±0.04 (1.5-1.9)	1.57±0.03(1.5-1.7)	1.47±0.03 (1.3-1.6)	1.5±0.04 (1.4-1.6)	1.57±0.05 (1.5-1.7)
	E	0.4±0.02 (0.3-0.5)	0.53±0.02 (0.4-0.7)	0.5±0.02 (0.4-0.6)	0.5±0.02 (0.4-0.6)	0.45±0.02 (0.4-0.5)	0.6±0.02 (0.5-0.7)

R= Root; S= Stem; E= Edible part; ± values are SD; values in bracket denote range

**Table 4: Concentration of heavy metals in various parts of corn plant (mg kg<sup>-1</sup> dry weight) in presence of different concentration of carbofuran, sewage sludge, nitrogen fertilizer and their mixture**

Metals		Carbofuran	Sewage -sludge	Nitrogen fertilizer	Carbofuran+ sewage sludge	Carbofuran+ Nitrogen fertilizer	Carbofuran+ sewage sludge +Nitrogen fertilizer
Zn	R	60±2.2 (52-66)	61.4±2.4 (53-69)	61.4±2.4 (53-69)	60±1.8 (54-66)	63±2 (56-68)	75±1.4 (70-78)
	S	38±1.4 (34-42)	38.3±1.1 (35-42)	37±0.9 (34-39)	39±1 (35-42)	36±1 (33-39)	45±0.9(43-48)
	E	11±0.8 (8-13)	12±0.9 (9-15)	10±0.5(8-11)	10.7±0.4 (9-12)	12.3±0.9 (9-15)	19±1 (16-22)
Cu	R	16±0.4 (15-17)	21±1.2 (16-25)	17±0.8 (15-19)	19±0.7 (16-21)	21±1.5 (16-24)	29.4±1.1 (25-32)
	S	10.7±0.4 (10-12)	11.6±0.4 (10-13)	11±0.5 (10-12)	12±0.4 (10-13)	14.5±0.8 (11-17)	15.5±0.5 (14-17)
	E	1.9±0.04 (1.8-2.0)	1.9±0.05 (1.8-2.2)	1.9±0.04 (1.8-2.0)	1.9±0.05 (1.7-2.0)	2.0±0.09 (1.7-2.3)	2.3±0.07(2.1-2.5)
Mn	R	34±1.3 (30-38)	40±1.8 (32-45)	36±1.5 (30-38)	38±1.7 (32-43)	38±1.6 (33-42)	50±1.6 (46-53)
	S	27±0.8 (25-30)	32.7±1.4 (27-37)	27±0.6 (25-29)	34.6±1.6 (28-40)	29±1.8 (24-34)	39±1 (36-42)
	E	14±0.6 (12-15)	17±1.0 (13-20)	13±0.6 (12-15)	15.4±0.8 (13-18)	17±1.3 (13-20)	21±1.0 (17-24)
Fe	R	598±17(542-646)	612±14 (564-666)	608±19 (542-652)	578±12(555-614)	580±7 (558-600)	682±6 (660-700)
	S	382±12 (370-430)	395±11 (362-436)	403±10 (370-426)	384±8 (360-412)	443±15 (392-478)	453±10 (420-482)
	E	202±6.1(185-222)	206±8 (180-236)	196±6 (182-216)	238±9.1(204-262)	197±8 (172-216)	253±7 (230-274)
Cr	R	1.7±0.04 (1.6-1.8)	1.85±0.04 (1.7-2.0)	1.7±0.04 (1.6-1.8)	1.76±0.08 (1.6-1.9)	1.9±0.04 (1.8-2.0)	2.17±0.05 (2.0-2.3)
	S	1.11±0.01(1.1-1.2)	1.33±0.04 (1.2-1.5)	1.18±0.04 (1.1-1.3)	1.3±0.04 (1.2-1.4)	1.3±0.03 (1.2-1.4)	1.5±0.04 (1.4-1.6)
	E	0.35±0.02 (0.3-0.4)	0.34±0.02 (0.3-0.4)	0.33±0.02 (0.3-0.4)	0.44±0.02 (0.4-0.5)	0.35±0.02 (0.3-0.4)	0.53±0.03 (0.5-0.6)
Ni	R	2.35±0.04 (2.2-2.6)	2.6±0.06(2.4-2.8)	2.35±0.05(2.2-2.5)	2.43±0.05 (2.3-2.6)	2.5±0.05(2.3-2.6)	3.13±0.04 (3 -3.2)
	S	1.4±0.03(1.3-1.5)	1.76±0.04 (1.5-1.8)	1.4±0.04 (1.3-1.5)	1.27±0.04 (1.2-1.4)	1.5±0.03 (1.4-1.6)	2.03±0.04 (1.9-2.2)
	E	0.33±0.02 (0.3-0.4)	0.5±0.03 (0.4-0.6)	0.4±0.03 (0.3-0.5)	0.34±0.02 (0.3-0.4)	0.43±0.02 (0.4-0.5)	0.7±0.02 (0.6-0.8)
Pb	R	1.8±0.05(1.7-1.9)	2.07±0.04 (1.8-2.3)	1.85±0.05 (1.7-2.0)	2.0±0.05 (1.8-2.1)	2.07±0.03 (1.8-2.2)	2.5±0.05 (2.4-2.6)
	S	1.2±0.03 (1.1-1.3)	1.42±0.04 (1.2-1.6)	1. 2±0.03 (1.1-1.3)	1.4±0.05 (1.2-1.6)	1.4±0.04 (1.2-1.6)	2.0±0.04 (1.8-2.2)
	E	0.37±0.02 (0.3-0.4)	0.5±0.03 (0.4-0.6)	0.4±0.03 (0.3-0.5)	0.4±0.04 (0.3-0.5)	0.47±0.03 (0.4-0.6)	0.77±0.03 (0.7-0.8)

R= Root; S= Stem; E= Edible part; ± values are SD; values in bracket denote range

**Table 5: Concentration of heavy metals in various parts of carrot plant (mg kg<sup>-1</sup> dry weight) in presence of different concentration of carbofuran, sewage sludge, nitrogen fertilizer and their mixture**

Metals		Carbofuran	Sewage -sludge	Nitrogen fertilizer	Carbofuran+ sewage sludge	Carbofuran+ Nitrogen fertilizer	Carbofuran+ sewage sludge +Nitrogen fertilizer
Zn	R	110±6.8 (88-128)	101±3.8(90-114)	94±2 (88-100)	134±3 (120-144)	132±3 (125-142)	150±4 (138-160)
	S	66±2.4 (58-74)	66±2.5 (56-74)	58.5±1.3 (56-62)	77.4±1.6(72-82)	76±1.3 (72-80)	83±1(80-86)
Cu	R	28±1.2 (24-32)	31±1.9 (25-36)	26.3±0.7 (24-28)	35.7±1.4 (30-40)	34.5±0.9 (32-37)	43±1.0 (40-46)
	S	15.7±0.7 (13-17)	18±1.3 (14-22)	14.3±0.5 (13-16)	18±0.6 (16-20)	19±0.4 (18-20)	23±0.9 (20-25)
Mn	R	34.3±1.3 (30-38)	40±1.8 (33-46)	32±0.7 (30-34)	38.6.1±0.9 (35-41)	37±0.8 (35-39)	41±1.3 (38-45)
	S	24±0.8 (21-26)	25±0.6 (22-26)	21.3±0.5(20-23)	24.4±0.5(23-26)	27±0.4 (26-28)	30±1.0 (26-34)
Fe	R	656±27(566-736)	593±17 (545-650)	589±14 (544-624)	735±12 (686-776)	723±9 (700-754)	764±11 (724-792)
	S	478±24 (402-542)	461±14 (412-502)	436±12 (412-480)	555±12 (522-602)	555±8 (534-582)	603±10 (582-628)
Cr	R	2±0.04 (1.9-2.1)	2.23±0.06 (2.0-2.4)	2.17±0.05 (2.0-2.3)	2.4±0.06 (2.2-2.6)	2.4±0.03 (2.3-2.5)	2.6±0.04 (2.5-2.7)
	S	1.21±0.03(1.1-1.3)	1.27±0.03 (1.2-1.4)	1.13±0.03 (1.1-1.3)	1.4±0.03 (1.3-1.5)	1.27±0.03(1.2-1.3)	1.65±0.04 (1.6-1.7)
Ni	R	3.35±0.05 (3.1-3.6)	3.46±0.07(3.2-3.6)	3.15±0.06(3.0-3.3)	3.5±0.05 (3.4-3.7)	3.7±0.04 (3.6-3.8)	3.6±0.04 (3.5-3.7)
	S	2.0±0.04(1.8-2.1)	2.1±0.04 (1.9-2.3)	1.9±0.03 (1.8-2.0)	2.17±0.04 (2.1-2.3)	2.2±0.03 (2.1-2.3)	2.3±0.04 (2.2-2.4)
Pb	R	2.95±0.06(2.8-3.1)	3.2±0.06 (3.0-3.41)	3.15±0.04 (3-3.3)	3.17±0.06 (3.0-3.3)	3.43±0.04 (3.2-3.6)	3.5±0.05 (3.3-3.6)
	S	1.66±0.04 (1.6-1.8)	1.84±0.04 (1.7-2.0)	1.7±0.03(1.6-1.8)	1.9±0.04 (1.8-2.0)	2.0±0.03 (1.8-2.1)	1.93±0.03 (1.9-2.0)

R= Root; S= Stem; E= Edible part; ± values are SD; values in bracket denote range

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