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Effect of Different Levels of Chromium With and Without Organic Sources on the Availability of Primary Nutrients and Yield of Wheat

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Abstract: A pot experiment (2020-21) was conducted with different levels of chromium (0, 10,20,30,40,50 mg kg^{-1}) with and without FYM or vermicompost (25g/10 kg soil) in completely factorial redomised block design in net house of the Department of Soil Science & Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment was conducted in factorial completely randomized design (FCRD). Maximum plant height was recorded in Cr0+VC (21.6 cm) followed by Cr0+FYM (19.8 cm)at 30 DAS. The increasing chromium concentration decrease the chlorophyll content in all the treatments Highest grain and straw yields of wheat were associated with Cr0+VC treatment, highest available N, P, K was recorded with Cr20+VC, Cr30+VC and Cr10+VC respectively.

Key words: *Chromium, crop growth, farm yard manure and vermicompost.*

Introduction

The higher availability of chromium in soil and its higher uptake cause toxicity in wheat plant resulting in reduced growth, grain yield, dry matter production etc. This technology can also be exploited for the remediation of Cr-contaminated soils. The application of large quantities of compost or organic matter to immobilizes Cr as stable complexes with organic colloids. During the decomposition of organic matter, compounds such as citric acid or Gallic acid are formed which have the potential for chelating Cr(III) or reducing Cr(VI), and thereby reducing the toxicity of Cr (James and Bartlett 1983). With these aspects in view, the present experiment was conducted to study the effect of different concentrations of chromium with and without FYM OR vermicompost on grown yield of wheat and availability of NPK in post-harvest soil.

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Materials and Methods

A pot experiment (2020-21) was conducted in net house of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi following Factorial Completely Randomized Design (FCRD) with wheat as a test, processed 10 kg soil was filled in each polythene lined pots. The pots were irrigated up to field capacity and moisture level was maintained. 10 kg of soil was treated with required amount of Cr through potassium dichromate ($K_2Cr_2O_7$) as per treatments (0, 10, 20, 30, 40, 50 mg kg^{-1} soil). After 15 days of application of chromium, the farmyard manure (FYM) and vermicompost (25g 10 kg^{-1} soil) was applied to the soil and thoroughly mixed. All pots were incubated for 15 days, watered at field capacity, then sowing of seed was done in each pot with 10 seed pot^{-1}. The recommended dose of N, P and K (120, 60 and 40 kg ha^{-1}). Were applied through urea, DAP and MOP respectively. Chlorophyll content of the plants was measured by Chlorophyll Meter (SPAD -502) at after 30, 60, 90 DAS. The crop was harvested (plot-wise), sun dried and threshed to obtain grain and straw yield (g pot^{-1}). The post harvest soils was analysed for pH and EC. Organic Carbon in the soil was determined using Walkley and Black method (Walkley and Black 1934). Available Nitrogen content in soil was measured using Kjeldahl Semi-Auto Nitrogen Analyzer by alkaline Potassium permanganate method as proposed by (Subbiah and Asija 1956). Available phosphorus content of soil was determined by Olsen's method (Olsen *et al*. 1954). Available potassium in soil determined by using 1 N ammonium acetate method using Flame Photometer. (Hanway and Heidal 1952).

Result and Discussion

Plant Height of Wheat

The plant height generally increased from 30, 60, 90 DAS and thereafter a gradual decline was found. With increase in the level of chromium concentration 0, 10, 20, 30, 40, 50 (mg kg^{-1}), the plant height was reduced accordingly. These results are in conformity with the findings of (Nagarajan 2014). The highest plant height was observed in treatment Cr0 +VC followed by treatment Cr0+FYM at 30 DAS. The similar trend was found with plant height 60 DAS and 90 DAS. Higher concentration of Cr (VI) might have exerted toxic effects on growth of the plant (Kumari *et al*. 2011).

Table 1. Effect of chromium levels with and without organics on plant height (cm) of wheat at 30, 60, 90 days and harvesting

Treatments	30 DAS	60 DAS	90 DAS	At Harvesting
Cr 0	16.5	34.2	81.3	81.0
Cr 10	15.7	33.7	79.9	79.1
Cr 20	14.8	32.8	78.7	78.1
Cr 30	13.9	31.6	77.6	77.1
Cr 40	13.1	30.7	75.9	75.2
Cr 50	12.4	29.6	73.8	72.9
Cr 0+FYM	19.8	37.5	84.1	83.9
Cr 10+FYM	18.9	36.8	82.9	82.2
Cr 20+FYM	18.1	35.7	81.7	81.1
Cr 30+FYM	17.5	34.7	80.8	80.3
Cr 40+FYM	16.9	33.9	78.9	77.9
Cr 50+FYM	15.5	32.1	76.8	75.7
Cr 0+VC	21.6	39.6	88.4	88.2
Cr 10+VC	21.0	38.5	86.8	88.4
Cr 20+VC	20.5	37.6	84.9	84.0
Cr 30+VC	19.8	36.7	82.5	82.1
Cr 40+VC	18.7	35.6	80.4	80.1
Cr 50+VC	17.9	35.2	78.3	77.5
SEm ±	0.240	0.510	1.074	1.206
CD	0.691	1.470	3.093	3.473

The increase in the chromium concentration decreased total tillers per hill as 2.1, 1.9,1.8,1.6,1.5,1.3 respectively (Table 2) . Cr-treated wheat plants showed stunted growth and produced less number of tillers compared to control (Ahmad *et al.*2011). The highest total tillers hill^{-1} were observed in Cr0+VC followed by Cr0+ FYM treatment. FYM or vermicompost offer more balanced nutrition to the plants, especially micro-nutrients and hence caused better tillering in plants. (Amitava *et al.*2008).

Table 2. Effect of chromium levels with and without organics on number of tillers of wheat

Treatments	30 DAS	60 DAS	90 DAS	At Harvesting
Cr 0	2.1	3.2	5.1	5.0
Cr 10	1.9	2.8	4.8	4.6
Cr 20	1.8	2.6	4.6	4.5
Cr 30	1.6	2.5	4.5	4.1
Cr 40	1.5	2.3	4.3	4.0
Cr 50	1.3	2.1	3.5	3.2
Cr 0+FYM	2.5	4.5	6.5	6.6
Cr 10+FYM	2.4	3.9	6.4	6.3
Cr 20+FYM	2.2	3.7	6.1	5.9
Cr 30+FYM	2.1	3.5	5.5	5.2
Cr 40+FYM	1.9	3.1	4.9	4.6
Cr 50+FYM	1.8	2.9	4.6	4.4
Cr 0+VC	2.8	5.9	8.4	8.3
Cr 10+VC	2.7	4.8	8.3	8.6
Cr 20+VC	2.5	4.5	8.1	7.8
Cr 30+VC	2.4	4.0	7.7	7.4
Cr 40+VC	2.2	3.5	7.1	6.8
Cr 50+VC	2.1	3.0	6.6	6.4
SEm ±	0.031	0.057	0.93	0.092
CD	0.09	0.164	0.266	0.265

Chlorophyll content

The increasing level of chromium concentration has decreased the chlorophyll content (Table 3). The highest chlorophyll content (37.85) was found in Cr0+VC followed by Cr0+ FYM (35.90) at 30 DAS. The vermicompost and FYM treated pots had significantly higher chlorophyll content of wheat. (Anburani and Manivannan 2002) also reported similar findings. Chromium induced oxidative stress involves induction of lipid peroxidation in plants that causes severe damage to cell membranes can disturb the chloroplast ultrastructure thereby disturbing the photosynthetic process (Clijsters and Van Assche 1985).

Table 3. Effect of chromium levels with and without organics on chlorophyll content (nmol/cm^2) of wheat plant

TREATMENTS	30 DAS	60 DAS	90 DAS
Cr 0	31.80	30.14	23.67
Cr 10	31.30	29.93	21.29
Cr 20	30.98	29.62	20.48
Cr 30	30.63	28.91	19.74
Cr 40	30.25	28.70	19.03
Cr 50	29.98	28.57	18.55
Cr 0+FYM	35.90	32.07	25.81
Cr 10+FYM	35.27	31.83	23.27
Cr 20+FYM	34.91	31.55	20.44
Cr 30+FYM	34.57	31.07	19.91
Cr 40+FYM	34.22	30.64	18.78
Cr 50+FYM	33.00	30.19	18.19
Cr 0+VC	37.85	32.81	26.02
Cr 10+VC	37.13	32.63	25.37
Cr 20+VC	36.43	32.03	24.60
Cr 30+VC	36.07	31.84	23.93
Cr 40+VC	35.87	31.69	23.28
Cr 50+VC	35.43	31.47	22.81
SEm ±	0.498	0.539	0.371
CD	1.435	1.552	1.068

Grain and straw yield of wheat

Maximum yield (10.1g pot^{-1}) was found in Cr0+VC followed by Cr0+FYM (8.65g pot^{-1}) while he lowest value (4.8 g pot^{-1}) was observed in treated pot (Table 4). Similar results was also observed by (Parmar and Patel 2015). This improvement in yield could be mainly attributed due to the reduction of Cr (VI) to Cr (III) and thus reduce toxic effects of Cr in the soil.

Table 4. Effect of chromium levels with and without organics on grain yield (g pot^{-1}) of wheat in chromium contaminated soil

Treatments	Control	FYM	VC	MEAN
Cr 0	7.1	8.65	10.1	8.61
Cr 10	6.8	7.9	9.5	8.06
Cr 20	6.4	7.5	9.3	7.73
Cr 30	5.9	7.2	8.8	7.30
Cr 40	5.1	6.8	7.9	6.60
Cr 50	4.8	6.1	7.1	6.00
MEAN	6.01	7.35	8.78	
	SE (m)	CD		
C	0.058	0.168		
A	0.041	0.119		
C*A	0.101	0.291		

Table 5. Effect of chromium levels with and without organics on wheat straw yield (g pot^{-1})

Treatments	Control	FYM	VC	MEAN
Cr 0	11.3	13.1	14.1	12.83
Cr 10	10.8	12.9	13.8	12.30
Cr 20	10.5	12.5	13.2	12.06
Cr 30	10.1	11.9	12.9	11.63
Cr 40	9.5	11.0	12.1	10.86
Cr 50	8.8	10.2	10.9	9.96
MEAN	10.16	11.93	12.73	
	SE (m)	CD		
C	0.123	0.355		
A	0.087	0.251		
C*A	0.214	N/A		

Chemical properties of soil

Maximum pH (8.35) was found with treatment Cr50 +VC and minimum pH was observed with the treatment Cr0 (8.0). Application of organics in chromium contaminated pots showed a slight change in pH of the soil. The EC of the soil ranged between 0.31 to 0.42 dSm^{-1}. The EC of the soil increased with the application of organic materials. Highest organic carbon was found in Cr0+VC treatment (0.41 %) followed by Cr0+FYM (0.36 %) and Cr0 (0.29%). With the increase in chromium concentration, the organic carbon content in soil got decreased. The minimum organic carbon observed in treatment Cr50.The interaction effect of organics and chromium was found significant.

Table 6. Effect of chromium levels with and without organics on pH, EC, OC of post harvest soils

TREATMENTS	pH	EC	OC
Cr 0	8.0	0.31	0.29
Cr 10	8.1	0.34	0.29
Cr 20	8.23	0.34	0.28
Cr 30	8.23	0.3	0.28
Cr 40	8.23	0.35	0.26
Cr 50	8.23	0.30	0.25
Cr 0+FYM	8.0	0.39	0.36
Cr 10+FYM	8.1	0.37	0.35
Cr 20+FYM	8.2	0.36	0.35
Cr 30+FYM	8.25	0.36	0.34
Cr 40+FYM	8.26	0.34	0.33
Cr 50+FYM	8.25	0.34	0.33
Cr 0+VC	8.1	0.42	0.41
Cr 10+VC	8.21	0.40	0.41
Cr 20+VC	8.25	0.40	0.40
Cr 30+VC	8.25	0.38	0.39
Cr 40+VC	8.3	0.38	0.38
Cr 50+VC	8.35	0.37	0.38
SEm ±	0.114	0.005	0.006
CD	N/A	0.015	0.017

Highest available N (206 kg ha^{-1}) was found in the treatment Cr0+VC followed by Cr0+FYM (198 kg ha^{-1}) and Cr0 (187 kg ha^{-1}). Application of chromium levels with and without organics significantly influenced the nitrogen availability in soil. The available P content ranged from 18 to 20 kg ha^{-1}. The control pot had lowest available phosporous (18.14kgha^{-1}) whereas maximum P content (19.93 kg $ha-^{1}$) was observed in organic amended pots Cr0+VC followed by Cr0+FYM (19.44 kg$ha-^{1}$). Similar results have also been reported by (Ranganathan and Salvseelan 1997). Highest available K was found in the treatment Cr0+ VC (217 kg $ha-^{1}$) followed by treatment Cr0+FYM (214 kg $ha-^{1}$).The soil used in experiment, was medium in available K content in the soil and upon addition of organics there was an increase in soil available K. An increase in chromium concentration, the available K decreased in both amended and non-amended soil.

Table 7. Effect chromium levels with and without organics on N, P, K (kg ha^{-1}) content in post harvest soil

TREATMENTS	Av N Kg ha^{-1}	Av P Kg ha^{-1}	Av K kg ha^{-1}
Cr 0	187.0	18.14	212.0
Cr 10	189.2	18.44	213.2
Cr 20	192.1	18.69	210.3
Cr 30	191.6	18.95	209.5
Cr 40	190.3	19.24	205.4
Cr 50	189.8	19.12	202.4
Cr 0+FYM	198.6	19.44	214.2
Cr 10+FYM	199.2	19.76	216.2
Cr 20+FYM	200.7	19.93	215.6
Cr 30+FYM	201.5	20.31	214.6
Cr 40+FYM	201.9	20.16	212.6
Cr 50+FYM	200.7	19.88	210.2
Cr 0+VC	206.1	19.93	217.5
Cr 10+VC	207.9	20.11	218.2
Cr 20+VC	208.7	20.46	217.1
Cr 30+VC	208.1	20.73	216.0
Cr 40+VC	207.7	20.44	215.2
Cr 50+VC	207.0	20.02	213.2
SEm ±	2.621	0.288	3.552
CD	7.548	0.828	N/A

Conclusion

The study showed that the application of increasing levels of chromium in soil adversely affected the growth parameters and wheat yield, however, incorporation of FYM and vermicompost alleviated the toxicity of chromium. Therefore FYM and vermicompost may be used as potential tool for phytoremediation of chromium contaminated soil.

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