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Nishant Singh
Department of Agricultural Chemistry & Soil Science, P.G. College, Ghazipur, Uttar Pradesh, India

Awadhesh Kumar Singh
Department of Agricultural Chemistry & Soil Science, P.G. College, Ghazipur, Uttar Pradesh, India

Dinesh Kumar Singh
Department of Soil Science, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Nishant Singh
Department of Agricultural Chemistry & Soil Science, P.G. College, Ghazipur, Uttar Pradesh, India

Effect of organic amendment on growth and yield under rice sequence grown in chromium contaminated soil

Nishant Singh, Awadhesh Kumar Singh and Dinesh Kumar Singh

Abstract
Globally, the agricultural soils area where crop yields are affected by water contminations has increased. This research aimed to evaluate the outcome of the edaphic application of organic amendments upon the growth and yield of rice in contaminated soil. Malviya Dhan 3022variety was selected for the experiment and grown with conventional cultural practices.

Keywords: poultry manure, chromium, rice attributes

Introduction
Water contamination is one of the biggest challenges facing our environment today. Many industries discharge their untreated effluents into open ground due to the high cost of treatment, the absence of water for dilution, and a lack of sewage treatment facilities. When used as irrigation, certain industrial effluents contain a combination of nutrients that promote the growth of agricultural plants but may also contain harmful substances that reduce crop growth and production. (Sundaramoorthy, *et al*., 2010, Chhonkar, *et al*., 2000) [18, 1]. Among the industries that release waste water are distilleries, sugar mills, pulp and paper mills, detergent, chemical manufacturers, textile dyeing industries, tanneries, electroplating, pharmaceuticals, and dairy sectors. Tanneries are one of them, and through generating a variety of pollutants as effluents, they play a key role in environmental contamination. In India, over 40,000 tonnes of basic chromium are used annually in the chromium tanning operations that account for around 80% of the country's tanneries. The majority of the Cr is released through the effluent, with only a small portion of it being absorbed during the tanning process. According to reports, these companies discharge 12,000–20,000 tonnes of Cr in effluent each year. (Shukla, O.P., *et al*., 2007) [16].

Biochar has proven to be a feasible additive for mitigating nitrogen loss during the composting process. The finished product of control compost recorded the high contents of $NO_2$and NO_3(366 mg/kg and 600 mg/kg) with reduced the total NH_4 + content to 10 mg/kg. (Zainudin, *et al*., 2020) [21] Recently, biochar has received interest in various composting processes. This is due to its potential for reducing the nitrogen loss, accelerating the organic matter degradation, and also improving the microbial activity (Vandecasteele, *et al*., 2016) [20]. The chicken manure biochar is efficient in reducing the bioavailability of Cr as it decreases Cr mobility (immobilize Cr (III)) and speciation from Cr(VI) in to Cr (III) Choppala *et al*. (2015) [2].

Materials and Methods
The pot experiment was conducted in P G College Farm Ghazipur, in two consecutive kharif seasons 2018 and 2019 respectively. Paddy (*Oryza sativa* L.) Malviya Dhan 3022 seeds of were obtained from the Agrill. form, Banaras Hindu University The experimental treatment was conducted under various chromium treatment T1 Control (0 ppm Chrominium(Cr) + No amendment), T2 (20ppm Cr + No amendment), T3 (40ppm Cr + No amendment),T4 (60ppm Cr + No amendment), T5 (20ppm Cr + 0.690gm Paddy Straw Poultry Manure (PSPM)), T6 (20ppm Cr + 1.38gm PSPM), T7 (40ppm Cr + 0.690gm PSPM), T8 (40ppm Cr + 1.38gm PSPM), T9 (60ppm Cr + 0.690gm PSPM) and T10 (60ppm Cr + 1.38gm PSPM). The Observations were related with morphological and yield related parameter *viz*., Plant height, Tiller Number of Penicle per pot, Test Weight, Rice grain per penicle, Grain yield per pot Straw yield Harvest Index were recorded at 30, 60, and 90 DAS.

All observations were recorded in four replications and mean values were calculated. Data were analyzed following completely randomized design (Panse and Sukhatme (1967). Critical difference (C.D) values were calculated at 1%t level.

Result and Discussion

Plant height

A summarized data on plant height, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 1.0 and depicted in figure 1.0 Plant height increased as the growth progressed towards the 90 DAS during both the years of field experimentation.

At 30 DAS maximum plant height measured in T_6 (54.50) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum plant height recorded in T6 (53.20) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during 2020. On pooled data basis maximum plant height 53.85 cm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}. The treatment with the application of no plant nutrients (T_1) recorded minimum plant height 52.7 and 47.20 cm during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. On the basis of two years pooled data application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) recorded significantly higher plant height (53.85 cm) was respectively.

At 60 DAS, the maximum plant height 100.80 and 102.70 cm during 2018 and 2019, respectively recorded in T_6 was found significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} statistically at par to rest of the treatments. The minimum plant height 93.20 and 92.35 cm during 2018 and 2019 respectively was recorded in T_1. On pooled data basis maximum plant height 101.75 cm recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At 90 DAS, the maximum plant height 122.50 and 123.70 cm during 2018 and 2019, respectively recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during both the year and statistically *at par* to the remaining treatments. Treatments consisting application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) significantly among themselves in respect of plant height. Significantly the lowest plant height 114.80 and 117.5 cm during 2018 and 2019, respectively was observed in T_1. On pool data basis the maximum plant height recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At harvest, the maximum plant height 176.20 and 175.95 cm during 2018 and 2019, respectively recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during both the year and statistically *at par* to the remaining treatments. Treatments consisting application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) significantly among themselves in respect of plant height. Significantly the lowest plant height 168.10 and 167.85 cm during 2018 and 2019, respectively was observed in T_9. On pool data basis the maximum plant height recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}. Reduction in the plant height might be mainly due to the reduction in root growth and ensuing lesser nutrient and water transport to the above part of the plant. In addition to this, chromium transport to the aerial part of the plant can have a direct impact on cellular metabolism of shoots contributing to the reduction of plant height (Nematshahi *et al*., 2012; Tandon and Vikram 2014) [6, 19]. Poultry manure and paddy straw are recognized for their capability to immobilize heavy metals in soils for plant uptake and filtering to ground water. Chromium uptake in roots was higher than shoots. Application of poultry manure and paddy straw reduced the Cr toxicity (Sattar, H., *et al*., 2019) [13]. The most bioavailable fraction of soil organic carbon, promotes the reduction of Cr (VI) in soils such that richest source of paddy straw and poultry manure (Choudhary *et al*. 2017, Ding *et al*. 2016) [3, 22].

Tiller

A summarized data on tiller, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 2.0 and depicted in figure 2.0 tiller increased as the growth progressed towards the athavest during both the years of field experimentation.

At 30 DAS maximum tiller measured in T_6 (22.33) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum tiller recorded in T6 (23.00) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during 2020. On pooled data basis maximum tiller 22.67 cm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T_9) recorded minimum tiller 15.33 and 17.00 cm during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. On the basis of two years pooled data application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) recorded significantly higher tiller (22.67) was respectively.

At 60 DAS, the maximum tiller 27.00 and 27.33 during 2018 and 2019, respectively recorded in T_6 was found significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} statistically at par to rest of the treatments. The minimum tiller 21.00 and 20.33 during 2018 and 2019 respectively was recorded in T_9. On pooled data basis maximum tiller 27.16 recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At 90 DAS, the maximum tiller 28.00 and 27.73 during 2018 and 2019, respectively recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during both the year and statistically at par to the remaining treatments. Treatments consisting application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) significantly among themselves in respect of plant height. Significantly the lowest tiller 22.00 and 21.33 cm during 2018 and 2019, respectively was observed in T_9. On pool data basis the maximum plant height recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At harvest, the maximum tiller 27.89 and 27.83during 2018 and 2019, respectively recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during both the year and statistically *at par* to the remaining treatments. Treatments consisting application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) significantly among themselves in respect of plant height. Significantly the lowest tiller 22.00 and 21.33 cm during 2018 and 2019, respectively was observed in T_9. On pool data basis the maximum tiller recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

Number of Panicle per pot

A summarized data on Number of Penicle per pot, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 3.0 and depicted in figure 3.0 Number of Penicle per pot increased as the growth progressed towards the at havest during both the years of field experimentation.

The maximum Number of Penicle per pot measured in T_6 (98.00) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum Number of Penicle per pot recorded in T6 (98.66) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during 2020. On pooled data basis maximum Number of Penicle per pot 98.33 obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T_9) recorded minimum Number of Penicle per pot 86.00 and 87.66 during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. On the basis of two years pooled data application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T_6) recorded significantly higher Number of Penicle per pot (98.33) was respectively.

Test Weight

A summarized data on Test Weight, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 3.0 and depicted in figure 4.0 Test Weight increased as the growth progressed towards the at havest during both the years of field experimentation. The maximum Test Weight measured in T6 (24.70gm) during 2018 was significantly higher than T1, T2, T3, T4, T9 and T10 while maximum No of grain per penicle recorded in T6 (22.40gm) was significantly higher than T1, T2, T3, T4, T5, T9 and T10 during 2020. On pooled data basis maximum test weight 23.55gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T6) was significantly higher than T1, T2, T3, T4, T5, T9 and T10. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T4) recorded minimum Test Weight 20.60 and 19.30 during 2018 and 2019 respectively, which was significantly lower than all the remaining treatments during both the year. Kushwaha (2007) [4] also reported an increase in yield attributing characters with use of rock phosphate along with PSB and attributed to the increased availability of phosphorus with addition of organic manures which also favored the symbiotic N_2 fixation and higher growth of plants, thereby had positive effect on yield attributes. These results are close conformity with the findings of Sharma *et al.* (2001) [15], Shanmugam (2001) [14], Shekhawat and Sharma (2001) [15], Raiger (2004) [11], Prasad (2009) [9], Yadav (2013) [23] and Saravanan and Panneerselvam (2014) [12]. The higher number of seeds/ plot with added P and S organo mineral fertilizer may probably be due to other benefits of organic matter exceeding P and S supply, such as improvements in microbial activities, better supply of secondary and micronutrients, which are not supplied by 100% RDF, and less losse of nutrients from the soil (Yadav *et al.* 2000; Singh *et al.* 2004) [24, 17].

Rice grain per panicle

A summarized data on grain per penicle, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 4.0 and depicted in figure 5.0 grain per penicle increased as the growth progressed towards the at havest during both the years of field experimentation.

The maximum grain per penicle measured in T6 (125) during 2018 was significantly higher than T1, T2, T3, T4, T9 and T10 while maximum grain per penicle recorded in T6 (100) was significantly higher than T1, T2, T3, T4, T5, T9 and T10 during 2019. On pooled data basis maximum grain per penicle 112.5 obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T6) was significantly higher than T1, T2, T3, T4, T5, T9 and T10. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T4) recorded minimum grain per penicle 102 and 87.66 during 2018 and 2019 respectively, which was significantly lower than all the remaining treatments during both the year.This results are confermed by the similar findings or reported by Jain *et al.* (1987); Patel and Patel (2006) [8]. The highest and lowest straw yields were obtained significantly from TSP and RP, respectively. Statistically, panicle length, 1000-grain weight and grain P concentration were similar among the treatments. Maximum and minimum filled grains were obtained from straw compost and TSP, respectively. Osivand *et al.* (2009) [7].

Grain yield per pot

A summarized data on grain per penicle, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 4.0 and depicted in figure 6.0 grain per penicle increased as the growth progressed towards the at havest during both the years of field experimentation.

The maximum grain per penicle measured in T6 (48.00gm) during 2018 was significantly higher than T1, T2, T3, T4, T9 and T10 while maximum grain per penicle recorded in T6 (48.50gm) was significantly higher than T1, T2, T3, T4, T5, T9 and T10 during 2019. On pooled data basis maximum grain per penicle 48.25gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T6) was significantly higher than T1, T2, T3, T4, T5, T9 and T10. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T4) recorded minimum grain per penicle 38.00gm and 27.60gm during 2018 and 2019 respectively, which was significantly lower than all the remaining treatments during both the year. Rahman *et al.* (2006) [10] found that amended compost increased the number of nodules in pulses. Meena and Sharma (2005) [5] also found that application of DAP in soybean registered significantly higher yield attributes *viz.* number of pod plant, number of seed per pod,total nodules seed index and seed yield plant as compared to control.

Straw yield

A summarized data on Straw yield, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 4.0 and depicted in figure 7.0 Straw yield increased as the growth progressed towards the at harvest during both the years of field experimentation.

The maximum straw yield measured in T6 (72.80gm) during 2018 was significantly higher than T1, T2, T3, T4, T9 and T10 while maximum grain per penicle recorded in T6 (74.80gm) was significantly higher than T1, T2, T3, T4, T5, T9 and T10 during 2019. On pooled data basis maximum grain per penicle 73.80gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T6) was significantly higher than T1, T2, T3, T4, T5, T9 and T10. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T4) recorded minimum grain per penicle 64.40gm and 51.90gm during 2018 and 2019 respectively,which was significantly lower than all the remaining treatments during both the year. Similar result was also reported by Osivand*et al.* (2009) [7]. Sulphur plays an important role in improving the quality of pulses (Paricha *et al*., 1993). Findings of Patel *et al*. (2010) [8] are similar to the present investigation. Reviewing the work done on effect of gypsum on a variety of crops, it was inferred that its application promoted root growth (Shainberg *et al*., 1982). Better root development can therefore, be reasoned for greater extraction of nutrients from the soi

Harvest Index

A summarized data on Straw yield, an index of growth and development recorded periodically at 30, 60, 90 DAS and at harvest presented in Table 4.0 and depicted in figure 8.0 Straw yield increased as the growth progressed towards the at harvest during both the years of field experimentation.

The maximum straw yield measured in T6 (40.60%) during 2018 was significantly higher than T1, T2, T3, T4, T9 and T10 while maximum grain per penicle recorded in T6 (40.80%) was significantly higher than T1, T2, T3, T4, T5, T9 and T10 during 2019. On pooled data basis maximum grain per penicle 40.70% obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38gm PSPM (T6) was significantly higher than T1, T2, T3, T4, T5, T9 and T10. The treatment with the application of 60ppm Cr* + 0.690gm PSPM (T4) recorded minimum grain per penicle 35.90% and 32.70% during 2018 and 2019 respectively, which was significantly lower than all the remaining treatments during both the year. Kushwaha (2007) [4] also found similar results for an increase in yield attributing characters and yield with higher levels of rock phosphate with PSB and their interaction alonge with organic manures application. This may probably be due to the increased availability of phosphorus which also favored symbiotic N_2 fixation and higher growth of plants, thereby had positive effect on yield and attributes.

Table 1: Effect of organic amendments on plant height (cm) of Rice in chromium contaminated soils

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T1	54.70	55.80	55.25	100.80	102.70	101.75	122.30	123.60	122.95	175.6	175.35	175.475
T2	54.40	52.40	53.40	96.30	97.60	96.95	119.00	114.90	116.95	172.3	172.05	172.175
T3	54.20	50.40	52.30	93.20	91.50	92.35	114.50	106.40	110.45	170.5	170.25	170.375
T4	53.90	48.40	51.15	88.80	77.10	82.95	108.90	89.10	99.00	166.8	166.55	166.675
T5	54.30	52.80	53.55	96.50	97.90	97.20	119.50	115.80	117.65	175.2	174.95	175.075
T6	54.50	53.20	53.85	96.80	98.50	97.65	119.70	117.00	118.35	176.2	175.95	176.075
T7	54.40	50.90	52.65	93.60	92.30	92.95	115.30	108.50	111.90	171.4	171.15	171.275
T8	54.5	51.50	53.00	94.00	93.50	93.75	115.80	110.20	113.00	172.2	171.95	172.075
T9	54.10	49.10	51.60	89.30	79.00	84.15	109.00	91.10	100.05	168.1	167.85	167.975
T10	54.20	49.60	51.90	89.60	80.40	85.00	109.50	92.80	101.15	169.6	169.35	169.475
S.Em±	0.138	0.016	0.077	1.046	0.188	0.617	1.151	0.211	0.681	1.154	0.221	0.23
CD (P=0.05)	0.412	0.048	0.23	3.131	0.560	1.8455	3.447	0.632	2.0395	3.430	0.642	0.67

T_1= Control, T_2=20ppm Cr* + NA, T_3= 40ppm Cr* + NA, T_4= 60ppm Cr* + NA, T_5 = 20ppm Cr* + 0.690gm PSPM, T_6 = 20ppm Cr* + 1.38gm PSPM, T_7 = 40ppm Cr* + 0.690gm PSPM, T_8 = 40ppm Cr* + 1.38gm PSPM, T_9 = 60ppm Cr* + 0.690gm PSPM, T_{10} = 60ppm Cr* + 1.38gm PSPM, Cr=Chrominium, PSPM= Paddy straw Poultry Manure, NA= No amendment, ppm= Part Per Million

Table 2: Effect of organic amendments on tiller per hill of Rice in chromium contaminated soils.

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T1	21.33	22.67	22.00	26.33	26.67	26.50	27.67	27.33	27.50	27.67	27.33	27.50
T2	19.33	21.00	20.17	25.00	24.33	24.67	26.00	25.33	25.67	26.00	25.33	25.67
T3	18.33	19.00	18.67	23.00	22.33	22.67	24.00	23.33	23.67	24.00	23.33	23.67
T4	15.33	17.00	16.17	21.00	20.33	20.67	22.00	21.33	21.67	22.00	21.33	21.67
T5	19.67	21.00	20.34	25.00	24.33	24.67	26.00	25.33	25.67	26.00	25.33	25.67
T6	22.33	23.00	22.67	27.00	27.33	27.16	28.00	27.73	27.86	27.89	27.83	27.86
T7	20.67	19.00	19.84	23.00	22.33	22.67	24.00	23.33	23.67	24.00	23.33	23.67
T8	18.67	20.00	19.34	24.00	23.33	23.67	25.00	24.33	24.67	25.00	24.33	24.67
T9	15.33	17.00	16.17	21.00	20.33	20.67	22.00	21.33	21.67	22.00	21.33	21.67
T10	16.33	18.00	17.17	22.00	21.33	21.67	23.00	22.33	22.67	23.00	22.33	22.67
S.Em±	1.03	0.11	0.57	0.21	0.11	0.16	0.10	0.21	0.16	0.10	0.21	0.16
CD (P=0.05)	3.07	0.32	1.70	0.63	0.32	0.48	0.32	0.63	0.48	0.32	0.63	0.47

T_1=Control, T_2=20ppm Cr* + NA, T_3= 40ppm Cr* + NA, T_4= 60ppm Cr* + NA, T_5 = 20ppm Cr* + 0.690gm PSPM, T_6 = 20ppm Cr* + 1.38gm PSPM, T_7 = 40ppm Cr* + 0.690gm PSPM, T_8 = 40ppm Cr* + 1.38gm PSPM, T_9 = 60ppm Cr* + 0.690gm PSPM, T_{10} = 60ppm Cr* + 1.38gm PSPM,Cr=Chrominium, PSPM= Paddy straw Poultry Manure, NA= No amendment, ppm= Part Per Million

Table 3: Effect of Organic amendments of number panicle and test weight of rice in chromium contaminated soils.

Treatment	Number of Panicle			Test weight		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T1	97.66	98.00	98.16	23.10	21.70	22.40
T2	96.33	96.66	96.50	22.50	18.10	20.30
T3	92.00	92.66	92.33	21.50	19.90	20.70
T4	86.00	87.66	86.83	20.60	19.30	19.95
T5	96.00	97.00	96.50	22.60	21.30	21.95
T6	98.00	98.66	98.33	24.70	22.40	23.55
T7	93.33	93.66	93.50	21.50	20.70	21.10
T8	94.66	95.66	95.16	21.70	20.90	21.30
T9	89.00	89.66	89.33	20.70	20.50	20.60
T10	92.33	91.66	92.00	20.70	20.70	20.70
S.Em±	0.288	0.613	0.45	0.016	0.344	0.18
CD (P=0.05)	0.861	1.834	1.35	0.047	1.03	0.54

T_1= Control, T_2=20ppm Cr* + NA, T_3= 40ppm Cr* + NA, T_4= 60ppm Cr* + NA, T_5 = 20ppm Cr* + 0.690gm PSPM, T_6 = 20ppm Cr* + 1.38gm PSPM, T_7 = 40ppm Cr* + 0.690gm PSPM, T_8 = 40ppm Cr* + 1.38gm PSPM, T_9 = 60ppm Cr* + 0.690gm PSPM, T_{10} = 60ppm Cr* + 1.38gm PSPM, Cr= Chrominium, PSPM= Paddy straw Poultry Manure, NA= No amendment, ppm= Part Per Million

Table 4: Effect of Organic amendments of number of grains per panicle, grain yield straw yield and harvest index (%) of rice in chromium contaminated soils.

Treatment	Grains per panicle			Grain yield per pot			Straw yield per pot			Harvest index (%) per pot		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T1	122	98.66	110.33	47.00	48.00	47.50	72.00	73.00	72.50	39.50	40.60	40.05
T2	111	96.66	103.83	43.00	41.40	42.20	71.50	69.10	70.30	38.30	38.30	38.30
T3	104	92.66	98.33	41.00	38.50	39.75	64.80	65.40	65.10	37.00	36.60	36.80
T4	102	87.66	94.83	38.00	27.60	32.80	64.40	51.90	58.15	35.90	32.70	34.30
T5	111	97.00	104.00	43.00	42.00	42.50	71.70	69.40	70.55	38.40	38.50	38.45
T6	125	100.00	112.5	48.00	48.50	48.25	72.80	74.80	73.8	40.60	40.80	40.7
T7	105	93.66	99.33	41.00	39.20	40.10	65.50	65.90	65.70	37.30	36.90	37.10
T8	105	95.66	100.33	42.00	39.50	40.75	66.00	66.40	66.20	37.40	37.30	37.35
T9	103	89.66	96.33	38.00	28.40	33.20	64.70	53.20	58.95	36.00	33.00	34.50
T10	104	91.66	97.83	38.00	30.10	34.05	64.90	54.10	59.50	36.30	33.40	34.85
S.Em±	0.751	0.613	0.682	0.196	0.012	0.104	0.053	0.123	0.088	0.017	0.014	0.0155
CD (P=0.05)	2.249	1.834	2.0415	0.586	0.036	0.311	0.157	0.368	0.2625	0.051	0.041	0.046

T_1= Control, T_2=20ppm Cr* + NA, T_3= 40ppm Cr* + NA, T_4= 60ppm Cr* + NA, T_5 = 20ppm Cr* + 0.690gm PSPM, T_6 = 20ppm Cr* + 1.38gm PSPM, T_7 = 40ppm Cr* + 0.690gm PSPM, T_8 = 40ppm Cr* + 1.38gm PSPM, T_9 = 60ppm Cr* + 0.690gm PSPM, T_{10} = 60ppm Cr* + 1.38gm PSPM,Cr=Chrominium, PSPM= Paddy straw Poultry Manure, NA= No amendment, ppm= Part Per Million

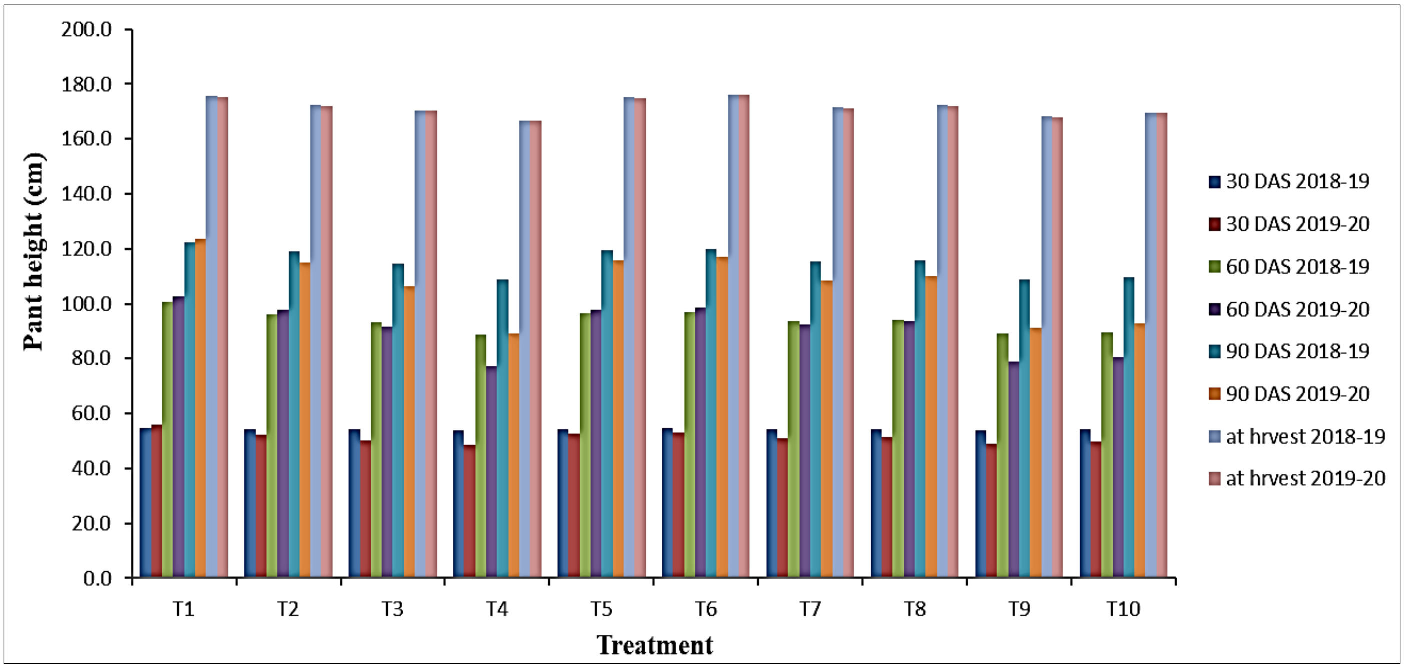

Fig 1: Effect of organic amendments on plant height (cm) of Rice in chromium contaminated soils

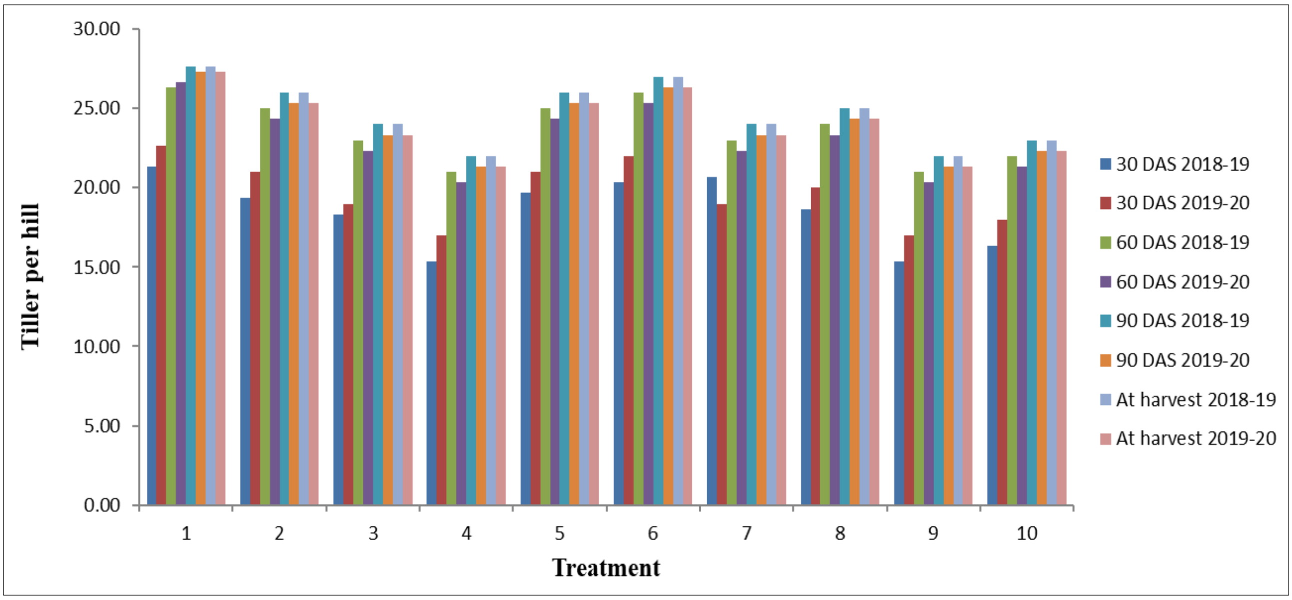

Fig 2: Effect of organic amendments on plant height (cm) of Rice in chromium contaminated soils

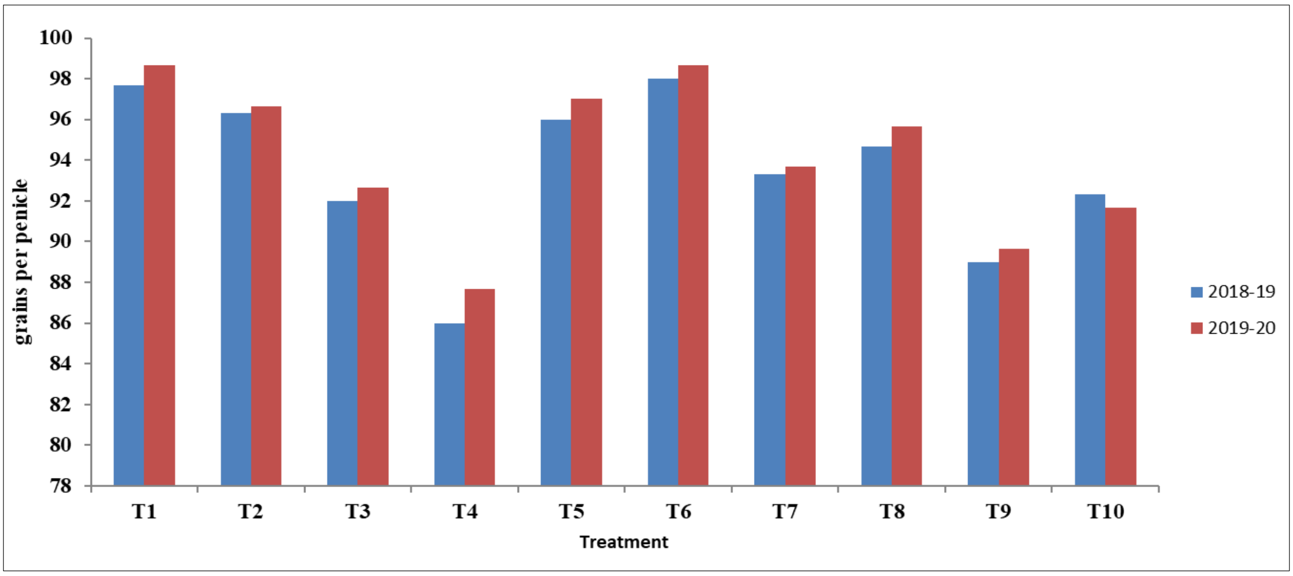

Fig 3: Effect of organic amendments on number of panicle of Rice in chromium contaminated soils

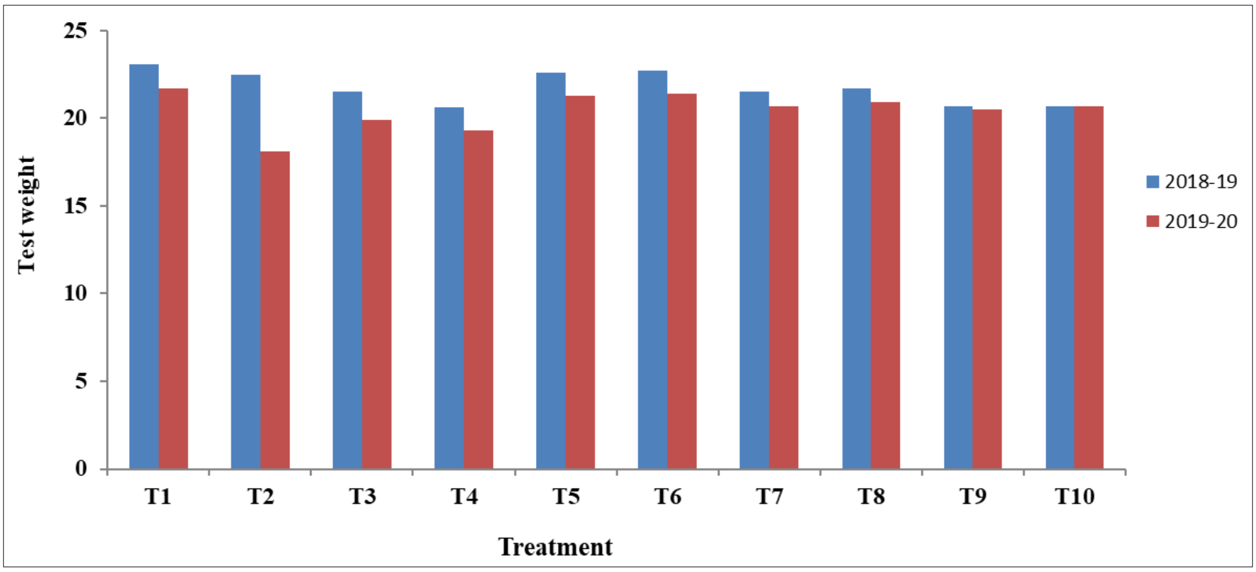

Fig 4: Effect of organic amendments on test weight of Rice in chromium contaminated soils

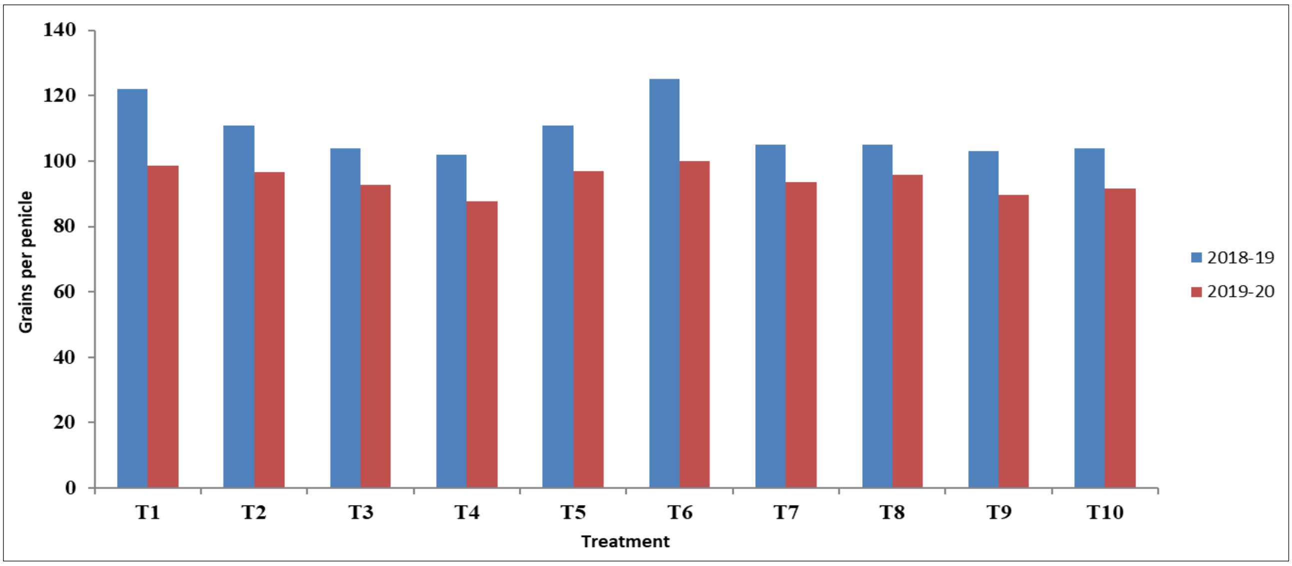

Fig 5: Effect of organic amendments on grains per panicle of Rice in chromium contaminated soils.

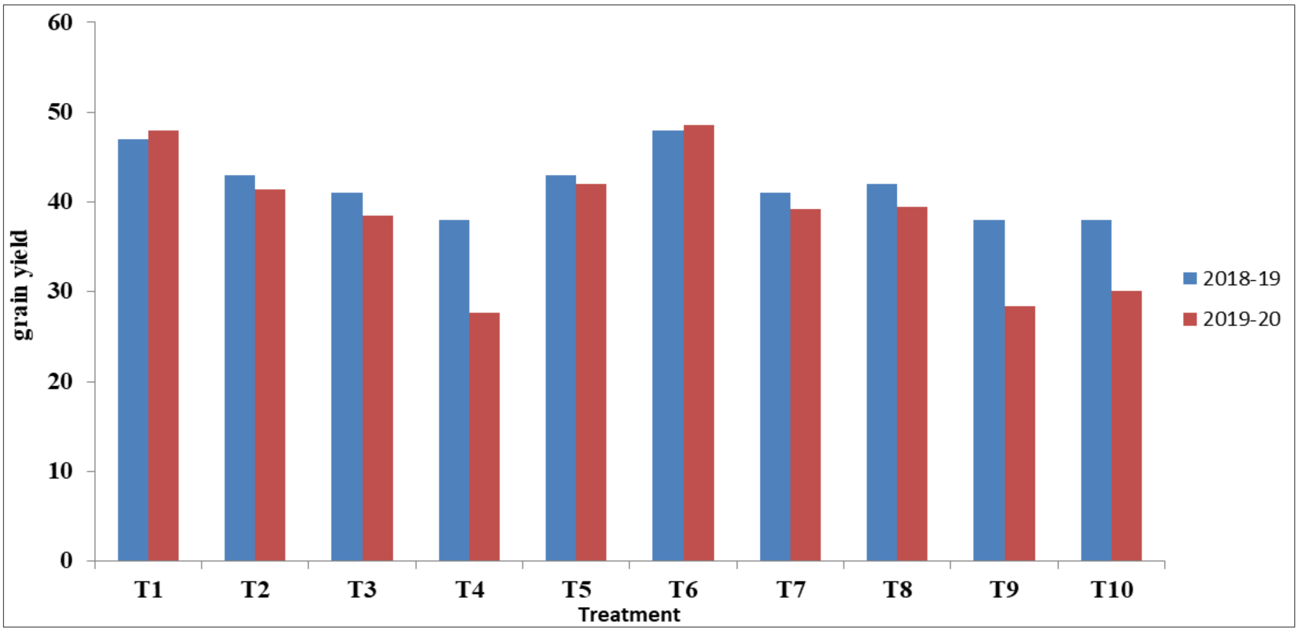

Fig 6: Effect of organic amendments on grain yield of Rice in chromium contaminated soils.

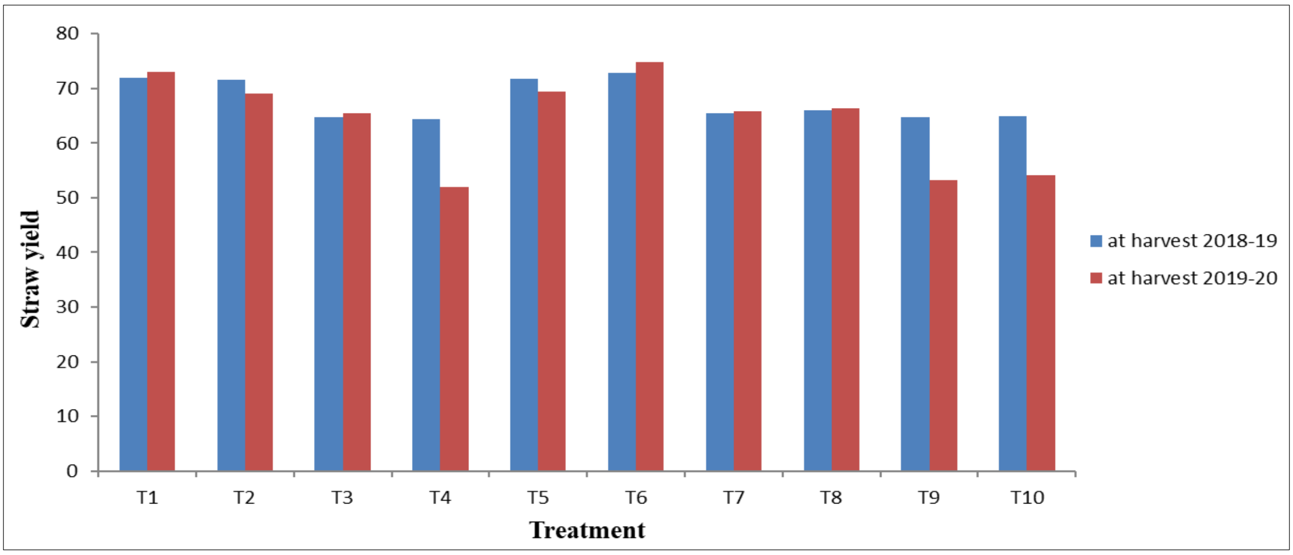

Fig 7: Effect of organic amendments on straw yield of Rice in chromium contaminated soils.

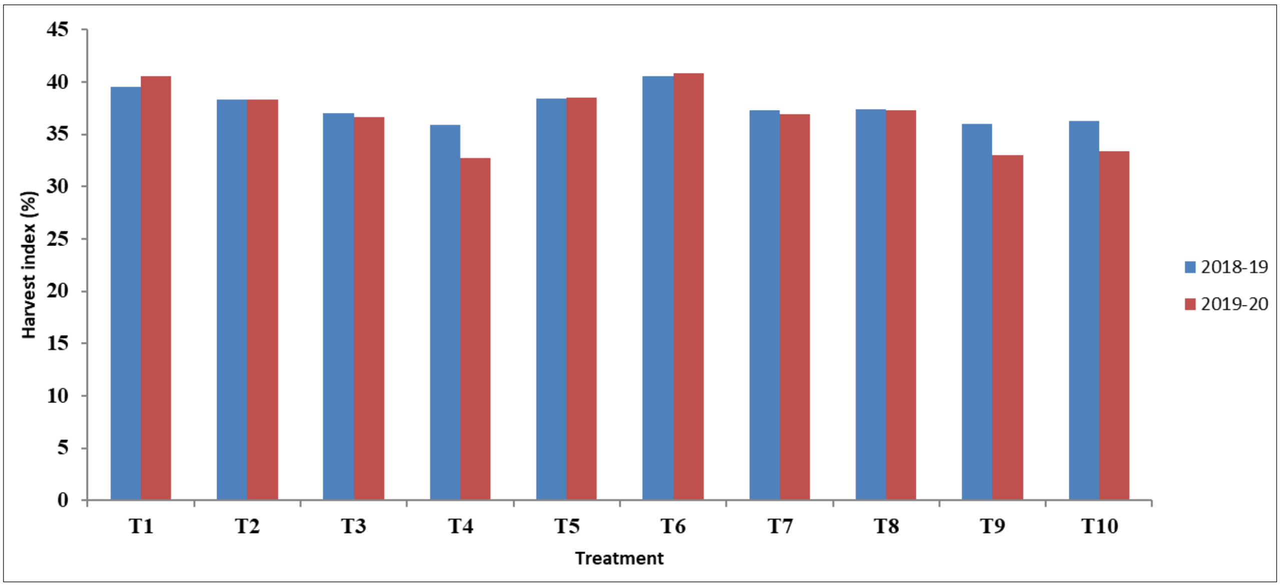

Fig 8: Effect of organic amendments on harvest index (%) of Rice in chromium contaminated soi

Conclusion

Plant height increased as the growth progressed towards the 90 DAS during both the years of field experimentation. At 30 DAS maximum plant height measured in T_6 (54.50) during 2018 was significantly higher thaT_1 T_2, T_3, T_4, T_9 and T_{10} while maximum plant height recorded in T6 (53.20) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10} during 2020.

Under fluoride toxicity condition, Ca form complexes and precipitates with F- resulting in lower activity or deficiency of calcium in the plant body. The mechanisms by which F is toxic are thought to involve inhibition of enzymes and interference with membrane permeability through precipitation with Ca (Suttie, 1977). If Ca concentrations in plants are already low, the plants would be more sensitive to F exposure. Changes in membrane permeability could overcome the barrier to F uptake in the cortex of the root and increase F concentrations in plant to phytotoxic levels. The toxic action of F is also thought to involve the inactivation of Mg at its sites of physiological activity (Weinstein and Alscher-Herman, 1982). However, concentrations of Mg in plant shoots showed no changes with F treatment suggesting that F concentrations in solutions had no effect on Mg nutrition in the plant (Stevens *et al*., 1998)

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