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

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

Keywords: Poultry manure, chromium, mustard attributes

Introduction
Chromium is a chemical element with the symbol (Cr) is a white metal and it have high melting point. Its hardness and resistance to corrosion properties, has become one of the very important and vital industrial metals and is universally used in everyday life. Unorganized and speedy industrial developments have contributed to enhancing the levels of heavy metals in ecosystem of many developing countries like India, China, Argentina, Guyana and Brazil. Chromium is not only potential pollutant but heavy metal which enhancing due to different natural and mining, the discharge of industrial waste, the amalgam of ore, the burning of fossil fuels, particularly coal, the use of As-loaded water for the irrigation, and the use of pesticides, herbicides, and fertilizers based on As. Because Chromium (VI) is high bioavailable and has a more solubility than Cr (III), which contributes to form stable complexes in the soil, it is more hazardous at lower concentrations. Regarding the result come back and translocation of Cr are inconclusive (VI). While few no. of writers confront that dissolved Cr (VI) is absorbed by plants without reduction. Anothers contend that Cr (VI) is reduced to Cr (III) on the root surface (Diwan *et al* 2012) [5]. Percentage of germination chlorophyll content (SPAD) height of the plant, number of leaves per plant, and number of branches per plant all had a substantial negative impact on growth as chromium levels rose. (Ashraa, F., *et al*., 2021) [2]. Tandon and Vikram (2014) [12] reported that growth and water content of rice plants was found to be decreased at increasing levels of chromium. The plant height decreased significantly with the increase in chromium concentration. The decrease in plant height was 10.67%, 15.58% and 39.50% at 0.25mM, 0.5mM and 1mM chromium respectively. According to Anjum *et al*. (2017) [1], Cr stress reduced the number of leaves per plant. When compared to the control, Wandan 30 and Runnong 35 under 150 µmol L−1 Cr level had reduced number of leaves per plant by 7% and 9%, respectively. According to Coelho *et al*. (2017) [13], Tagetes erecta's production of dry biomass decreased importantly as the amount of Chromium (III) in the rose solutions of nutrient; a loss of 82% was seen after exposure to 0.24 mmol L1Cr (III). It was simple to see how linear growth decreased when Cr (III) concentration enhanced, notably in the concentration range of 0.12 to 0.24 mmol L1. In comparison to healthy soil, the chromium toxicity causes a 33.32% drop in the percentage of seeds that germinate. The typical plant height fell quite substantially. (Devi, P., 2020 and Kumar, V., et al., 2018) [4, 7].

Materials and methods
The pot experiment was conducted in P G College Farm Ghazipur, in two consecutive kharif seasons 2018 and 2019 respectively. Mustard (*Brassica spp.)* Kala Sona seeds of were obtained from the Agrill. farm, Banaras Hindu University The experimental treatment was conducted under various chromium treatment T_1 Control (0 ppm Chrominium (Cr) + No

amendment), T_2 (20 ppm Cr + No amendment), T_3 (40 ppm Cr + No amendment), T_4 (60 ppm Cr + No amendment), T_5 (20 ppm Cr + 0.690 gm Paddy Straw Poultry Manure (PSPM)), T_6 (20 ppm Cr + 1.38 gm PSPM), T_7 (40 ppm Cr + 0.690 gm PSPM), T_8 (40 ppm Cr + 1.38 gm PSPM), T_9 (60 ppm Cr + 0.690 gm PSPM) and T_{10} (60 ppm Cr + 1.38 gm PSPM). The

observations were related with morphological and yield related parameter *viz*., Plant height, leaves per plant, branches per plant, no. of siliqua/plant, length of silique, No. of seeds/silique, dry matter accumulation (g/plant), dry matter accumulation g/pot), seed yield (g/plant) Seed yield (g/pot) 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) [14]. Critical difference (C.D) values were calculated at 1% t level.

Plant height

A summarized data on plant height, an index of growth and development recorded periodically at 30, 60 and at harvest presented in Table 1. and depicted in figure 1. Plant height increased as the growth progressed towards at harvesting during both the years of field experimentation.

At 30 DAS maximum plant height measured in T_6 (26.50cm) 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 (26.60cm) 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 26.55 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_4) recorded minimum plant height 16.60 and 16.70 cm during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year.

At 60 DAS, the maximum plant height 93.50 and 94.0 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 63.60 and 64.10cm during 2018 and 2019 respectively was recorded in T_4. On pooled data basis maximum plant height 93.75 cm recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At harvesting, the maximum plant height 157.00 and 157.10 cm during 2018 and 2019, respectively recorded in T_6 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 per 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 141.00 and 141.70 cm during 2018 and 2019, respectively was observed in T_4. 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}.

The plant height of crops was significantly influenced by the use of organo-mineral fertilizers compared to controls as reported by several worker (Saravanan and Panneerselvam 2014, Yadav 2013 and Osivand *et al*. 2009) [11, 15, 9]

Leaves per plant

The revealed data on leaves per plant, an index of growth and development recorded periodically at 30, 60 and at harvest presented in Table 2. and depicted in figure 2. Leaves per plant increased as the growth progressed towards at harvesting during both the years of field experimentation.

At 30 DAS maximum leaves per plant measured in T_6 (7.33) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum leaves per plant recorded in T_6 (8.00) 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 leaves per plant 7.665 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_4) recorded minimum leaves per plant 4.33 and 5.00 during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year.

At 60 DAS, the maximum leaves per plant 18.33 and 18.67 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 per to rest of the treatments. The minimum leaves per plant 12.00 and 12.33 during 2018 and 2019 respectively was recorded in T4. On pooled data basis maximum leaves per plant 18.50 recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At harvesting, the maximum leaves per plant 57.33 and 59.33 during 2018 and 2019, respectively recorded in T_6 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 per to the remaining treatments. Treatments consisting application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm PSPM (T_6) significantly among themselves in respect of leaves per plant. Significantly the lowest leaves per plant 38.00 and 39.335 during 2018 and 2019, respectively was observed in T_4. On pool data basis the maximum leaves per plant 58.33 recorded in T_6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

Osivand *et al*. (2009) [9] also reported similar result with application of rock phosphate and compost application.

Number of tillers per unit area is the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield. More number of tillers might be due to the more availability of nutrient with P and S organo mineral fertilizers that played a vital role in cell division. These results are in accordance to the findings of Rahman and Rashid (2006) [10].

Branches per plant

The revealed data on branches per plant, an index of growth and development recorded periodically at 30, 60 and at harvest presented in Table 3. and depicted in figure 3. Leaves per plant increased as the growth progressed towards at harvesting during both the years of field experimentation.

At 30 DAS maximum branches per plant measured in T_6 (5.67) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum branches per plant recorded in T_6 (6.33) 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 branches per plant 6.00 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_4) recorded minimum branches per plant 3.67 and

3.68 during 2019 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year.

At 60 DAS, the maximum branches per plant 12.00 and 12.30 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 leaves per plant 10.67 and 9.00 during 2018 and 2019 respectively was recorded in T4. On pooled data basis maximum branches per plant 12.00 recorded in T6 was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

At harvesting, the maximum branches per plant 25.67 and 25.33 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 branches per plant. Significantly the lowest branches per plant 16.00 and 18.00 during 2018 and 2019, respectively was observed in T_4. On pool data basis the maximum branches per plant 25.50 recorded in T6 was significantly branches per plant T_1, T_2, T_3, T_4, T_5, T_9 and T_{10}.

No. of Siliqua/plant

The revealed data on branches per plant, an index of in Table 4. and depicted in figure 4 (a). Leaves per plant increased as the growth progressed towards at harvesting during both the years of field experimentation. The maximum No. of Siliqua/plant measured in T_6 (167.00) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum No. of Siliqua/plant recorded in T6 (168.00) 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 No. of Siliqua/plant 167.50 obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm PSPM (T_6) was significantly higher than T_1, T_2, T_3, T_4, T_5, T_9 and T10. The treatment with the application of no plant nutrients (T_4) recorded minimum branches per plant 104.00 and 69.00 during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year.

Length of Siliqua

The revealed data on length of Siliqua, an index of growth in Table 4. and depicted in figure 4 (b). length of Siliqua increased as the growth progressed towards at harvesting during both the years of field experimentation. The maximum length of Siliuqameasured in T_6 (4.87 cm) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum length of Siliuqarecorded in T_6 (4.88 cm) 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 length of Siliuqa4.87 cm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm 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_4) recorded minimum branches per plant 4.64 and 4.53 during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. Babana and Antoun (2006) [3].

No. of seeds/siliuqa

The revealed data on No. of seeds/siliqua, an index of growth in Table 4. and depicted in figure 4 (c). No. of seeds/siliuqa increased as the growth progressed towards at harvesting during both the years of field experimentation. The maximum No. of seeds/siliuqa measured in T_6 (12.00) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum No. of seeds/siliuqa recorded in T_6 (10.00) 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 No. of seeds/siliuqa11.00 obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm 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_4) recorded minimum No. of seeds/siliuqa9.00 and 7.00 during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. Similar results were reported by Al– Mustafa *et al*. (1995) [16] reported that Green gram and wheat yields increased as a result of Purulia rock phosphate and SSP's residual effects, and the fertilizers combination was also beneficial at boosting crop production and absorption.

Dry matter accumulation (g/plant)

The revealed data on dry matter accumulation (g/plant), an index of growth in Table 5. and depicted in figure 5 (a). dry matter accumulation (g/ plant) increased as the growth progressed towards at harvesting during both the years of field experimentation.

The maximum dry matter accumulation (g/ plant) measured in T_6 (7.99gm) during 2018 was significantly higher than T1, T_2, T_3, T_4, T_9 and T_{10} while maximum dry matter accumulation (g/ plant) recorded in T6 (7.67gm) 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 dry matter accumulation (g/plant) 7.83gm 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_4) recorded minimum dry matter accumulation (g/plant) 3.80gm and 3.48gm during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year reported that significant interaction between sowing dates and nutrient sources was seen in the buildup of dry matter.

Dry Matter Accumulation g/pot)

The revealed data on dry matter accumulation (g/pot), an index of growth in Table 5. and depicted in figure 5 (b). dry matter accumulation (g/ pot) increased as the growth progressed towards at harvesting during both the years of field experimentation.

The maximum dry matter accumulation (g/ pot) measured in T_6 (12.15 gm) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum dry matter accumulation (g/ pot) recorded in T_6 (14.31gm) 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 dry matter accumulation (g/pot)

13.23 gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm 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_4) recorded minimum dry matter accumulation (g/pot) 5.68 and 6.62 gm during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year reported that significant interaction between sowing dates and nutrient sources was seen in the buildup of dry matter.

Seed Yield (g/plant)

The revealed data on seed Yield (g/plant) an index of growth in Table 5. and depicted in figure 5 (c) Seed Yield (g/plant) increased as the growth progressed towards at harvesting during both the years of field experimentation. The maximum seed Yield (g/plant) measured in T_6 (8.19gm) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum Seed Yield (g/plant) recorded in T6 (8.35 gm) 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 Seed Yield (g/plant) 8.27 gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm 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_4) recorded minimum Seed Yield (g/plant) 2.71 and 2.87 gm during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year.

Seed Yield (g/pot)

The revealed data on Seed Yield (g/pot) an index of growth in Table 5. and depicted in figure 5 (d) Seed Yield (g/plant) increased as the growth progressed towards at harvesting during both the years of field experimentation.

The maximum Seed Yield (g/pot) measured in T_6 (12.38 gm) during 2018 was significantly higher than T_1, T_2, T_3, T_4, T_9 and T_{10} while maximum Seed Yield (g/pot) recorded in T6 (14.44gm) 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 Seed Yield (g/pot) 13.41 gm obtained with the application of recommended dose of fertilizer with 20 ppm Cr + 1.38 gm PSPM (T_6) was significantly higher than T_1, T_2, T_3, T_4, T_5, T9 and T_{10}. The treatment with the application of no plant nutrients (T_4) recorded minimum Seed Yield (g/plant) 3.91 and 4.38 gm during 2018 and 2020 respectively, which was significantly lower than all the remaining treatments during both the year. Kumar, V., *et al*. (2020) [8] reported that significant effect on yield of mustard under organic amendment of chromium contaminated soil in mustard field.

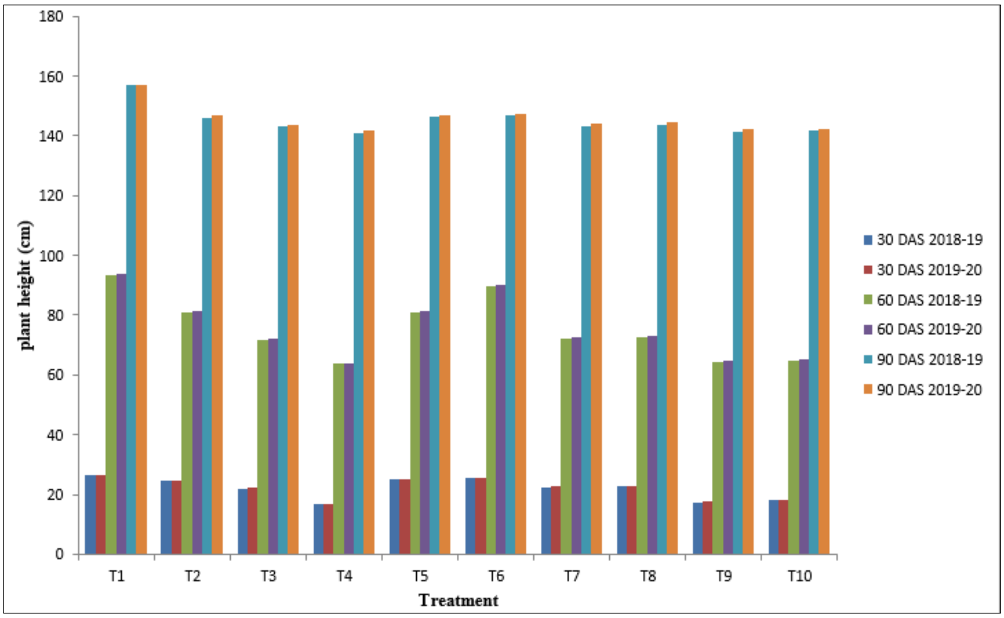

Fig 1: Effect of organic amendments on plant height (cm) of Mustard in chromium contaminated soils

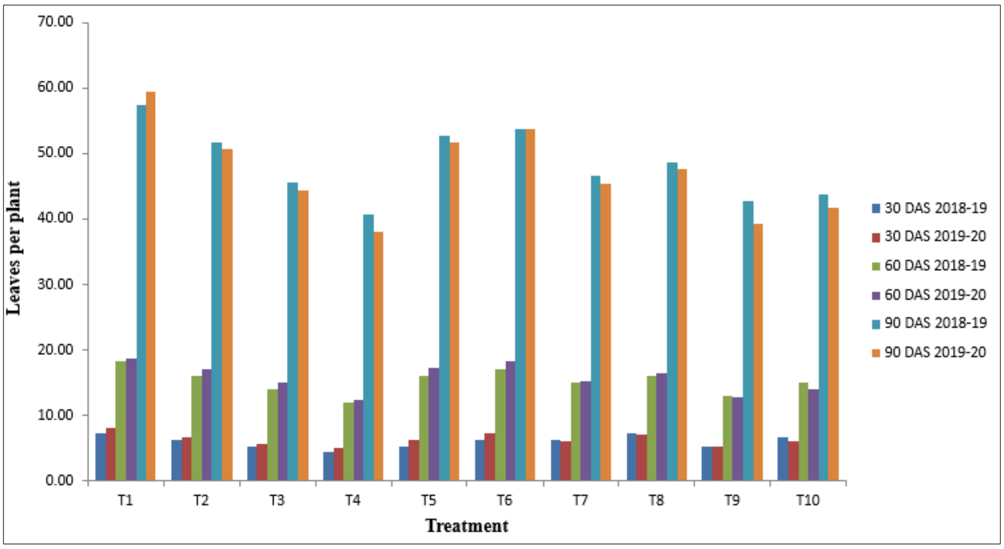

Fig 2: Effect of organic amendments on leaves per plant of Mustard in chromium contaminated soils

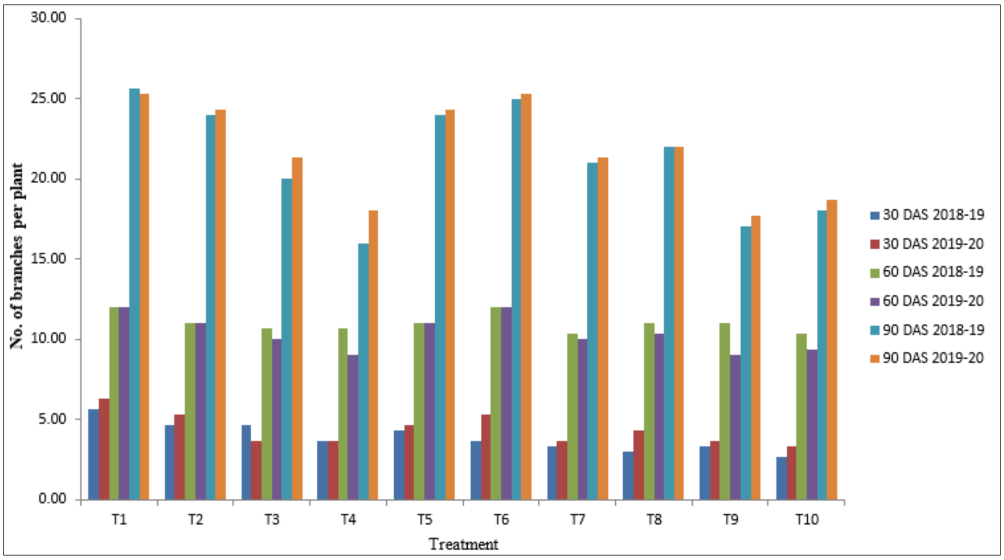

Fig 3: Effect of organic amendments on branches per plant of Mustard in chromium contaminated soils

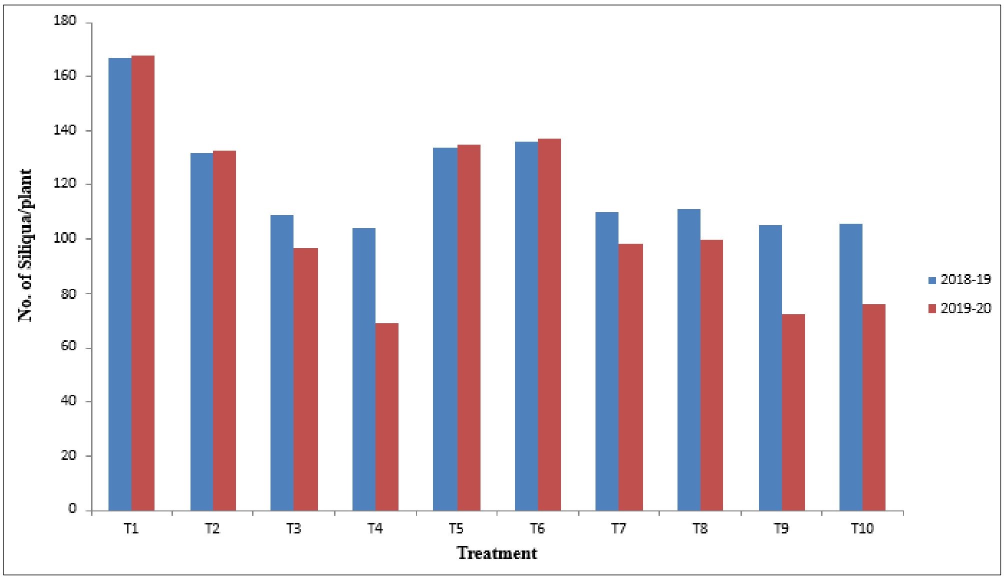

Fig 4 a): Effect of organic amendments No. of Siliqua/plant of Mustard in chromium contaminated soils

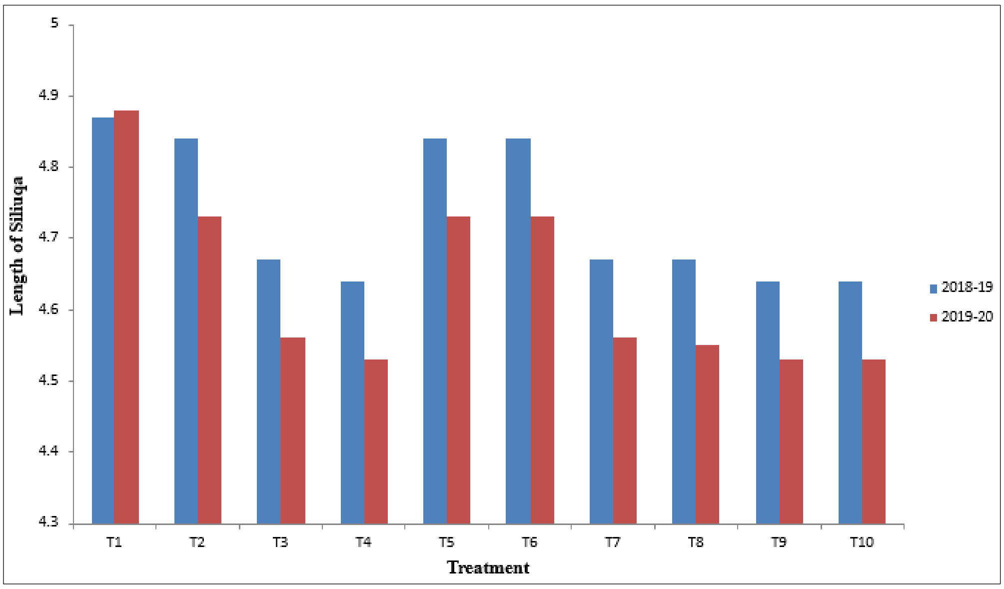

Fig 4 b): Effect of organic amendments length of Siliqua of Mustard in chromium contaminated soils

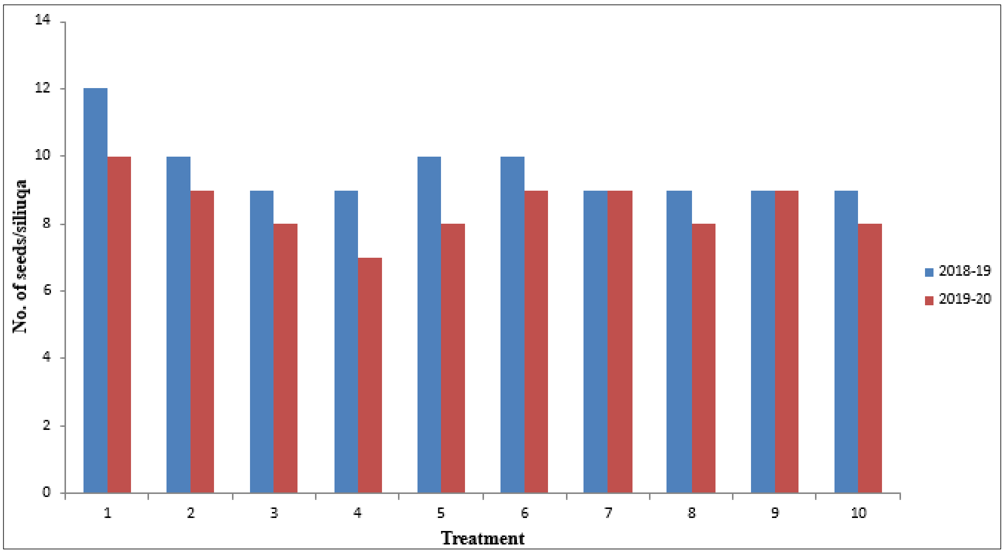

Fig 4 c): Effect of organic amendments no. of seed of Siliqua of Mustard in chromium contaminated soils

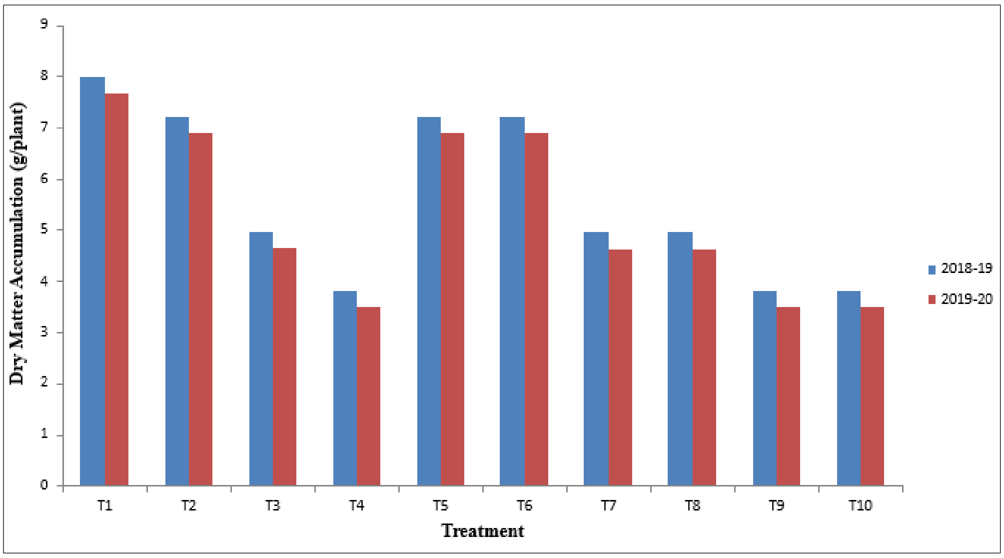

Fig 5 a): Effect of organic amendments dry matter Accumulation (g/plant) of Mustard in chromium contaminated soils

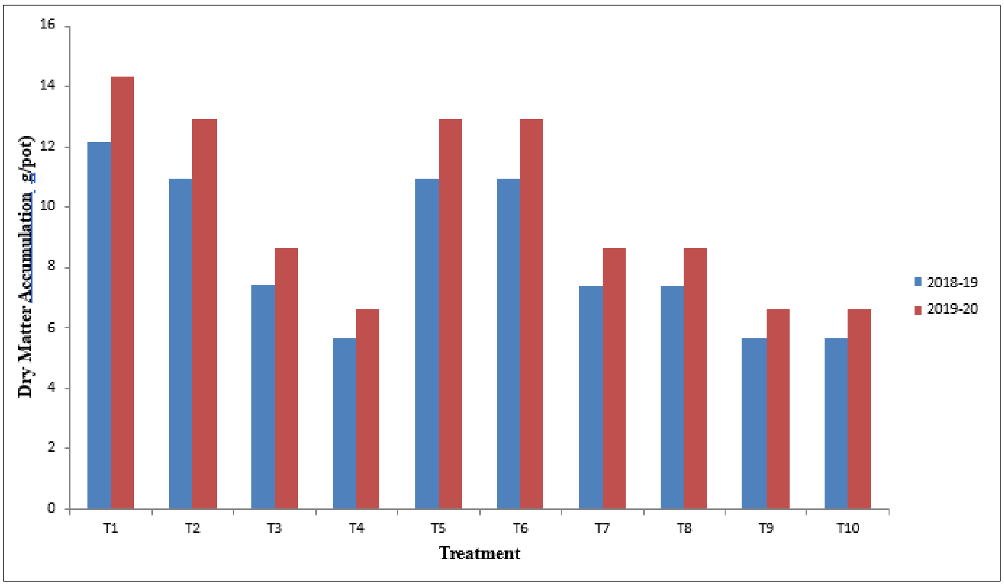

Fig 5 b): Effect of organic amendments dry matter Accumulation (g/pot) of Mustard in chromium contaminated soils

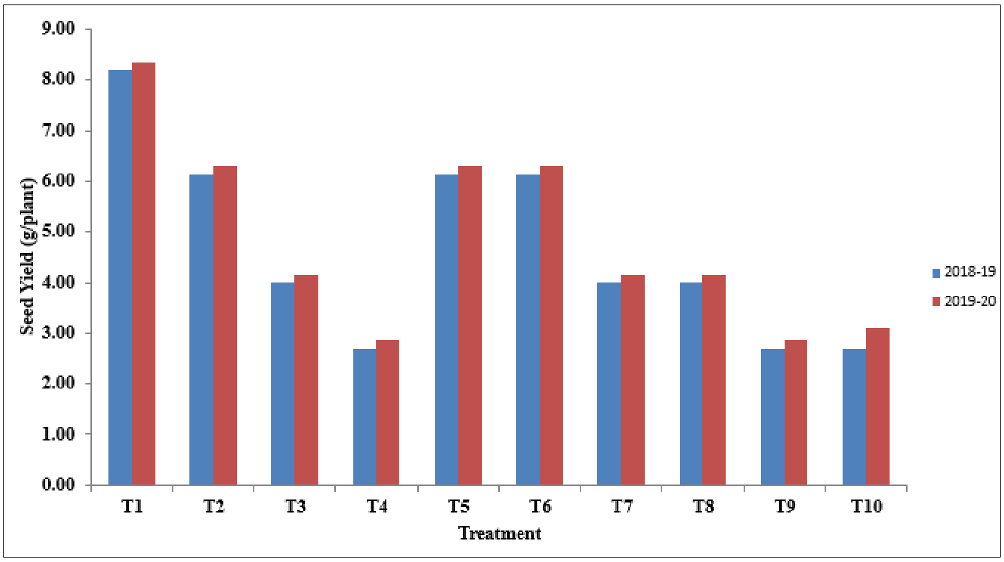

Fig 5 c): Effect of organic amendments seed yield (g/plant) of Mustard in chromium contaminated soils

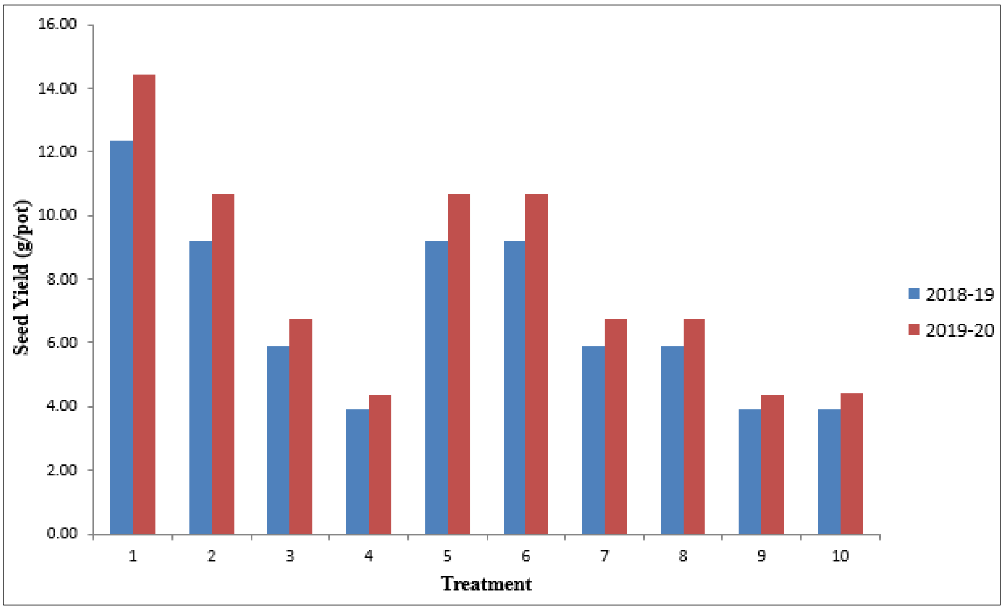

Fig 5 d): Effect of organic amendments seed yield (g/pot) of Mustard in chromium contaminated

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

Treatment	30 DAS			60 DAS			at harvesting		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T_1	25.40	25.50	25.45	89.50	90.00	89.75	146.70	147.40	147.05
T_2	24.70	24.80	24.75	80.80	81.20	81.00	146.00	146.70	146.35
T_3	22.00	22.10	22.05	71.50	72.00	71.75	143.00	143.70	143.35
T_4	16.60	16.70	16.65	63.60	64.10	63.85	141.00	141.70	141.35
T_5	25.10	25.20	25.15	81.00	81.50	81.25	146.40	147.10	146.75
T_6	26.50	26.60	26.55	93.50	94.00	93.75	157.00	157.10	157.05
T_7	22.50	22.60	22.55	72.20	72.70	72.45	143.30	144.00	143.65
T_8	22.80	22.90	22.85	72.70	73.10	72.90	143.60	144.30	143.95
T_9	17.40	17.50	17.45	64.20	64.70	64.45	141.40	142.10	141.75
T_{10}	18.10	18.20	18.15	64.60	65.10	64.85	141.70	142.50	142.10
SEm±	0.018	0.01	0.014	0.025	0.02	0.0225	0.041	0.078	0.0595
CD (P=0.05)	0.052	0.03	0.041	0.074	0.061	0.0675	0.121	0.233	0.177

T_1= Control, T_2=20 ppm Cr* + NA, T_3= 40 ppm Cr* + NA, T_4= 60 ppm Cr* + NA, T_5 = 20 ppm Cr* + 0.690 gm PSPM, T_6 = 20 ppm Cr* + 1.38 gm PSPM, T7 = 40 ppm Cr* + 0.690 gm PSPM, T_8 = 40 ppm Cr* + 1.38 gm PSPM, T_9 = 60 ppm Cr* + 0.690 gm PSPM, T_{10} = 60 ppm Cr* + 1.38 gm PSPM, Cr=Chrominium, PSPM= Paddy straw Poultry Manure, NA= No amendment, ppm= Part Per Million

Table 2: Effect of organic amendments on leaves per plant of Mustard in chromium contaminated soils

Treatment	30 DAS			60 DAS			90 DAS		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T_1	6.33	7.33	6.83	17.00	18.33	17.665	53.67	53.67	53.67
T_2	6.33	6.67	6.50	16.00	17.00	16.50	51.67	50.67	51.17
T_3	5.33	5.67	5.50	14.00	15.00	14.50	4567	4433	45.00
T_4	4.33	5.00	4.66	12.00	12.33	12.165	40.67	38.00	39.335
T_5	5.33	6.33	5.83	16.00	17.33	16.665	52.67	51.67	52.17
T_6	7.33	8.00	7.665	8.33	18.67	18.50	57.33	59.33	58.33
T_7	6.33	6.00	6.16	15.00	15.33	15.165	46.67	45.33	46.00
T_8	7.33	7.00	7.16	16.00	16.33	16.165	48.67	47.67	48.17
T_9	5.33	5.33	5.33	13.00	12.67	12.835	42.67	39.33	41.00
T_{10}	6.67	6.00	6.34	15.00	4.00	14.50	43.67	41.67	42.67
SEm±	0.11	0.33	0.22	0.11	0.40	0.255	0.21	0.50	0.355
CD (P=0.05)	0.32	0.90	0.61	0.32	1.19	0.755	0.63	1.50	1.065

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

Table 3: Effect of organic amendments on branches per plant of Mustard in chromium contaminated soils

Treatment	30 DAS			60 DAS			At harvesting		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T_1	3.67	5.33	4.50	12.00	12.00	12.00	25.00	25.33	25.17
T_2	4.67	5.33	5.00	11.00	11.00	11.00	24.00	24.33	24.17
T_3	4.67	3.67	4.17	10.67	10.00	10.335	20.00	21.33	20.67
T_4	3.67	3.68	3.67	10.67	9.00	9.835	16.00	18.00	17.00
T_5	4.33	4.67	4.50	11.00	11.00	11.00	24.00	24.33	24.17
T_6	5.67	6.33	6.00	12.00	12.30	12.00	25.67	25.33	25.50
T_7	3.33	3.67	3.50	10.33	10.00	10.165	21.00	21.33	21.17
T_8	3.00	4.33	3.665	11.00	10.33	10.665	22.00	22.00	22.00
T_9	3.33	3.67	3.50	11.00	9.00	10.00	17.00	17.67	17.34
T_{10}	2.67	3.33	3.00	10.33	9.33	9.83	18.00	18.67	18.34
SEm±	0.21	0.21	0.21	0.28	0.15	0.215	0.21	0.79	0.5
CD (P=0.05)	0.63	0.64	0.635	0.84	0.46	0.65	0.63	2.38	1.505

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

Table 4: Effect of organic amendments No. of Siliqua/plant, Length of Siliuqa and No. of seeds/siliuqa of Mustard in chromium contaminated soils

Treatment	No. of Siliqua/plant			Length of Silique			No. of seeds/silique		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T_1	136.00	137.00	136.50	4.84	4.73	4.78	10.00	9.00	9.50
T_2	132.00	133.00	132.50	4.84	4.73	4.78	10.00	9.00	9.50
T_3	109.00	97.00	103.00	4.67	4.56	4.61	9.00	8.00	8.50
T_4	104.00	69.00	86.50	4.64	4.53	4.58	9.00	7.00	8.00
T_5	134.00	135.00	134.50	4.84	4.73	4.78	10.00	8.00	9.00
T_6	167.00	168.00	167.50	4.87	4.88	4.87	12.00	10.00	11.00
T_7	110.00	98.00	104.00	4.67	4.56	4.61	9.00	9.00	9.00
T_8	111.00	100.00	105.50	4.67	4.55	4.61	9.00	8.00	8.50
T_9	105.00	72.00	88.50	4.64	4.53	4.58	9.00	9.00	9.00
T_{10}	106.00	76.00	91.00	4.64	4.53	4.58	9.00	8.00	8.50
SEm±	0.172	0.211	0.1915	0.001	0.013	0.007	0.211	0.105	0.158
CD (P=0.05)	0.515	0.631	0.573	0.002	0.038	0.02	0.631	0.316	0.4735

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

Table 5: Effect of organic amendments dry matter accumulation (g/plant), Dry matter accumulation (g/pot), seed yield (g/plant) and seed yield (g/pot) of Mustard in chromium contaminated soils

Treatment	Dry Matter Accumulation (g/plant)			Dry Matter Accumulation g/pot)			Seed Yield (g/plant)			Seed Yield (g/pot)		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
T_1	7.22	6.90	7.06	10.96	12.90	11.93	6.14	6.30	6.22	9.21	10.68	9.94
T_2	7.22	6.90	7.06	10.96	12.90	11.93	6.14	6.30	6.22	9.21	10.68	9.94
T_3	4.97	4.65	4.81	7.41	8.65	8.03	4.00	4.16	4.08	5.90	6.75	6.32
T_4	3.80	3.48	3.64	5.68	6.62	6.15	2.71	2.87	2.79	3.91	4.38	4.14
T_5	7.22	6.90	7.06	10.96	12.90	11.93	6.14	6.30	6.22	9.21	10.68	9.94
T_6	7.99	7.67	7.83	12.15	14.31	13.23	8.19	8.35	8.27	12.38	14.44	13.41
T_7	4.97	4.63	4.80	7.39	8.64	8.00	4.00	4.16	4.08	5.90	6.75	6.32
T_8	4.97	4.63	4.80	7.39	8.64	8.02	4.00	4.16	4.08	5.90	6.75	6.32
T_9	3.80	3.48	3.64	5.68	6.62	6.15	2.71	2.87	2.79	3.91	4.38	4.14
T_{10}	3.80	3.48	3.64	5.68	6.62	6.15	2.71	3.10	2.905	3.93	4.40	4.16
SEm±	0.002	0.025	0.0135	0.043	0.044	0.044	0.002	0.076	0.039	0.007	0.003	0.005
CD (P=0.05)	0.005	0.075	0.04	0.13	0.131	0.1305	0.006	0.227	0.1165	0.022	0.010	0.016

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

Conclusion

Present study concludes that negative impact of chromium-contaminated soil on mustard crop can be minimized by using this treatments, T_6 (20 ppm cr + 1.38 gm PSPM) and result in plant height, leaves per plant, branches per plant, length of siliqua, No of seeds/siliqua, dry matter accumulation (gm/plant), dry matter accumulation (gm/pot) and seed yield (gm/plant) and seed yield (gm/pot) have increased progressively toward at harvesting during both the year of field experimentation. Maximum no. of siliqua per plant observed in T_6 (167.00) and T_6 (168.00) during the years 2018 and 2020 respectively. Conclusively it is clear that chromium contamination causes decrease in mustard plant but along with paddy straw and poultry manure (PSPM) plant shows good growth and sufficient yield.

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