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Effect of bioremediation on internodal length and leaf area of maize plant cultivated in contaminated soil with chromium metal

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Abstract

From the diverse sources of the heavy metal like human activities which changes the cycles of heavy metal worldwide by biogeochemically hence emitting the different concentration of heavy metal in the atmosphere as well as in soil. With the increase in the industrialization and urbanization now a day leads to increase the heavy metal pollutants in the atmosphere and in the soil which have the toxic effects on the human as well as on the plants. There are various sources of heavy metal like weathering of rocks which comes under natural processes and lot many anthropogenic activities due to which it enters the environment. Due to various anthropogenic activities of human, the hexavalent chromium was found in drinking water which was discharged from the different industry like steel, leather, cement and also from trivalent chromium natural deposited by erosion. This investigation was aimed to analyze the role of biofertilizers in mitigating the chromium stress (Cr VI), given at the rate of 100 ppm per pot by keeping the organic approach into consideration for maintenance of sustainable agriculture. The present research work was carried out during the *Zaid* season in the Department of Agronomy as a pot culture experiment in the farm, School of Agriculture, Lovely Professional University, Phagwara. A pot experiment was set up with *Zea mays*, as test plant to evaluate the role of trichoderma, rhizobium and mycorrhiza mediated mitigation of chromium toxicity on morphological parameters of maize. The result indicates that when the plants are exposed to the chromium stress (T1) the average internodal length (cm) was significantly decreased with 17.60%, 14.25% and 2.16% as compared to that of control treatments (T0) at different growth interval 30, 60 and 90 DAS respectively. It was also found that when the application of mycorrhiza was done along with the chromium stress (T7) which helps in mitigating the effect of stress by increasing the average leaf area(cm^{-2}) by 4.77%, 12.64% and 61.52% as compared to the treatment where only chromium was applied (T1) at 30, 60 and 90 DAS respectively and this increase in leaf area helps the plants to survive in that harsh conditions.

Keywords: Biofertilizers, chromium, heavy metal, internodal length, leaf area

Introduction

The increasing rate of the industrialization and urbanization along with the improper waste disposal is the main source of the heavy metals concentration in the surroundings. There are various anthropogenic activities which include excess herbicides use, fertilization as well as sludge which are responsible for the heavy metal contamination in the environment but the most common source for trace element is the mining process. If the concentration of heavy metal is more than their permissible limits have adverse effects in the microbial activities as well as in plants and also effects the environment Miransari (2011).

In the environment, heavy metal concentration is increasing every year (Govindasamy *et al.*, 2011) [9]. The deposition of cadmium, lead and zinc in the atmosphere in the region of combine in the Netherlands with 700 km area was contaminated (Meers *et al.*, 2010) [17]. The area in china which is destroyed due to the activities of mining of 46700 ha annually. Due to severe pollution and soil erosion as well as off-site pollution, there is no vegetation on that destroyed land (Xia 2007). To minimize their impact on the environment it is necessary to remove the heavy metal from contaminated soils but there are so many challenges in terms of cost and complex technical skills (Barcel *et al.*, 2003) [5]. There are different method to achieve the purpose of heavy metal removal by chemical, biological as well as physical methods. The various conventional remediation ways include incineration of soil, in situ vitrification, landfill, washing off soil and solidification (Sheoran *et al.*, 2011 and Wauna *et al.*, 2011) [19, 23].

Maize is among the major cereal crops that help to meet the growing population demand for food, but adverse environmental conditions may affect their growth and productivity. Various researchers have previously reported adverse effects on maize plants of various environmental stresses. For example, (Zhu *et al.*, 2012) [26] reported that the warmer climate has reduced world maize yield while salt conditions have increased oxidative stress in maize crop plants.

Among them mostly grown maize in united states is yellow which in South Africa is not common allied with their social status whereas for production of animal feed yellow Kernal Zea mays used in that particular industry. (Chamber of Milling, South Africa 2013).
It is the best method in which the plants and related microbes of soil are used to diminish the toxicity and concentration of contaminants from the soil (Vithanage *et al.,* 2012; Greipsson 2011) [22]. Heavy metals, organic pollutants like polynuclear, biphenyls, pesticides, hydrocarbon, and radionuclides can be removed by using this technique. It is such a new approach in which plants or green substitute solution are used to mitigate the effect of heavy metal in soil. Phytoremediation concepts were given by Chaney in 1983 and now it is accepted as good pleasant among the public. A very large field is one of the best methods which is suitable for remediation where other methods are not effective in cost as well as practically feasible(Garbisu and Alkorta 2003) [8]. As compared to the other remediation it has a very low cost for the initial instalment (Van Aken, 2009) [21] and its cost is less than other remediation by 5 % (Prasad, 2003). When on polluted soil the vegetation is grown which also helps in leaching of metal and prevent erosion of soil (Chaudhry *et al.,* 1998) [7]. In this method plants with high biomass, fast-growing like poplar, jatropha and willow are used for the production of energy as well as phytoremediation (Abhilash *et al.,* 2012) [2]. From the different research work, it was indicated that mycorrhizae have the benefits effects on the host plant growth under different stresses like drought, salinity, heavy metal stress, etc. Many more have to be clarified some mechanisms which increase the fungal tolerance and host plant mechanism under heavy metal stress (Kumar *et al*., 2018a, 2018b, 2018c, Beshamgan *et al*., 2019) [16, 14, 15]. Due to the fabulous ability of the mycorrhizae in the morphological and physiological developing mechanism having, the improving effects of the fungal mycorrhizal on the growth of plants as well as on environment under the heavy metal stress (Kumar *et al*., 2016a, 2016b) [11, 12]. Due to the high toxicity of heavy metal stress, it is one of the most important stress which harmfully affects the growth of plants and the environment (Kumar *et al*., 2018a; Alzahrani *et al*., 2019) [16, 3].
From the contaminated soil with heavy metals one of the best strategy which involves the use of microbial management like plant growth-promoting rhizobacteria. Under the different level of the metal, A. chroococcum was able to live up to 1400 and 2000 microgram per millilitre of Copper and lead respectively and it was stated that growth of the plant was enhanced even under the mental stress. Those plants which are inoculated with strain increased the root biomass with 28% in copper and 205 in the lead-contaminated soil. The applied strain also improved the biochemical processes of the plants like reduction in proline content, MDA and the activities of the antioxidant enzymes in foliage. The metal accumulation of metal in the roots of inoculated plants are more as compared to that of normal other parts. The concentration of the lead was more in the kernel of maize as compared to the copper concentrations. With the application of the bacteria strain the concentration of metal was reduced in the shoots, roots and the kernel of the maize plant. Under the lead and copper stress, it was found that the leaf of maize plants are effected and the morphology of the root was the disturbing result in the death of the cell. This result indicates that the application of strain of rhizobacteria was a more effective option to increase the production of maize in the contaminated soil with heavy metals (Rizvi *et al.,* 2018) [18].
Increase in the population and pollution of industries has threats to the environment which leads to disturbance in agriculture. This indicated that characters of molecular of new fungal isolation and their impact of the seed biopriming to mitigate the effect of the salt stress in the maize as the dose-dependent manner. The genetic lineages of fungal were found by the use of internal transcribed spacer which results in revealing the *Trichoderma citrinoviride* species. The content of the relative water content, proline as well as soluble protein was high in the treated treatments with biopriming and also increased the osmoregulatory capacity. The current research is directed towards the developing powdered fungal which later can be used as the bio preparation to mitigate the various type of stresses like salt stress, heavy metal stress result in increasing the plant growth and crop production in the most important cereals crop like maize (Abdullah *et al .,* 2018) [25].

Methodology

The pot experiment was conducted in the poly house of the School of Agriculture, Lovely Professional University, Jalandhar, Punjab with one variety of Maize PMH -1. Maize variety was taken from Punjab Agriculture University, Punjab. Pot size for the experiment was diameter: 30 cm and height 25 cm and area of pot was 0.0706 m^2. Chromium stress was created in the plant by exogenous application of Chromium dichromate in soil. One best concentration after initial screening within the range of 1-100 ppm of Cr was finally selected. There is one concentration of heavy metals after the screening that is 100 ppm per pot, was applied in the soil for creating stress in Maize plant. Trichoderma, Rhizobium and Mycorrhiza were applied at the rate of the recommended dose in soil. For Trichoderma recommended dose is 20-25 gm/100m^2 and for 0.0706m2 it is 17.6 mg. For mycorrhiza, the recommended dose is 10 kg/ha and for 0.0706 m2 it is 70 mg. For rhizobium the recommended 3 litres for 1000 kg of farmyard manure and 1 kg of FYM it is 3ml. The various measurements were made at three stages such as 30 day, 60 days and 90 days.

Treatments Details

T0- Control; T1- Chromium (Potassium dichromate:100ppm/pot); T2-Trichoderma (*T.viride*:17.6 mg/pot); T3-Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot); T4-Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot); T5-Chromium (Potassium dichromate:100 ppm/pot) + Trichoderma (*T.viride*:17.6mg/pot); T6- Chromium (Potassium dichromate:100ppm/pot) + Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot); T7- Chromium (Potassium dichromate:100 ppm/pot)+Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot): T8- Chromium (Potassium dichromate:100 ppm/pot) + Trichoderma (*T.viride*:17.6mg/pot) + Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot); T9-Chromium (Potassium dichromate:100 ppm/pot) + Trichoderma (*T.viride*:17.6mg/pot)+ Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot); T10- Chromium (Potassium dichromate:100 ppm/pot)+Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot) + Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot); T11- Chromium (Potassium dichromate:100 ppm/pot)+Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot)+Trichoderma (*T.viride*:19mg/pot) + Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot); T12- Endomycorrhizal fungi (AMF, *Glomus* species: 70 mg/pot)+Trichoderma (*T.viride*:17.6 mg/pot) + Rhizobium (*R. trifoli*: 3ml in 1 kg of FYM/pot).

Observation was recorded

Internodal length (cm)

Internodes are the sections of stem between nodes. The length of the internodes was recorded from one node to another node in each plant. The mean of the intermodal length per plant was taken as the final intermodal length of the plant. It was observed that several internodes were present in the Maize. So, the mean value of the intermodal length was expressed as the internodal length of the plant.

Leaf area (cm^2)

The leaf area was calculated by the leaf area meter at 30, 60 and 90 DAS interval and after that mean leaf area was calculated in cm^2.

At 30 DAS At 60 DAS At 90 DAS

Fig 1: Leaf area (cm^2) was recorded by leaf area meter

Results and Discussion

This present research work was entitled "Trichoderma, Rhizobium and Mycorrhiza Mediated Mitigation of Chromium Toxicity in Maize (*Zea mays* L.)" was done during the *Zaid* season as the pot experiment in the Department of Agronomy, in the polyhouse, School of Agriculture, Lovely Professional University Phagwara. This study was done to investigate the role of the different biofertilizers in the mitigation effect of the chromium stress in maize crop (PMH-1) at 30, 60 and 90 DAS. This experiment was done to evaluate morphological parameters which lead towards the quantity attributes. The morphological parameters of maize plant (PMH-1) at 30, 60 and 90 DAS was evaluated under the chromium mental stress along with the application of Trichoderma, Rhizobium and Mycorrhiza in all treatments.

Internodal length (cm)

Mitigation effect of the Trichoderma, Rhizobium and Mycorrhiza and their combined application on intermodal length (cm) was evaluated in maize variety PMH-1 during the Zaid season grown under the chromium metal stress. Data were recorded at different growth interval 30, 60 and 90 DAS shown in (Table 4.1.4, Fig. 4.1.4). It was reported that when the plants are exposed to the chromium stress (T1) the average internodal length (cm) was significantly decreased with 17.60%, 14.25% and 2.16% as compared to that of control treatments (T0) at different growth interval 30, 60 and 90 DAS respectively. Similarly, Rizvi *et al.*, (2019) found that toxic effect of three different heavy metal named as Chromium, Cadmium and nickel on different parameters like attributes of seeds, enzymes of antioxidant and distribution of metal in maize plant was measured. Within the increase in the metal concentration, the growth of maize plants and yield attributes was decreased with increasingly. From the result, it was found that length of the shoot, as well as root length, was reduced by 65%, 32% in 36 mg/kg respectively under cadmium toxicity whereas, in case of chromium protein content, yield, chlorophyll was decreased by 16%, 84% and 77% respectively in 204 mg/kg. It is evident that when the biofertilizers are applied along with the chromium stress shows the mitigating effect to toxic produced by metal and it was found that among the three applied biofertilizers with chromium metal, the mycorrhiza (T7) was able to ameliorate the toxic effect of metal by increasing the internodal length (cm) by 5.6%, 10. 42% at 30 and 60 DAS respectively as compared to the treatment where Trichoderma was applied with chromium metal (T5) which helps the plant to attain the maximum height leads to the better growth of maize plant. Singh *et al.*, (2015) this experiment was conducted to know about the promotion of maize growth plants in the heavy metal-rich soil by the application of Arbuscular mycorrhizal fungi. The potential of phytoremediation, as well as the growth of the plants, was significantly improved by the application of the AMF fungi treatments. The weight of the shoot and length of the root of maize plant was increased with 113 and 49% respectively in that treatment which was treated with F. mosseae as compared to the control. Kumar (2018a) [16] reported that the combined application of putrescine and mycorrhiza in maize crop under cadmium toxicity. The combination was suitable for mitigating Cadmium toxicity linked to internal nodal length and node number. Singh *et al.*, (2019) this experiment was conducted to know about the promotion of maize growth plants in the heavy metal-rich soil by the application of Arbuscular mycorrhizal fungi. The potential of phytoremediation, as well as the growth of the plants, was significantly improved by the application of the AMF fungi treatments. The weight of the shoot and length of the root of maize plant was increased with 113 and 49% respectively in that treatment which was treated with F. mosseae as compared to the control. It acts as the biochar and found that enhancing the translocation of heavy metals like Cr, Ni, Pb and Cd. From the study, it was found that the application of AMF in the cultivation of *Zea mays* is the most suitable methods for the phytoremediation of the heavy metal from the contaminated soil with heavy metal.

Table 1: Internodal length (cm) of maize in *Zaid* season

Treatments	30 DAS	60DAS	90 DAS
T0	2.67^{abc}±0.29	9.33^{a}±2.52	13.83^{ab}±0.29
T1	2.20^{cd}±0.26	8.00^{ab}±2.00	13.53^{ab}±0.57
T2	2.83^{ab}±0.29	7.67^{ab}±1.53	13.83^{ab}±0.29
T3	2.83^{ab}±0.29	5.67^{bc}±0.58	14.17^{a}±0.31
T4	2.50^{bc}±0.50	6.67^{abc}±1.15	13.00^{abc}±1.00
T5	3.00^{a}±0.00	6.33^{bc}±1.53	10.33^{c}±1.53
T6	2.33^{cd}±0.29	6.33^{bc}±1.53	12.67^{abc}±0.76
T7	2.83^{ab}±0.12	5.67^{bc}±0.58	11.17^{bc}±2.57
T8	2.57^{abc}±0.17	4.67^{c}±2.08	10.33^{c}±1.53
T9	2.60^{abc}±0.17	6.67^{abc}±2.08	11.17^{bc}±1.26
T10	2.20^{cd}±0.00	7.00^{abc}±1.00	11.97^{abc}±1.70
T11	2.00^{d}±0.25	5.67^{bc}±0.58	12.33^{abc}±2.08
T12	2.27^{cd}±0.37	8.33^{ab}±0.58	10.33^{c}±1.53

where, DAS : Days after sowing, Data in form of Mean±SD at $p<0.05$, T0- Control; T1- Chromium (Cr VI); T2-Trichoderma; T3-Rhizobium; T4-Endomycorrhizal fungi (AMF) ; T5-Chromium (Cr VI) + Trichoderma; T6-Chromium (Cr VI) + Rhizobium; T7- Chromium (CrVI)+Endomycorrhizal fungi (AMF); T8- Chromium (Cr VI) + Trichoderma + Rhizobium; T9-Chromium (Cr VI) + Trichoderma + Endomycorrhizal fungi(AMF); T10-Chromium(Cr VI)+Endomycorrhizal fungi (AMF) + Rhizobium; T11- Chromium (Cr VI)+Endomycorrhizal fungi (AMF)+Trichoderma+Rhizobium; T12-Endomycorrhizal fungi (AMF) +Trichoderma + Rhizobium.

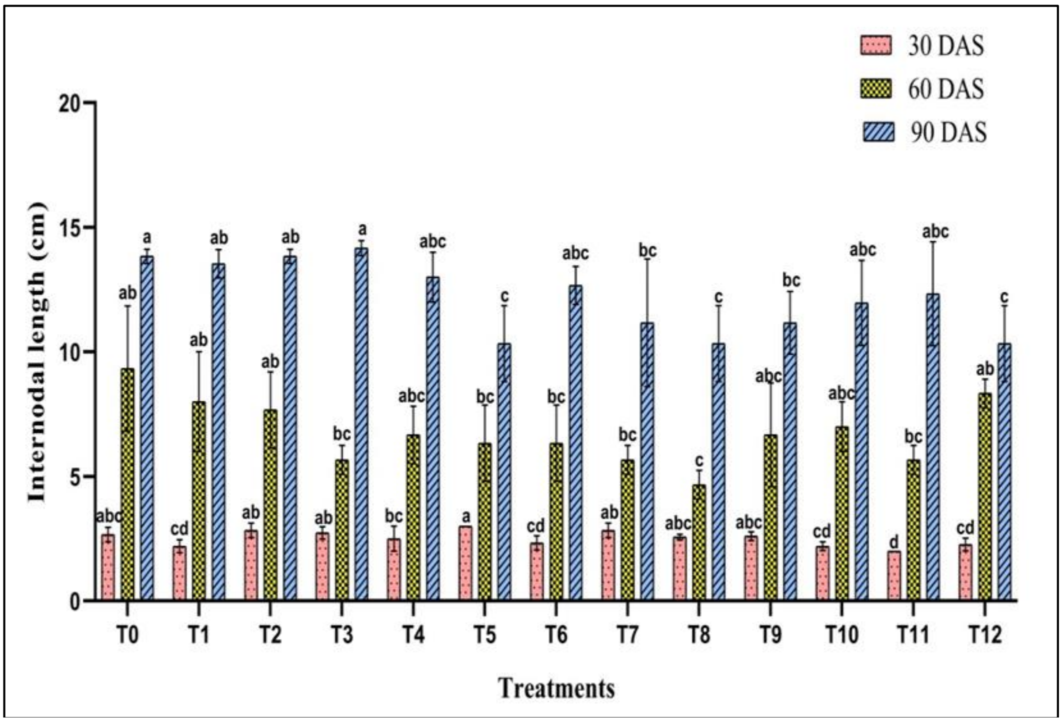

Fig 2: Internodal length (cm) of maize in *Zaid* season

where, DAS : Days after sowing, Data in form of Mean±SD at $p<0.05$, T0- Control; T1- Chromium (Cr VI); T2-Trichoderma; T3-Rhizobium; T4-Endomycorrhizal fungi (AMF) ; T5-Chromium (Cr VI) + Trichoderma; T6-Chromium (Cr VI) + Rhizobium; T7- Chromium (CrVI)+Endomycorrhizal fungi (AMF); T8- Chromium (Cr VI) + Trichoderma + Rhizobium; T9-Chromium (Cr VI) + Trichoderma + Endomycorrhizal fungi(AMF); T10-Chromium(Cr VI)+Endomycorrhizal fungi (AMF) + Rhizobium; T11- Chromium (Cr VI)+Endomycorrhizal fungi (AMF)+Trichoderma+Rhizobium; T12-Endomycorrhizal fungi (AMF) +Trichoderma + Rhizobium.

Leaf area (cm^2)

Mitigation effect of the Trichoderma, Rhizobium and Mycorrhiza and their combined application on leaf area (cm^2) was evaluated in maize variety PMH-1 during the *Zaid* season in the year of 2019 grown under the chromium metal stress. Data were recorded at different growth interval 30, 60 and 90 DAS shown in (Table 4.1.6, Fig. 4.1.6). It is evident that when plants are exposed to the chromium stress there is decreased in the average leaf area (cm^2) with 10.6%, 38.33% and 35.00% as compared to the control treatment (T0) at different growth intervals 30, 60 and 90 DAS. Anjum *et al.*, (2016) study was conducted to know about the effect of varying chromium toxicity in the maize plants in which level of stress of Cr affect the growth of plants, photosynthesis, different responses of yield and capacities of gas exchange into two-hybrid of maize i.e Wan Dan 13 and Run Nong 35 were grown in different concentration of contaminated soil in pots. It was also found that the height of the plant, leaves number, area of leaves, the diameter of the stem, dry weight and fresh weight also reduced and reduction of yield attributes was also reduced. It was also found that when the application of mycorrhiza was done along with the chromium stress (T7) which helps in mitigating the effect of stress by increasing the average leaf area(cm^{-2}) by 4.77%, 12.64% and 61.52% as compared to the treatment where only chromium was applied (T1) at 30, 60 and 90 DAS respectively and this increase in leaf area helps the plants to survive in that harsh conditions. Johnson *et al.*, (2016) [10] states that various methods for mitigation the toxicity of heavy metals but the most common method which is suitable in this modern world to maintain the sustainability i.e biological methods which work as long term without any harmful residual methods. When the application of mycorrhizae in the soil then there is the growth of fungal spores in soil and hyphae network like extensive structure is formed with vesicle and arbuscular. For the interaction between water and nutrients arbuscular is responsible and for the high vacuoles, the vesicle is responsible to withstand in the harsh conditions and provide the potential to plants against the heavy metal stress conditions. Rizvi *et al.,* (2019) this study was done to evaluate the toxic effect of three different heavy metal named as Chromium, Cadmium and nickel on different parameters like attributes of seeds, enzymes of antioxidant and distribution of metal in maize plant was measured. Within the increase in the metal concentration, the growth of maize plants and yield attributes was decreased with increasingly. From the result, it was found that length of the shoot, as well as root length, was reduced by 65%, 32% in 36 mg/kg respectively under cadmium toxicity whereas in case of chromium protein content, yield, reduction in leaf area which leads to decreased chlorophyll by 16, 84, 77% respectively in 204 mg/kg. With the increase in the concentration of metal the stress of oxidative was also increased. The content of proline and MDA was improved by 59 and 72% correspondingly when the control measured was taken. When maize was grown in the heavy metal stress it was found that antioxidant enzymes expression was higher. The result recommended the alarming concerns of toxicity of heavy metal in maize plants as well as the heavy metal accumulation within the grains of maize plants promoting the troubling concerns of public health.

Table 2: Leaf area (cm^2) of maize in *Zaid* season

Treatments	30 DAS	60DAS	90 DAS
T0	$34.93^{ef}\pm0.80$	$196.07^{c}\pm43.43$	$200.77^{d}\pm42.01$
T1	$31.20^{f}\pm2.57$	$206.03^{bc}\pm49.50$	$209.77^{cd}\pm46.34$
T2	$43.63^{bc}\pm1.37$	$205.53^{bc}\pm19.62$	$217.03^{cd}\pm27.41$
T3	$34.27^{ef}\pm1.02$	$139.90^{e}\pm9.81$	$145.00^{f}\pm9.71$
T4	$37.33^{cd}\pm1.00$	$144.33^{e}\pm6.92$	$150.07^{f}\pm7.56$
T5	$50.43^{a}\pm2.01$	$158.87^{de}\pm3.05$	$163.83^{ef}\pm5.79$
T6	$38.73^{cde}\pm3.45$	$129.00^{e}\pm3.18$	$136.52^{f}\pm5.25$
T7	$40.67^{bcd}\pm1.58$	$248.40^{a}\pm24.49$	$253.80^{a}\pm23.73$
T8	$44.27^{b}\pm1.19$	$148.00^{e}\pm3.34$	$153.27^{f}\pm4.72$
T9	$38.73^{cde}\pm1.72$	$154.17^{e}\pm2.57$	$159.50^{ef}\pm1.04$
T10	$40.70^{bcd}\pm0.72$	$267.40^{a}\pm9.70$	$280.00^{a}\pm9.15$
T11	$42.47^{bc}\pm5.61$	$193.40^{cd}\pm10.39$	$195.27^{de}\pm6.45$
T12	$43.30^{bc}\pm4.59$	$235.90^{ab}\pm4.16$	$242.37^{bc}\pm2.71$

where, DAS : Days after sowing, Data in form of Mean±SD at $p<0.05$, T0- Control; T1- Chromium (Cr VI); T2- Trichoderma; T3-Rhizobium; T4-Endomycorrhizal fungi (AMF) ; T5-Chromium (Cr VI) + Trichoderma; T6- Chromium (Cr VI) + Rhizobium; T7- Chromium (CrVI)+Endomycorrhizal fungi (AMF); T8- Chromium (Cr VI) + Trichoderma + Rhizobium; T9-Chromium (Cr VI) + Trichoderma + Endomycorrhizal fungi(AMF); T10- Chromium(Cr VI)+Endomycorrhizal fungi (AMF) + Rhizobium; T11- Chromium (Cr VI)+Endomycorrhizal fungi (AMF)+Trichoderma+Rhizobium; T12-Endomycorrhizal fungi (AMF) +Trichoderma + Rhizobium.

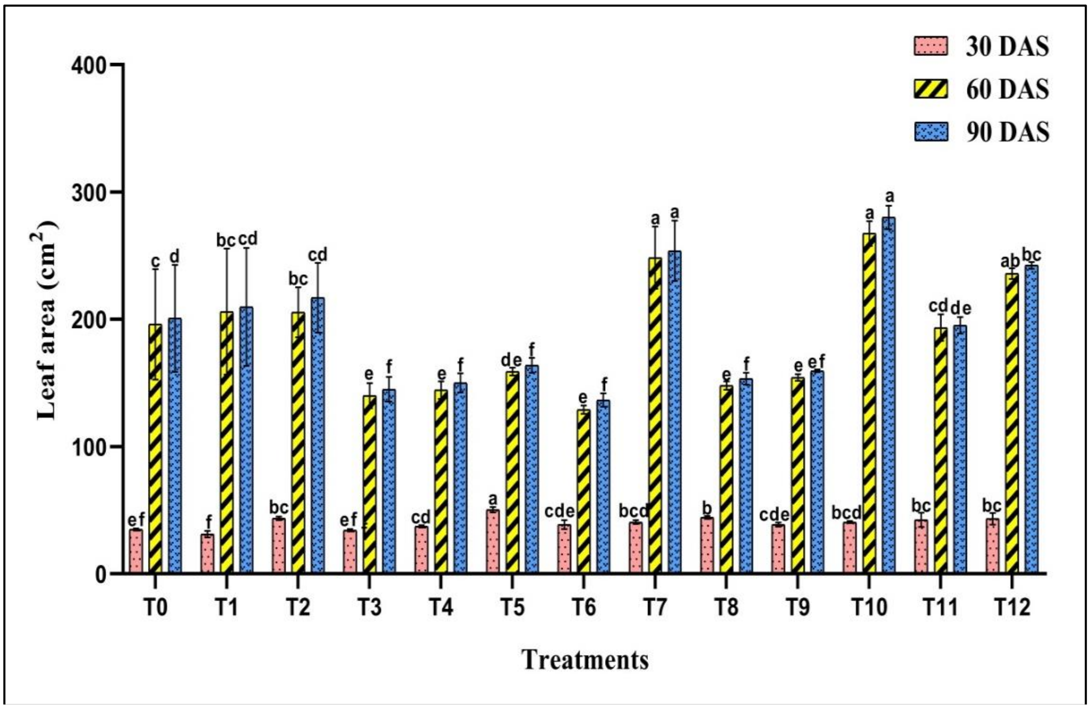

Fig 3: Leaf area (cm^2) of maize in *Zaid* season

where, DAS : Days after sowing, Data in form of Mean±SD at $p<0.05$, T0- Control; T1- Chromium (Cr VI); T2- Trichoderma; T3-Rhizobium; T4-Endomycorrhizal fungi (AMF) ; T5-Chromium (Cr VI) + Trichoderma; T6- Chromium (Cr VI) + Rhizobium; T7- Chromium (CrVI)+Endomycorrhizal fungi (AMF); T8- Chromium (Cr VI) + Trichoderma + Rhizobium; T9-Chromium (Cr VI) + Trichoderma + Endomycorrhizal fungi(AMF); T10- Chromium(Cr VI)+Endomycorrhizal fungi (AMF) + Rhizobium; T11- Chromium (Cr VI)+Endomycorrhizal fungi (AMF)+Trichoderma+Rhizobium; T12-Endomycorrhizal fungi (AMF) +Trichoderma + Rhizobium.

Conclusion

From the result, it was concluded that the Internodal length was reduced when exposed to chromium toxicity as compared to control. Exogenous application of biofertilizers with chromium metal was able to mitigate the chromium toxicity by enhancing the Internodal length which leads to an increase in plant height as compared to chromium stress. Similarly application of Mycorrhiza along with chromium metal able to reduce the toxicity of chromium by increasing the leaf area which directly enhances many physiological processes like photosynthesis as compared to the chromium stress.

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Author Contributions
P.K. designed the study, established the biochemical protocols, P.D performed the experiments and collected the data analyzed and interpreted the data. P.K. wrote the paper.

Conflict of Interest Statement
We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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