Trichoderma Mediated Mitigation of Lead Toxicity in Mustard with Special Reference to its Yield and Attributes

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Abstract

Effect of heavy metal is now a worldwide problem which posed environmental pollution and has a very negative impact on both biotic and abiotic substances. The heavy metals are naturally present in the soil but there are many human activities which increase the heavy metal concentration in the soil ecosystem which is very harmful to the soil health and affects various physiological functioning and yield of the crops. So, to check the toxic effect of lead (Pb) on plants various yield attributes of mustard are examined i.e. Pod per plant, Weight of silique, Silique length and chlorophyll index of pods. To examine these yield attributes mustard genotype (PBR-357) is grown in pots having diameter is 30 cm and height is 25 cm. Lead (Pb) toxicity is created by the exogenous application in the form of lead acetate (90 ppm per kg of soil) and application of Trichoderma (5g/10 kg of soil) to the soil before sowing. Trichoderma also applies in the combination with lead to know how it helps to mitigate the lead toxicity and improving the yield of the crop.

Keywords: Abiotic, Biotic, Chlorophyll index, Environmental, Ecosystem, Heavy metal, Lead

Introduction

There is the presence of minute fractions of heavy metals in the soil and many of them are essential for living organisms up to a certain level but if they are present in high amount then they are very harmful to animals, plants and human health (Kumar, P., Dwivedi, P. (2018a), Kumar, P., Kumar S. et al. (2018b), Kumar, P., Misao, L., et al., 2018c, Kumar P, Dwivedi, P. 2018d, Kumar, P. and Purnima et al., 2018e, Kumar, P. Pathak, S. 2019f, Kumar, P. Siddique, A. et al., 2019g, Siddique, A. Kumar, P. 2018h, Siddique, A., Kandpal, G., Kumar P. 2018i). The excess use of fertilizers in the soil cause accumulation of heavy metals in the soil. The effluents and waste from the industries also contain heavy metals in very high amount which can pose a threat to agriculture and toxic for the crop plants. Excessive accumulation of heavy metals in the soil such as lead, nickel, chromium, arsenic, cobalt, cadmium, zinc etc. result of mining and different technological activities of man (Pathak, S., Kumar, P., P.K Mishra, M. Kumar, M. 2017j, Prakash, A., P.

Kumar, 2017k., Kumar, P., Mandal, B., 2014L, Kumar, P., Mandal, B., Dwivedi P., 2014m., Kumar, P., Kumar, P.K., Singh, S. 2014n, Kumar, P. 2013o., Kumar, P., Dwivedi, P. 2015p, Gogia, N., Kumar, P., Singh, J., Rani, A. Sirohi, Kumar, P. 2014q, Kumar, P., 2014r., Kumar, P., Dwivedi, P., Singh, P., 2012s).

Heavy metals affect various physical and chemical activities in the living organisms and plants by increasing the release of reactive oxygen species (ROS), blocking glutathione and proteins functional groups and by displacing zinc or selenium from the proteins. There exist many different forms of lead in natural sources all over the world (Mishra, P.K., Maurya, B.R., Kumar, Pp. 2012t, Kumar, P., Mandal, B., Dwivedi, P. 2011u. Kumar, P., Mandal, B., Dwivedi, P. 2011v.

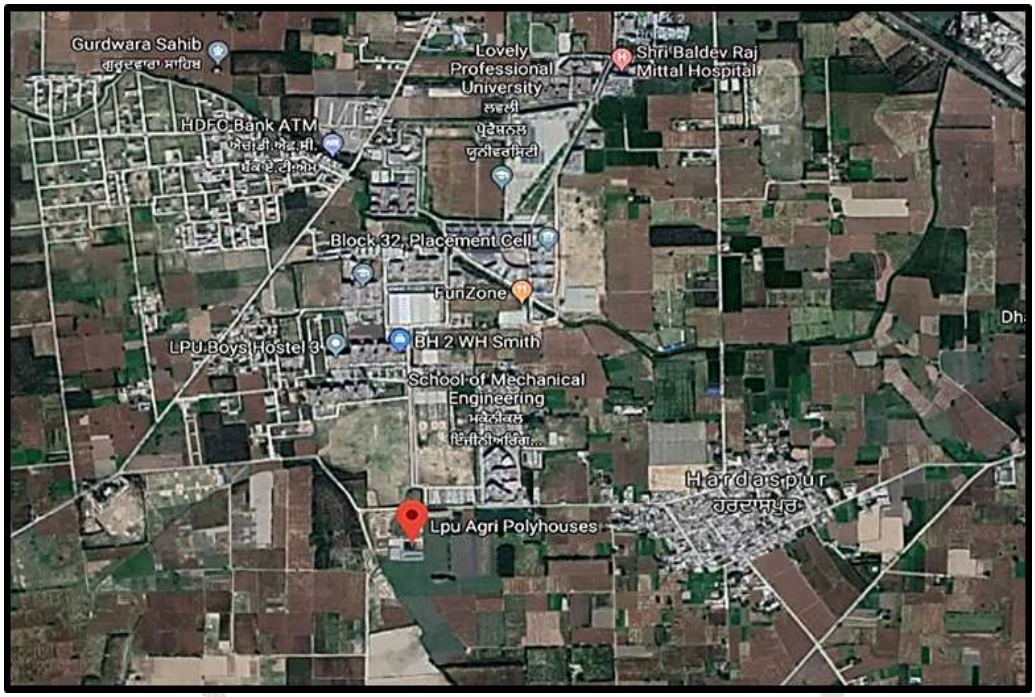
Kumar, P., Pathak, S. 2016w., Pathak, S., Kumar, P., Mishra, P.K., Kumar, M. 2016x, Kumar, P., Harsavardhn, M. et al., 2018y. Kumar, P., Yumnam, J. et al., 2018z, Kumar, P., Pandey, A.K., et al., 2018aa, Kumar, P., Kumar, S. et al., 2018bb, Kumar, P., Krishna, V., et al., 2018cc). According to the U.S. Environmental Protection Agency (EPA), the most common heavy metal which contaminates the environment is lead (Pb). Lead is one of the major heavy metal and has a greater potential to cause environmental pollution. Apart from the natural weathering processes, Pb contamination of the environment has resulted from the mining and smelting activities. The toxicity of lead cause inhibiting the root-shoot growth and disturb physiological functioning and mineral nutrition of plants. At the cellular level lead inhibits the enzymatic activities containing sulphydryl (-SH) groups necessary for their activity (van Assche and Clijsters, 1990) (Kumar, P. and Dwivedi, P. 2018gg. Kumar P., Siddique A., et al., 2018ff, Kumar, P, Pathak, S, Kumar, M and Dwivedi, P. 2018cd, Kumar P. and Pathak S. 2018kk, Kumar P and Pathak S. 2018pq. Singh et al 2020a., Singh et al., 2020b., Sood, et al., 2020., Bhadrecha et al 2020, Singh et al., 2020c, Sharma et al., 2020, Singh et al., 2020d, Bhati et al., 2020, Singh et al., 2019, Sharma et al., 2019).

To check the effect of lead toxicity and Trichoderma application on mustard we conduct a pot experiment and select one genotype of mustard (PBR-357) and grown in the pots having dimensions (30 cm in diameter and 25 cm in height) at Lovely Professional University, Jalandhar. Lead toxicity is produced by the application of lead acetate (90ppm/kg of soil) and *Trichoderma atroviridae* at the rate of 5g/10 kg of soil. The main objective behind our study is to check the effect of lead toxicity on the yield attributes i.e. Pod per plant, siliqua length, the weight of siliqua and chlorophyll index of pods etc. of mustard and how Trichoderma helps to mitigate the lead stress and improving the yield of the mustard crop.

Methodology

The pot experiment was conducted with all the natural conditions at the School of Agriculture, Lovely Professional University (LPU), Phagwara, Jalandhar (Punjab). The experimental area is situated at an altitude of 233 meters above the mean sea level, 31.245 latitudes and 75.701 longitudes (Figure 1).

Fig.1: Google photo of the experiment site



(Source: Google Earth, 2020)

Climatic Conditions:

There are hot and dry summers, wet and humid monsoons prevailing in the Jalandhar, Punjab. Phagwara region of Punjab falls in the central plain zones and situated in the Northeastern part of India with an annual rainfall of 686 mm. The mean annual temperature of Phagwara is 24 degree Celsius. January is the coldest month of the year with a mean temperature of 12.7 degree Celsius. The hottest month is June with an average temperature of 33.6 degree Celsius.

Treatments Details:

The experiment was conducted in the pot with one of the mustard genotypes PBR-357 which is taken from Punjab Agricultural University, Ludhiana (Punjab). The site of the experiment on the agricultural farm located at the Lovely Professional University, Jalandhar. Pots which are used for sowing having the dimensions like diameter is 30cm and height is 25cm. We used a total of 12 pots evenly filled with porous and well-pulverized soil and mix with vermicompost. We have decided four treatments (T0, T1, T2 and T3) and three replications (R1, R2 and R3) for this experiment. Soil application of all the treatments before sowing of mustard. Heavy metal treatment i.e. Lead in the form of lead acetate (90 ppm/kg of soil) and *Trichoderma atroviridae* (5g/10 Kg of soil)(Kumar P. 2018i., Kumar P. 2018ii., Kumar P. 2018iii, Kumar P.2018iv, Kumar P. 2018v. , Kumar P. 2018vi, Kumar P. 2018vii, Kumar P. 2018viii, Kumar P., Pathak S. 2018ix, Kumar P., Pathak S. 2018x, Kumar P., Pathak S. 2018xi, Kumar P., Pathak S, Kumar P., Pathak S. 2018xiii, Kumar P., Pathak S. 2018xiv, Kumar P., Pathak S. 2018xv, Kumar P., Pathak S. 2018xvi, Kumar P., Pathak S. 2018xvii, Kumar P., Pathak S. 2018xviii).

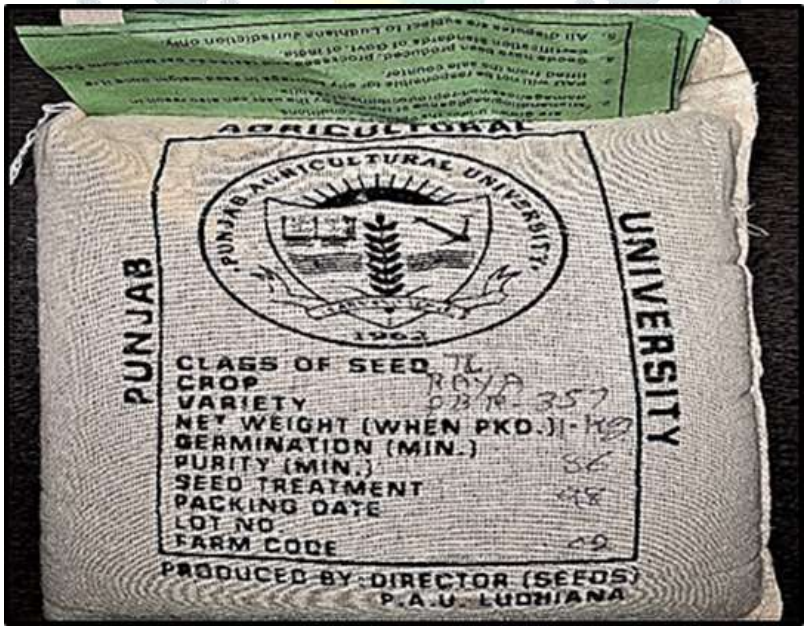
Table 1: Treatments Details

Treatments	Details of the treatments	Time of application
T0	Control	Before sowing
T1	Trichoderma (5g/10 kg of soil)	Before sowing
T2	Pb (90 ppm/kg of soil)	Before sowing
T3	Pb + Trichoderma (90ppm + 5g)	Before sowing

Table 2: Layout Details

S.No.	Particulars	Details
1.	Design	CRD
2.	Treatments	4
3.	Replication	3
4.	Total Pots	12
5.	Soil/pot	10 kg
6.	Genotype	PBR-357

Fig 2. Mustard Genotype (PBR-357)



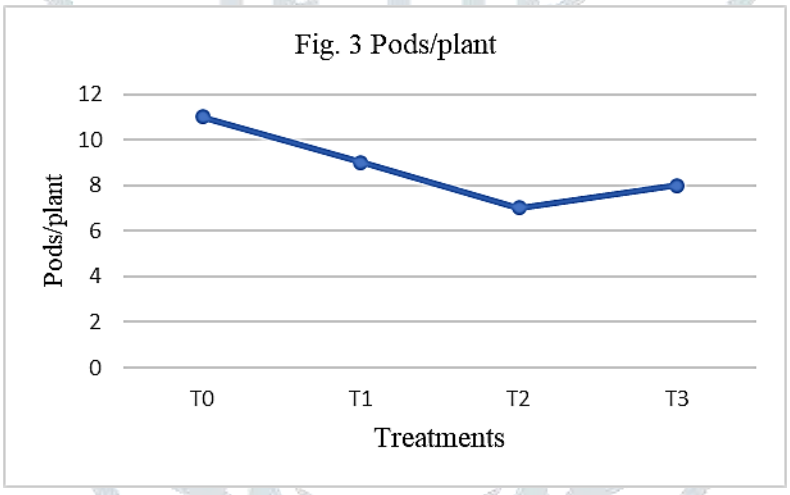
Observations to be recorded:

Observations are recorded about four and a half month after sowing (DAS) at the time of maturity. Instruments and materials used for the observation of different yield attribute via; Scissors, permanent marker, weighing machine, Ziplock cover pouch bags (Reusable/ Resalable) and SPAD meter etc.

Results and Discussion

Pods per plants

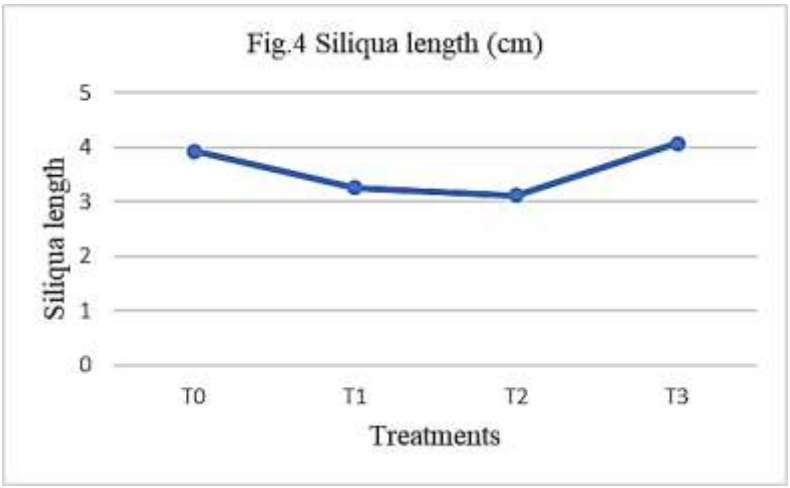
Maximum numbers of pods per plant are present in T0 (Control) as compare to all the treatments i.e. 18.18%, 36.36% and 27.27% more than T1, T2 and T3 respectively. There is 57.14% decrease in the number of pods in T2 when we compare with T0. There is a 12.5% increase in the number of pods in T3 as compared to T2. Therefore, we can say that the application of Trichoderma in lead affected soil can increase the number of pods and reduce the lead toxicity in soil.



where, T0: Control, T1: Trichoderma, T2: Lead & T3: Lead + Trichoderma

Siliqua length (cm)

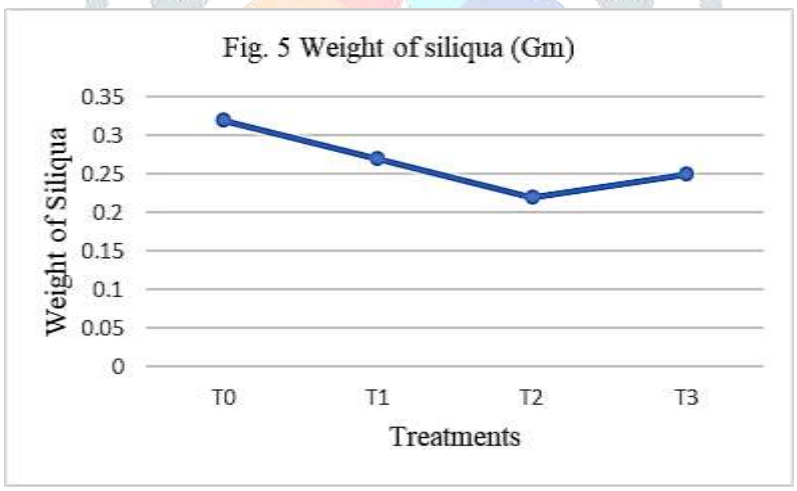
When we compare T2 with T0 then there is 26.04% decrease in siliqua length in T2 as compared to T0. Siliqua length is maximum in T3 as compared to all the treatments. Siliqua length is increased by 3.6% and 23.59% in T3 as compared to T0 and T2 respectively. Hence, the presence of Trichoderma can help to mitigate the lead toxicity in soil and has a positive effect in increasing the crop yield.



where, T0: Control, T1: Trichoderma, T2: Lead & T3: Lead + Trichoderma

Weight of siliqua (gm)

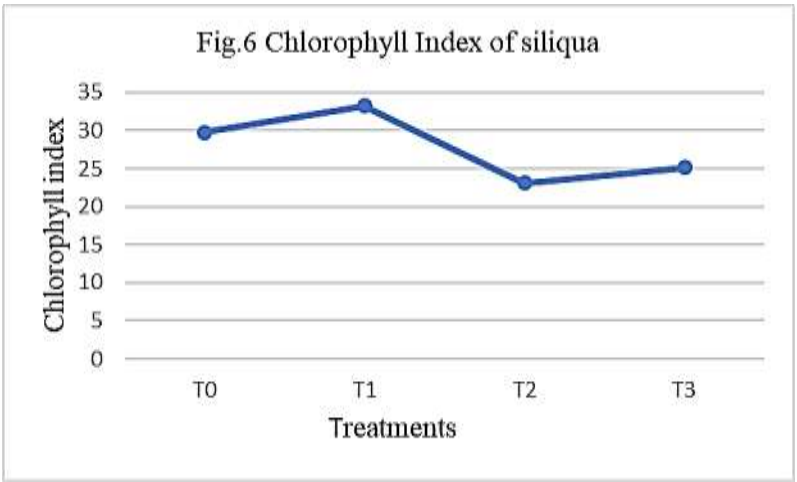
If we compare T2 with T0 then there is 45.45% decrease in weight of siliqua in T2 i.e. weight of siliqua is higher in T0 as compared to all treatments. According to the results, we found that there is a 12% increase in the weight of siliqua in T3 as compared to T2. Hence, we can say that the application of Trichoderma in lead affected soil can help to improve the performance of the crop and mitigate the toxic effect of lead in soil.



where, T0: Control, T1: Trichoderma, T2: Lead & T3: Lead + Trichoderma

Chlorophyll index of silique

Chlorophyll index of silique is measured with the help of SPAD (Soil Plant Analysis Development) meter after its harvesting. Chlorophyll index of silique is highest for the treatment where we apply Trichoderma i.e. T1 which is about 10.41% more than T0 (control). Whereas T2 has the lowest chlorophyll index among all the treatments which is about 28.87% low as compared to T0. Due to lead toxicity in the soil, the senescence phase of the plant occurred little earlier as compare to control, as a result, the length, size and weight of the pods in plants get affected.



where, T0: Control, T1: Trichoderma, T2: Lead & T3: Lead + Trichoderma

Conclusion

The lead toxicity in soil has a very negative impact on the performance of the crop because it inhibits the growth of roots and also causes chlorosis in plants. Lead even in very small quantity disturb various physiological processes in the plants like disturb hormonal status, water potential and enzymatic activities. From this experiment, we find that where we apply a treatment of lead in soil (T2), the performance and yield of the mustard highly affected. Due to which production of the crop is low. Therefore, according to the results, we can say that the application of Trichoderma in the lead affected soils can maintain the crop performance and also improve the yield of the crop.

Acknowledgements

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Author Contributions

The study was designed by Prasann Kumar, Yaman & Chandramohan Mehta and the biochemical protocolizations were established, the experiment was carried out and the data analyzed and interpreted were collected. The paper has been written by Prasann Kumar and Yaman.

Conflict of Interest Statement

The authors state that they have no interest in conflicts.

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