TRICHODERMA MEDIATED MITIGATION OF LEAD TOXICITY IN MUSTARD

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Abstract

Soils polluted with heavy metals have become common all around the world because of increase in geologic and anthropogenic activities. There is very adverse effect on the production of the crops, soil health, soil fertility and also very hazardous for the human health due to the accumulation of heavy metals in the soil and contaminate the environment. Among all the heavy metals lead (Pb) is one the major concerning metal which impose very disturbing effect on the physiological activities of the plants like electron transport, enzymatic activities, membrane structure, photosynthetic activities and hormonal status. It is also a potent factor for the pollution of environment. Pb pollutants are indispensable for modern human life, soil contamination with Pb is not likely to decrease in the near future. To check the effect of lead and Trichoderma on mustard various treatments are provided. Lead toxicity is produced by using lead acetate (90 ppm/kg of soil) and application of Trichoderma (5g/10 kg of soil) to the soil before sowing and estimate different biochemical parameters like total soluble protein, total soluble sugar, total soluble phenol, membrane injury index (MII) and membrane stability index (MSI) to know the physiological condition of the plant and how application of Trichoderma helps to mitigate the lead toxicity.

Keywords: Anthropogenic, Environment, Enzymatic, Geologic, Hormonal, Lead, Mitigate, Photosynthetic, Soil health, Trichoderma

Introduction

Problem of heavy metals contamination is increasing day by day in India due to mining activities, coal burning power plants, thermal power plants and excess use of fertilizers in agriculture for crop production. Lead, cadmium, chromium, copper and mercury are major heavy metals which cause various environmental pollution specially in areas with very high anthropogenic pressure. Due to the accumulation of heavy metals in crop land soils highly affects the agricultural production by decreasing the growth of the crops and soil health. Soil microbes plays very important role for maintaining the soil health and fertility but in heavy metals contaminated soils their population is very low. Metals toxicity impose very negative impact on the plants and also on the ecosystem.

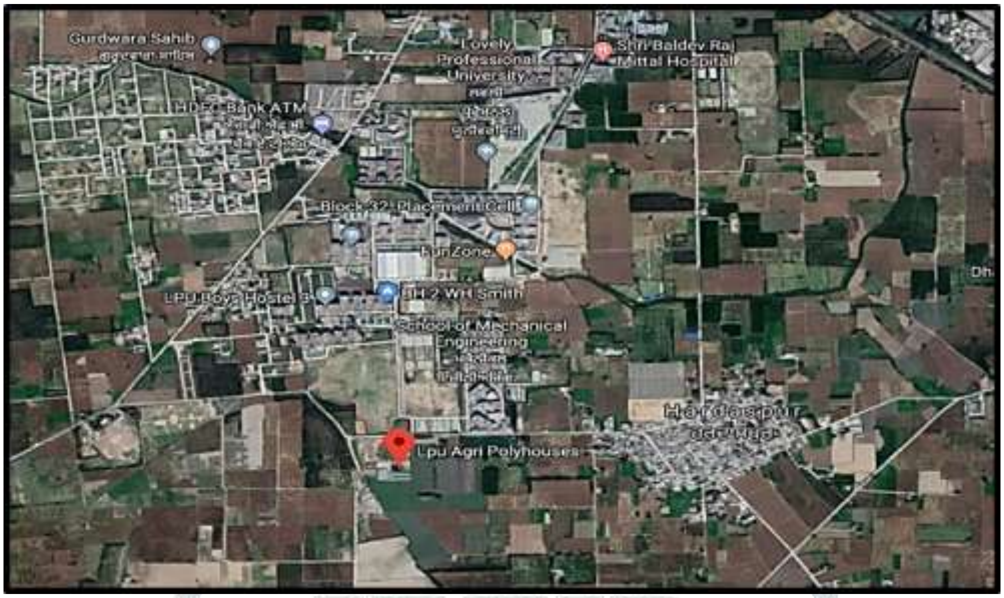
Lead (Pb) is one of the major heavy metal and has greater potential to cause environmental pollution. Apart from the natural weathering processes, Pb contamination of the environment has resulted from mining and smelting activities, Pb containing paints, gasoline and explosives as well as from the disposal of municipal sewage sludges enriched in lead (Chaney and Ryan, 1994). Major sources of lead are chimneys of factories using Pb, exhaust fumes of automobiles, effluents from storage batteries, industry, mining and smelting of Pb ores, metal plating, pesticides and fertilizers use. Lead contamination in soil and environment has become most serious global problem which has also bad effect on the human health. As many of the Pb pollutants are indispensable for modern human life, soil contamination with Pb is not likely to decrease in the near future (Yang et al., 2000). It has been observed that most of the lead contaminated soils are present near the industrial areas. Soils which are affected with lead contain 400-800 mg Pb/kg of soil while its range is 1000 mg/kg of soil near the industrial area (Angelon and Bini, 1992).

Lead adversely affects the production of the crop because it inhibits the growth of roots, stunted growth of the plant and chlorosis (Burton et al., 1984). Lead even in very small quantity disturb various physiological processes inside the plants like hormonal status, membrane structure, water potential, electron transport and enzymatic activities. At the cellular level lead inhibits the enzymatic activities containing sulphydryl (-SH) groups necessary for their activity (van Assche and Clijsters, (1990). Heavy metals affected areas are poor in organic matter and microbial activity is low. Therefore, application of Trichoderma helps to improve the performance of plants and protect them any kind of plant stress. To check the effect of lead toxicity and Trichoderma application on mustard we select one genotype of mustard (PBR-357) and grown in the pots having dimensions (30 cm in diameter and 25cm in height) at Lovely Professional University, Jalandhar. The main objective behind our study is to check the effect of lead on the biochemicals of mustard and how Trichoderma helps to mitigate the effect of lead toxicity in soil.

Methodology

The experiment was conducted in the pots with all the natural conditions at the School of Agriculture, Lovely professional University (LPU), Phagwara, Jalandhar (Punjab). Jalandhar is located on the irrigated plain between Sutlez and Beas rivers. Jalandhar is surrounded by Ludhiana district in East, Kapurthala in West, Hoshiarpur in North and Ferozepur in South. The experimental area is situated at an altitude of 232 m above mean sea level, having latitude and longitude 31.244604 and 75.701022 respectively (Figure 1).

Fig.1: Google photo of the experiment site



(Source: Google Earth, 2020)

Climatic Conditions:

Climate of Jalandhar is characterized by hot and dry summers and wet and humid monsoons. In winter, there is much less rainfall in Jalandhar than in summer. Phagwara's climate is a local steppe climate. The average annual temperature is 24.1 degree Celsius. June is the hottest month of the year with average temperature of 33.6 degree Celsius and with the average temperature of 12.7-degree Celsius January is the coldest month. The average annual rainfall is 686 mm.

Treatments Details:

The pot experiment was conducted with one genotype of Mustard PBR-357 taken from the Punjab Agricultural University, Ludhiana (Punjab). This experiment was conducted on the agricultural farm located at Lovely Professional University, Jalandhar. Pots which are used for sowing filled with well pulverized and porous soil and mix with vermicompost. We have use 12 pots having dimensions like diameter is 30cm and height is 25cm. For this experiment four treatments (T0, T1, T2 and T3) and three replications (R1, R2 and R3) were taken. There is soil application of all the treatments before sowing of the mustard. There is treatments of heavy metal i.e. Lead in the form of lead acetate (90 ppm/ kg of soil) and *Trichoderma atroviridae* (5g/10 kg of soil).

Fig. Mustard Genotype (PBR-357)

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

Observations to be recorded:

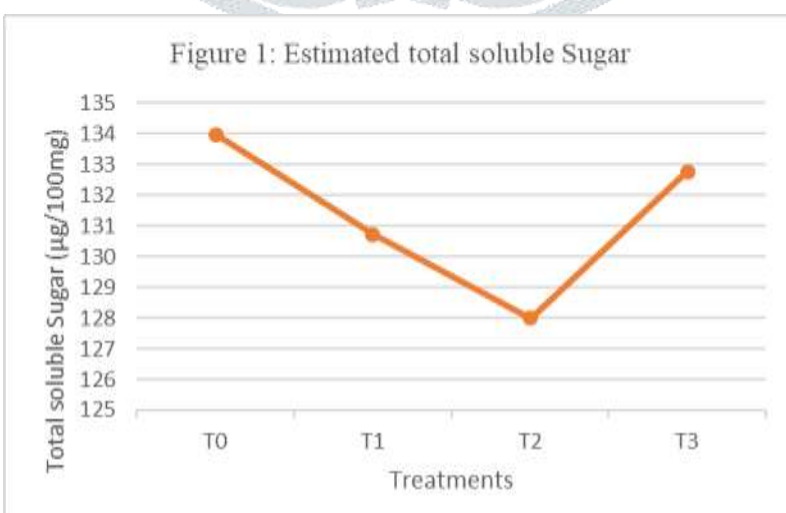
The various observations were recorded from the plant samples which were taken 15 days after sowing (DAS) by following the Standard procedure for estimation of biochemical's:

i. **Total Soluble Sugar:** It is estimated by the method proposed by Sadasuvam and Manickam (1992).
ii. **Total Soluble Protein:** It is estimated by the method proposed by Bradford (1976).
iii. **Total Phenols:** For the estimation of total phenol the protocol of Mahadevan and Sridhar (1982) is followed.
iv. **Chlorophyll Index:** SPAD meter is used for the measurement of chlorophyll.
v. **Membrane injury index (MII) and Membrane stability index (MSI):** Sullivan, C. Y., 1971

Results and Discussion

- **Total Soluble Sugar (TSS)**

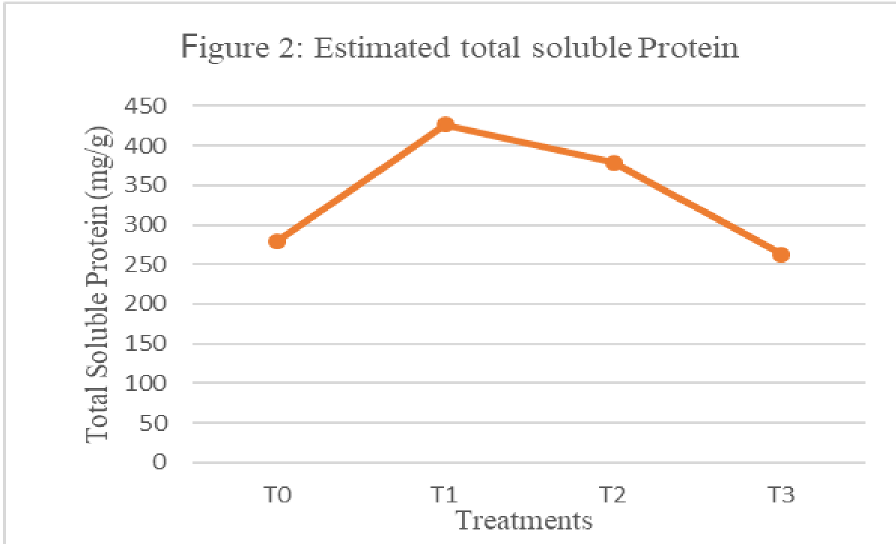
TSS is estimated with the help of Sadasuvam and Manickam (1992). Results have been shows that there is 4.46 % decrease in production of total soluble sugar in T2 as compare to T0. There is no significant difference between T0 and T3 for production of total soluble sugar. Hence, we can say that application of Trichoderma in lead affected soil maintain the production of total soluble sugar in mustard crop.



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

- **Total Soluble Protein (TSP)**

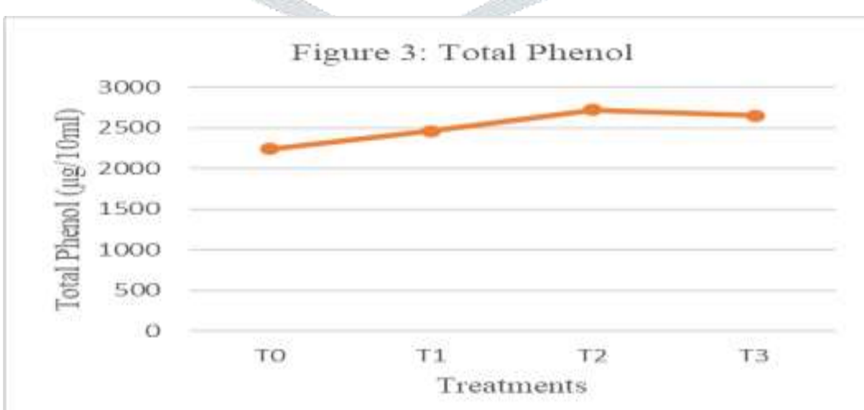
Bradford method is use for the estimation of total soluble protein. There is maximum amount of total soluble protein in the T1 as compare to the all treatments. According to the results we can say that application of Trichoderma can increase the total soluble protein in the mustard crop.



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

- **Total phenols**

For the estimation of total phenol Mahadevan and Sridhar's (1982) method is widely followed. Phenolic compounds play very significant physiological role in the plant life cycle. Phenol production is increased when plants are under abiotic stress conditions. Results also shows increased amount of phenol production when mustard crop is provided with lead stress (T2). According to the results we can say that application of Trichoderma to lead affected soils can reduce the production of phenolic compounds to a certain level.



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

- **Chlorophyll Index**

SPAD (Soil Plant Analysis Development) meter is use for the measurement of chlorophyll index. There is 15.32% decrease in chlorophyll index in T2 as compare to T0. Maximum amount of chlorophyll index is found in Trichoderma treated pots (T1) as compare to the all treatments.

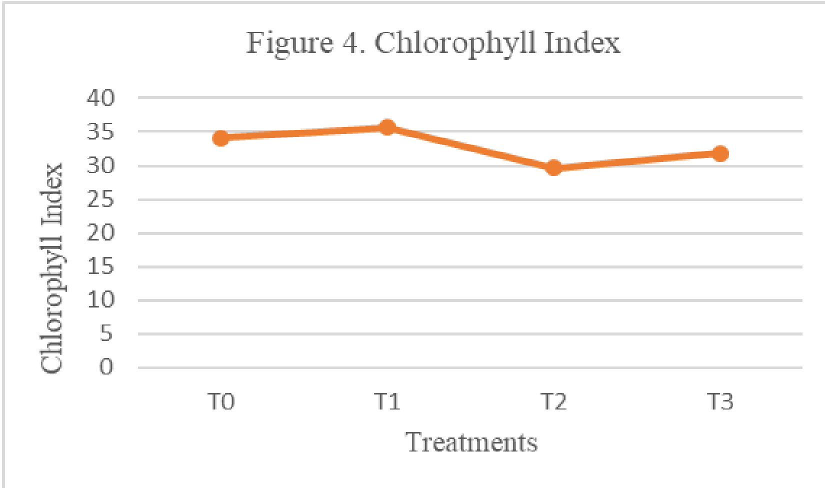


Figure 4. Chlorophyll Index

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

- **Membrane injury index (MII) and Membrane stability index (MSI):**

Results shows that membrane injury index (MII) is higher for the treatment where we apply heavy metal (T2) as compare to all treatments. T3 has the lowest MII among all the treatments i.e. 12.36%, 21.93% and 24.21% low as compare to T0, T1 and T2 respectively.

On the other hand, membrane stability index (MSI) is lowest for T2 among all the treatments. When we compare T3 with T2 then there is 15.98% increase in membrane stability index. Application of Trichoderma shows very positive results. Hence, according to the results we can say that if we apply Trichoderma in lead affected soil then it can help to reduce membrane injury and can maintain the membrane stability.

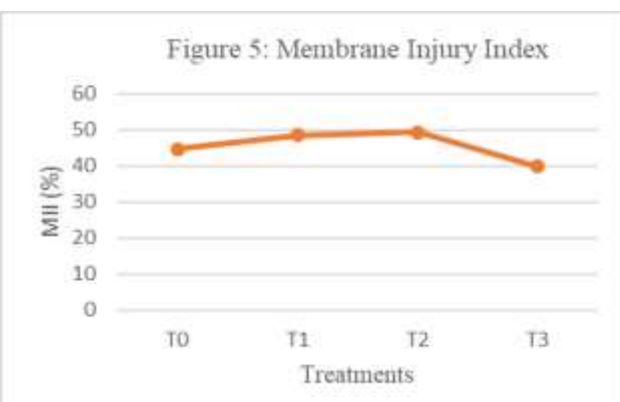


Figure 5: Membrane Injury Index

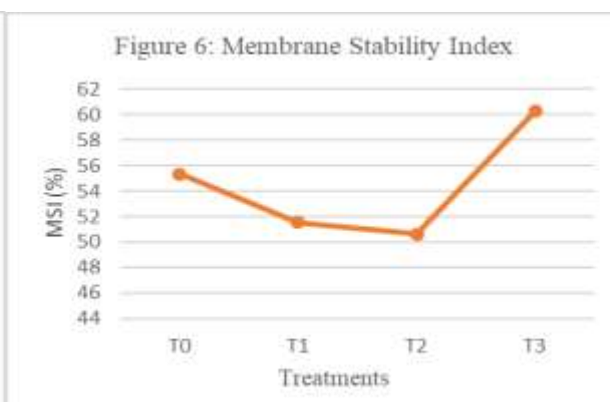


Figure 6: Membrane Stability Index

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

Conclusion:

Lead is the potential pollutants which readily accumulates in the soil, sediments and even in very small quantity in plants it highly disturbs the metabolical activities. However, lead has no useful effect on the plants but it is easily absorbed and uptake by the plants. Its uptake highly depends upon the soil pH, cation exchange capacity and particle size of the soil. Lead inhibits activities of many enzymes, reduce mineral uptake, disturb water balance and damage membrane structure. Lead toxicity causes synthesis of ATP synthesis, lipid peroxidation and DNA damage due to increase in ROS production. As a result, affects the growth and development of the crops. Hence, to reduce the impact of lead toxicity in soil application of Trichoderma plays very significant role which helps to improve physiological condition and performance of the plants.

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Author Contributions

The study was designed by Prasann Kumar & Yaman 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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