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YIELD ATTRIBUTE SHIFT OF MUSTARD GROWN UNDER CADMIUM CONTAMINATED SOIL

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Abstract

In the agriculture system the problem of heavy metal toxicity of increasing day by day its toxicity drastically affects the agriculture system by opposing negative effects on the plant growth as well as affects the surrounding environment viz; Soil health, Groundwater quality, and environmental sustainability. In humans toxicity of heavy metal like Cd causes the weakness of bones. In-plant system toxicity of Cd also affects the uptake of other beneficiary nutrients. So to check the effect of toxicity of Cd on plants various yield attributes of mustard are examined i.e. Pod per plant, Siliqua length, Weight per pod, Seed per pod, Chlorophyll index of pods. To examine these yield attributes mustard (Genotype PBR-357) is grown in pots having dimensions (30 cm diameter and 25cn in height) and Cd toxicity is created by applying 70 ppm of cadmium sulfate per 10 kg of soil. 150 spores of Vesicular Arbuscular Mycorrhiza (VAM) are also used in combination with 70 ppm soil Cd toxicity. VAM is selected in combination with Cd because it can mitigate the effect of heavy metal by arresting them in soil not allow to go inside the plant.

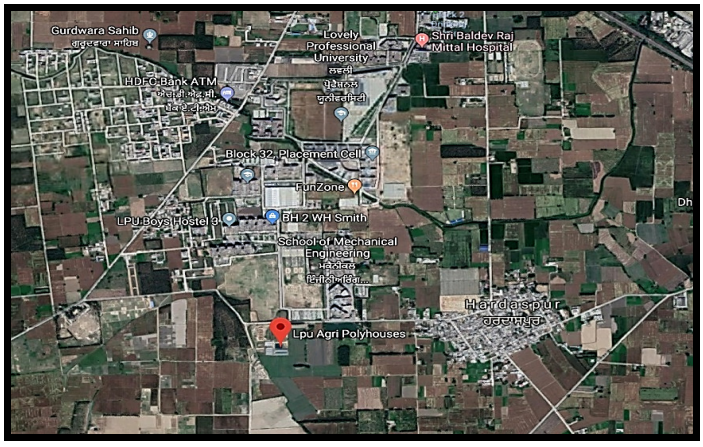
***Keywords*:** Agriculture, Cadmium, Dimensions, Effect, Groundwater, Mitigate, Vesicular Arbuscular Mycorrhiza (VAM).

Introduction

Heavy metal toxicity is previously not known to the agriculture system until the use of fertilizers and other chemicals begins in our agriculture system. In earth's core, there are sources of several compounds which include minerals, organic matter, soil air, soil water. These minerals also act as a source of heavy after weathering process but its rate is very slow (Kumar, 2018i; Kumar, 2018ii; Kumar, 2018iii; Kumar, 2018iv; Kumar, 2018v and Kumar, 2018vi). This slow rate is enhanced by the use of fertilizers, and other chemical inputs in agriculture. Heavy metal like Cd toxicity is increasing day by day because there are various sources of Cd via; Fertilizers, Municipal waste, Acid rain, Industries effluents (Leather industries), etc, (Kumar and Dwivedi, 2018a; Kumar *et al*., 2018b; Kumar *et al*. 2018c; Kumar and Dwivedi, 2018d; Kumar *et al*., 2018e; Kumar and Pathak, 2019f; Kumar *et al*., 2019g). The sources of these are increasing day by day but the precautionary measure should be taken to reduce the effects of these are not enough we can say that focus on this side of affected agriculture is less, therefore, there is need of research work and several precautionary measures to the handle this problem (Siddique and Kumar, 2018h; Siddique *et al*., 2018i; Pathak *et al*., 2017j; Prakash *et al*., 2017k; Kumar and Mandal, 2014L; Kumar *et al*., 2014m; Kumar *et al*., 2014n; Kumar, 2013o; Kumar and Dwivedi, 2015p; Gogia *et al*., 2014q). A small pot trial is conducted on Mustard (Genotype PBR- 357) having 70 ppm cadmium toxicity level per 10 kg of soil in a combination of 150 spores of VAM per Kg of soil. The effect of these treatments is examined on different yield attributes of mustard-like, Pod per plant, Siliqua length, Weight per pod, Seed per pod, Chlorophyll index of pods. PBR-357 (Raya) variety is recommended for global cultivation in those states having timely irrigation facilities. It is a medium-tall variety with more secondary branches and having moderately tolerant of Alternaria blight and an average yield of this variety is 8.5 quintals per acre. It contains about 39.0% of oil content and matures in 140-145 days after sowing (Kumar 2014r; Kumar *et al*., 2012t; Kumar *et al*., 2011u; Kumar *et al*., 2011v; Kumar and Pathak, 2016w; Pathak *et al*., 2016x; Kumar and Harsavardhn, *et al*., 2018y; Kumar *et al*., 2018z).

Methodology

A small pot experiment having three treatments and four replications are conducted in a natural condition, at school of agriculture, Lovely Professional University (LPU), Phagwara, Punjab. The experiment area is situated at an altitude of 234 meters (768 ft) above from mean sea level, 31.244604 N latitude and 75.701022 longitudes.



(**Source:** Google Earth, 2020)

Fig. 1 : Google photo of the experiment site

Climatic Conditions

The Phagwara region of Punjab falls in central plain zones and situated in the northeastern part of India. 250-1000 mm/year is the trend of annual rainfall in Punjab. The minimum temperature recorded in the night is 5 degrees Celsius and in the morning the temperature is around 12-15 degrees Celsius (Kumar, 2018i; Kumar, 2018ii; Kumar, 2018iii; Kumar, 2018iv; Kumar, 2018v; Kumar, 2018vi;

Kumar, 2018vii; Kumar, 2018viii; Kumar and Pathak, 2018ix; Kumar and Pathak, 2018x; Kumar and Pathak, 2018xi; Kumar *et al*., 2018xiii; Kumar and Pathak, 2018xiv; Kumar and Pathak, 2018xv; Kumar and Pathak, 2018xvi; Kumar and Pathak, 2018xvii; Kumar and Pathak, 2018xviii). The maximum temperature recorded in summers between 42-48 degrees Celsius. Humidity prevailing in this region is between 70-80%. The major crops grown in this region are Rice, Wheat and Sugarcane, etc.

Treatments Details

Mustard Genotype (PBR-357) is selected for the pot experiment took from the Punjab Agriculture University Ludhiana. The details of the seeds are given in figure 2. A pot, experiment was conducted by taking three treatments (T0, T1, T2, and T3) and three replications (R1, R2, and R3). The total count of pot was 12 and the dimensions of the pots are 30 cm in diameter and 25 cm is the height containing 10 kg of soil in each. The experiment was conducted in the experimental area of Lovely Professional University. For treatment 70ppm of cadmium, concentration is taken after screening with 150 spores of VAM (Vesicular Arbuscular Mycorrhiza) per kg of soil (Kumar *et al*., 2018y; Kumar *et al*., 2018z; Kumar *et al*., 2018aa; Kumar and Kumar, *et al*., 2018bb; Kumar *et al*., 2018cc; 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). Pre sowing treatment of Cd stress and VAM is applied in soil two days before sowing. For the estimation of different yield attributes of mustard, the sample was taken approx. four and a half months after sowing (Tables 1 and 2).

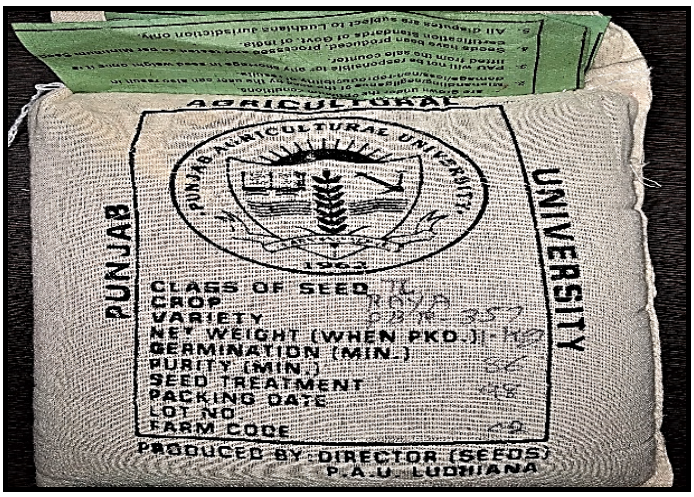


Fig. 2 : PBR-357 taken for research

Table 1: Treatments Details

Treatments	Details of the treatments	Time of application
T-0	Control	Before sowing
T-1	VAM (150spores per kg of soil)	Before sowing
T-2	Cd (70ppm per 10 kg of soil)	Before sowing
T-3	Cd + VAM (70ppm/10 kg soil + 150 spores/kg soil)	Before sowing

Table 2 : Treatment Details

S. No.	Particulars	Details
1.	Layout	CRD
2.	Treatment	4
3.	Replication	3
4.	Total numbers of pots	4*3= 12
5.	Soil per pot	10 kg
6.	Genotype	PBR-357

Observations to be recorded

Observations are recorded about four and a half months after sowing (DAS) means at the time of maturity. Instrument and materials used for the observation of different yield attribute via; Scissors, Ziplock cover pouch bags (Reusable/ Resealable), permanent marker, Weighing machine, SPAD mater, etc.

Results and Discussion

Pods per plants

Numbers of pods per plant is more in T0 (Control) in comparison to T0 there 27.58 percent decrease in numbers of pods in T2 (Cd 70ppm per 10 kg of soil) followed by T3 (Cd 70ppm/10kg soil + VAM 150 spores/kg soil) i.e. 23.33 percent. We can say that there is a 4.25% increase in the number of pods in T3 as compared to T2. Therefore we can say that the VAM application plays an important role in mitigating the effect of Cd toxicity. If T0 is compared to T2 there is a slight decrease in the number of pods in T2. Sown in figure 3.

Siliqua length (cm)

There is no significant difference in length of siliqua in T0 and T1 VAM (150spores per kg of soil). In comparison T0 (Control), T2 (Cd 70ppm per 10 kg of soil) has a 2.3 percent decrease in length of siliqua. If we compare to T0 with T3 Cd + VAM (70ppm/10 kg soil + 150 spores/kg soil) there is 1.26 % increase in length of siliqua. Therefore the presence of VAM in CD stress soil again so positive effects for a crop. Sown in figure 4.

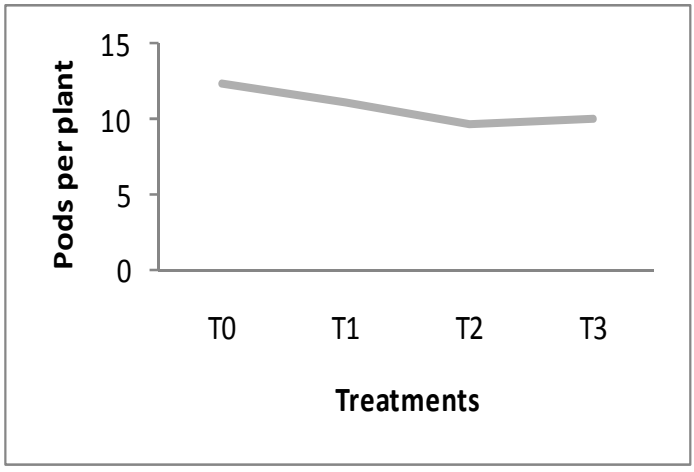


Fig. 3 : Pods per plant

Where, T0 (Control); T1 (150 spores per kg of soil), T2 Cd (70 ppm per 10 kg of soil); T3 Cd+ VAM (70ppm+150 spores)

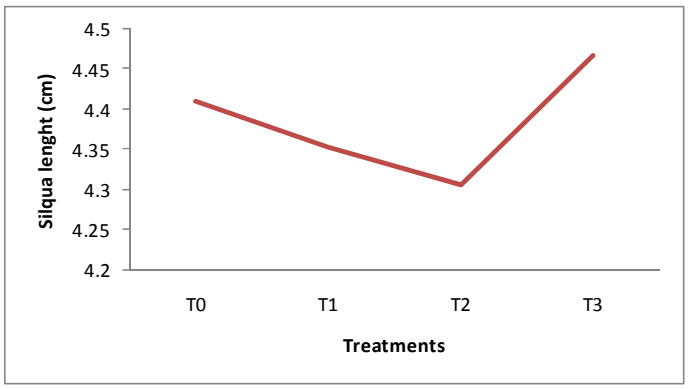


Fig. 4 : Siliqua length (cm)

Where, T0 (Control); T1 (150 spores per kg of soil), T2 Cd (70 ppm per 10 kg of soil); T3 Cd+ VAM (70ppm+150 spores)

Weight of Siliqua

There is 34.29 % decrease in weight of pods in T2 (70ppm per 10 kg of soil) if it is compared with T0 (Control) and T3 (Cd 70ppm/10 kg soil +VAM 150 spores/kg soil) has 25.06 % decrease in weight of pods if we observe the difference between T2 and T3 i.e. 9.2%. Thus we can say that the application of VAM increases the weight of pods in up to 9.2% in comparison to T2. T2 (VAM 150 spores/kg soil) and T0 have no significant difference in the weight of the pods. Sown in figure 5.

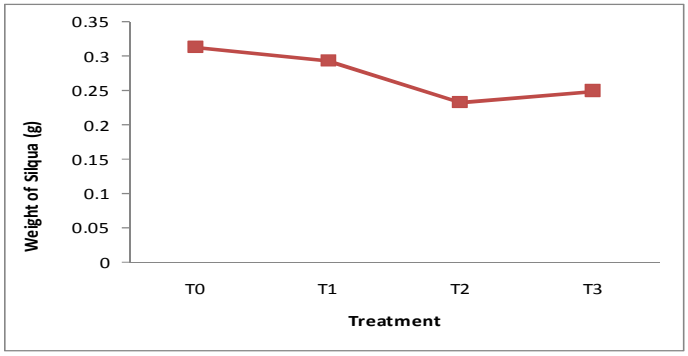


Fig. 5 : Weight of the Siliqua (g)

Where, T0 (Control); T1 (150 spores per kg of soil), T2 Cd (70 ppm per 10 kg of soil); T3 Cd+ VAM (70ppm+150 spores)

Chlorophyll Index of Siliqua

After just harvest of the siliqua of plant Chlorophyll index is measured by using the SPAD meter. In this treatment T2 (70ppm per 10 kg of soil) has the lowest chlorophyll index. If was compared with T0 (Control) there is a 25% decrease in chlorophyll index as compared to T0. From this we can say that due to the Cd stress senescence phase of the plant is occurring little earlier (By the release of ROS inside the plant) as compared to control, therefore, due to this the length, size and weight of pods in cd stress plants get affected (Kumar *et al.*, 2018aa; Kumar *et al.*, 2018bb; Kumar *et al.*, 2018cc; Kumar and Dwivedi, 2018gg; Kumar *et al.*, 2018ff; Kumar *et al.*, 2018cd; Kumar and Pathak, 2018kk; Kumar and Pathak, 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). Sown in Figure 6.

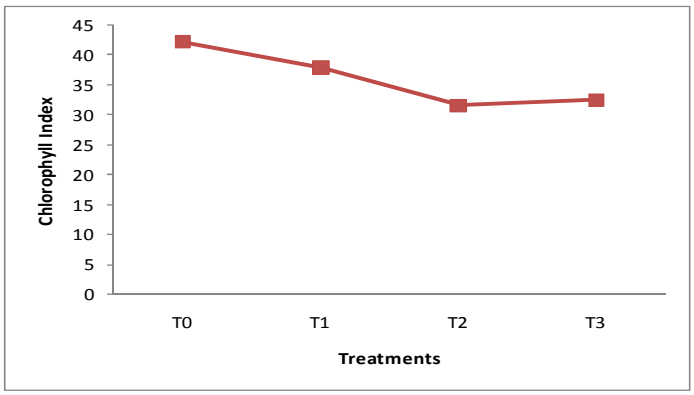


Fig. 6: Chlorophyll Index

where, T0 (Control); T1 (150 spores per kg of soil), T2 Cd (70 ppm per 10 kg of soil); T3 Cd+ VAM (70ppm+150 spores)

Seeds per Siliqua

Seeds are the main yield attributes of many crops. There is a 26.92 % decrease in the seed per siliqua in T2 (70ppm per 10 kg of soil) when compared with T0 (Control) and a slight decrease in T1. If T3 (Cd 70ppm/10kg soil + VAM 150 spores/kg soil) is compared with T2 (70 ppm Cd per 10 kg of soil) there is a 9.52 % increase in seeds per siliqua. Thus the application of VAM improves several seeds per siliqua in cadmium stressed plants. There is a slight decrease in seed per siliqua in T1 (VAM 150 spores/kg soil) when compared with T0 (Control) (Kumar, 2018i; Kumar, 2018ii; Kumar, 2018iii; Kumar, 2018iv; Kumar, 2018v; Kumar, 2018vi; Kumar, 2018vii; Kumar, 2018viii; Kumar and Pathak, 2018ix; Kumar and Pathak, 2018x; Kumar and Pathak, 2018xi; Kumar *et al.*, 2018xiii, Kumar and Pathak, 2018xiv; Kumar and Pathak, 2018xv; Kumar and Pathak, 2018xvi; Kumar and Pathak, 2018xvii; Kumar and Pathak, 2018xviii). Sown in figure 7.

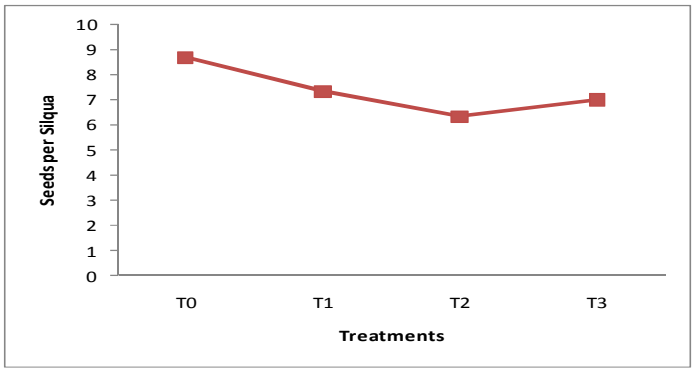


Fig. 7 : Seed per siliqua

Where, T0 (Control); T1 (150 spores per kg of soil), T2 Cd (70 ppm per 10 kg of soil); T3 Cd+ VAM (70ppm+150 spores)

Conclusion

From this pot experiment, small pot experiment having three treatments and three replications and mustard genotype PBR-357 is grown in 70 ppm Cd stressed per 10 kg of soil and application of VAM 150 spores per kg of soil to mitigate the effect of Cd toxicity the conclusion is clear that the presence of Cd in soil surely affects the plant growth that is reflected in terms of their yield attributes. Plants grown in Cd stressed soil having a decrease in all the yield attributes by significant difference and the application of VAM helps to mitigate the effect of Cd toxicity. Therefore, from these

above results, we can conclude that the VAM application proved beneficial on plant growth resulted in terms of their yield attributes on that soil where the Cd toxicity problem is occurring.

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Author Contribution

The study was designed by P.K. and J.C. the yield attributes are examined and data analyzed and interpretation was collected.

Conflict of Interest Statement

The authors state that they have no interest in conflicts.

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