

# Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com



E-ISSN: 2278-4136 P-ISSN: 2349-8234 JPP 2018; 7(6): 138-141 Received: 25-09-2018 Accepted: 26-10-2018

## Prasann Kumar

 Division of Research and Development Lovely
Professional University, Jalandhar, Punjab, India
Department of Plant
Physiology, Institute of Agricultural Sciences
Banaras Hindu University,
Varanasi, Uttar Pradesh, India

#### Padmanabh Dwivedi

Department of Plant Physiology, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

#### Correspondence Prasann Kumar

(1) Division of Research and Development Lovely Professional University, Jalandhar, Punjab, India (2) Department of Plant Physiology, Institute of Agricultural Sciences Banaras Hindu University, Varanasi, Uttar Pradesh, India

# Cadmium induced alteration in leaf length, leaf width and their ratio of *Glomus* treated sorghum seed

# Prasann Kumar and Padmanabh Dwivedi

#### Abstract

Cadmium induced hazardous (70 ppm and 150 ppm) were evidenced by decreased in leaf length, width and their ratio of seeds treated with *Glomus* mycorrhiza. However, these responses were reversed by exogenous application of mycorrhiza (*Glomus*; 150 inoculants per kg of soil).

Keywords: Agriculture, cadmium, forage, germination, Mycorrhiza

## Introduction

Cadmium is an exceedingly lethal follow component and has been positioned seventh among the best 20 poisons (Kumar and Dwivedi). Cadmium is a possibly dangerous metal and hence its exchange from plants to people is of major concern. Sorghum is a critical multipurpose grain crops utilized as nourishment, feed, grub, fuel and in the fabricate of modern item. Cadmium metal(s) are across the board poisons of great worry as they are non-degradable and in this way constant. These metals are utilized in different ventures from which effluents are therefore released into the earth (Kumar and Dwivedi, 2018a, b)<sup>[2, 5]</sup>.

# **Materials and Methods**

The pot experiment was conducted in the poly house of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, with one genotype of sorghum CSV 15. Sorghum seeds were taken from Directorate of Sorghum Research Hyderabad, India. The pot size for the experiment was in the diameter of 30 cm and 25 cm in height and each with capacity of 10 kg soil, with a small hole at the bottom. Pots containing soil mix (Soil + FYM in 3:1) are inoculated with seeds of *Sorghum vulgare*. According to plan of work, targeted pots were inoculated with Endomycorrhiza Glomus sp. And after that heavy metal stress was created in plant by the exogenous application of cadmium nitrate in soil. Two best concentrations of heavy metals on the basis of initial screening were selected i.e., 0.07% per ten kg and 0.15% per ten kg of soil.

# **Results and discussion**

Effect of polyamine (putrescine), mycorrhiza and their combination on leaf length was studied in sorghum variety CSV15 during the two years subsequently under the cadmium stress. Data were recorded at 30, 60 and 90 days after sowing (DAS) (Fig. 1a & b). During first year, it is evident that the average leaf length was significantly reduced by 16.99%, 11.08% and 8.22% when exposed to heavy metal stress (T6) as compared to control (T0) on dates of 30, 60 and 90 DAS of interval. Similarly, when plant was exposed to higher dose of heavy metal (T12) then its average leaf length was significantly reduced by 70.40%, 45.89% and 34.02% as compared to control (T0) on the proposed dates. Exogenous application of endomycorrhiza in the soil (T7) showed the mitigation effect by increasing the average leaf length with 1.1824%, 0.77% and 0.57% as compared to T6 on the proposed dates of interval. Similarly, when treatment T13 was compared to T12 the average leaf length significantly by 3.39%, 2.21% and 1.64% on proposed dates. In comparison to T6, the exogenous application of putrescine (T8) showed the mitigation of average leaf length by 5.56%, 3.62% and 2.69% increase on proposed dates. The average leaf length was significantly enhanced as compared to T6 by 8.54%, 5.57% and 4.13% when treated with higher dose of putrescine (T9) with respect to T8. Similarly when treatment T14 was compared with T12 the average leaf length was increases significantly by 4.69%, 3.05% and 2.27% on proposed date of interval. The average leaf length was significantly enhanced as compared to T12 by 7.09%, 4.62% and 3.43% when treated with higher dose of putrescine (T15) with respect to T14.

The combination of putrescine and mycorrhiza showed the best mitigation effect the average leaf length in treatment T10 by 12.01%, 7.83% and 5.81% with respect to treatment T6 on proposed date of interval. When treatment T11 was compared with treatment T6 then significant average leaf length was increased by 14.22%, 9.27% and 6.87% respectively. Similar effect was seen in the treatment (T16) with respect to treatment T12, and in this treatment the average leaf length was found significant with the 10.67%, 6.57% and 4.87% respectively. The treatment T17 was found significant by 15.02%, 9.79% and 7.26% with respect to T12. The combination of putrescine and mycorrhiza showed the best

combination for the mitigation of cadmium toxicity for the average leaf length. The similar trends were found during the study made in the second year. But the data was non-significant. According to Kumar and Dwivedi, 2014<sup>[1]</sup>, metals were found hazardous for on seed germination, root elongation, and coleoptiles and hypocotyls growth in *Triticum aestivum* and *Cucumis sativus*. Kumar, 2018, reported that heavy metal affect the growth and biochemical characteristics of barley. Kumar *et al.*, 2018, reported the effect of lead resistant Pseudomonads on the growth of *Triticum aestivum* seedlings under lead stress.



Fig 1a & 1b: Leaf length (cm) of sorghum during Kharif during subsequent years (left to right)

where, DAS=Days after sowing. Data are in the form of Mean  $\pm$  SEM. S=Significance at P $\leq$ 0.05 and P $\leq$ 0.01, NS= Non Significant at  $P \le 0.05$  and  $P \le 0.01$  using Origin 6.1. TO= Control, T1=Control + Mycorrhiza, T2=Control + 2.5mM Putrescine, T3=Control + 5mM Putrescine, T4= Control + 2.5mM Putrescine + Mycorrhiza, T5=Control + 5mM Putrescine + Mycorrhiza, T6=0.07% Cd(NO<sub>3</sub>)<sub>2</sub>, T7=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + Mycorrhiza, T8=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine, T9=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T10=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T11=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza, T12=0.15% Cd(NO<sub>3</sub>)<sub>2</sub>, T13=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + Mycorrhiza, T14=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine, T15=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T16=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza.

Leaf width was studied in sorghum variety CSV15 during the Kharif season of first and second years under the cadmium stress. Data were recorded at 30, 60 and 90 days after sowing (DAS) (Fig. 2a & b). During first year, it is evident that the average leaf width was significantly reduced by 55.37%, 35% and 27.71% when exposed to heavy metal stress (T6) as compared to control (T0) on dates of 30, 60 and 90 DAS of interval. Similarly, when plants exposed to higher dose of heavy metal (T12) then its average leaf width was significantly reduced by 79.88%, 50.6% and 39.98% as compared to control (T0) on the dates of proposed interval. Exogenous application of endomycorrhiza in the soil (T7) showed the mitigation effect by increasing the average leaf width by 6.37%, 4.04% and 3.19% as compared to T6 on the proposed dates of interval. Similarly when treatment T13 was compared to T12 the average leaf width increased significantly by 0.39%, 0.25% and 0.19%. In comparison to T6, the exogenous application of putrescine (T8) showed the

mitigation by increasing average leaf width by 10.75%, 6.81% and 5.38%. The average leaf width was significantly enhanced as compared to T6 by 11.75%, 7.44% and 5.88% when treated with higher dose of putrescine (T9) with respect to T8. Similarly when treatment T14 was compared with T12 the average leaf width was increases significantly by 0.79%, 0.50% and 0.39% on proposed date of interval. The average leaf width was significantly enhanced as compared to T12 with 1.19%, 0.75% and 0.59% when treated with higher dose of putrescine (T15) with respect to T14. The combination of putrescine and mycorrhiza showed the best mitigation effect by increasing the average leaf width in treatment T10 by 15.53%, 9.84% and 7.77% with respect to treatment T6 on proposed date of interval. When treatment T11 was compared with treatment T6 then significant average leaf width was increased by 15.93%, 10.10% and 7.97% respectively. Similar effect was seen in the treatment (T16) with respect to treatment T12 and in this treatment the average leaf width was found significant with the 1.39%, 0.88% and 0.69% respectively. The treatment T17 was found significant increase by 1.59%, 1.01% and 0.79% with respect to T12. So the combination of putrescine and mycorrhiza showed the best combination for the mitigation of cadmium toxicity for the average leaf width. The similar trends were found during the study made in the second year, subsequently. But the data were non-significant. Kumar et al. 2018, reported that metals were found hazardous for seed germination, root elongation, and coleoptiles and hypocotyls growth in Triticum aestivum and *Cucumis sativus*. Kumar and Dwivedi, 2018a<sup>[2]</sup>, reported that heavy metal affected the growth and biochemical characteristics of barley. Kumar and Dwivedi 2018b<sup>[5]</sup>, reported the effect of lead resistant Pseudomonads on the growth of Triticum aestivum seedlings under lead stress.



Fig 2a & b: Leaf width (cm) of sorghum during Kharif first & second year (left to right)

where, DAS=Days after sowing. Data are in the form of Mean  $\pm$  SEM. S=Significance at P $\leq$ 0.05 and P $\leq$ 0.01, NS= Non Significant at  $P \le 0.05$  and  $P \le 0.01$  using Origin 6.1. TO= Control, T1=Control + Mycorrhiza, T2=Control + 2.5mM Putrescine, T3=Control + 5mM Putrescine, T4= Control + 2.5mM Putrescine + Mycorrhiza, T5=Control + 5mM Putrescine + Mycorrhiza, T6=0.07% Cd(NO<sub>3</sub>)<sub>2</sub>, T7=0.07%  $Cd(NO_3)_2$  + Mycorrhiza, T8=0.07%  $Cd(NO_3)_2$  + 2.5mM Putrescine, T9=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T10=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T11=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza, T12=0.15% Cd(NO<sub>3</sub>)<sub>2</sub>, T13=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + Mycorrhiza, T14=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine, T15=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T16=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza.

Effect of polyamine (putrescine), mycorrhiza and their combination on leaf length and width ratio was studied in sorghum variety CSV15 during the first and second year under the cadmium stress. Data were recorded at 30, 60 and 90 days after sowing (DAS) (Fig. 3a & 3b). During the first year, it is evident that the average leaf length and width ratio significantly increased by 46%, 27% and 20.89% when exposed to heavy metal stress (T6) as compared to control (T0) on dates of 30, 60 and 90 DAS of interval. Similarly, when plant exposed to higher dose of heavy metal (T12) then its average leaf length and width ratio was significantly increased by 32.0%, 9.17% and 8.62% as compared to control (T0). Exogenous application of endomycorrhiza in the soil (T7) showed the mitigation effect by decreasing the average leaf length and width ratio by 20.58%, 7.07% and 3.77% as compared to T6 on the proposed dates of interval. Similarly when treatment T13 was compared to T12 the average leaf length and width ratio was increases significantly by 13.72%, 4.04% and 2.83% on proposed date of intervals. In comparison to T6, the exogenous application of putrescine (T8) showed the mitigation of average leaf length and width ratio by 25.49%, 8.08% and 13.20% on proposed date of interval. The average leaf length and width ratio was significantly decreased as compared to T6 by 23.52%, 6.06% and 3.77% when treated with higher dose of putrescine (T9) with respect to T8. Similarly when treatment T14 was compared with T12 the average leaf length and width ratio was increases significantly by 17.64%, 5.05% and 3.77% on proposed date of interval. The average leaf length and width ratio was significantly enhanced as compared to T12 by 25.49%, 7.07% and 4.71% when treated with higher dose of putrescine (T15) with respect to T14. The combination of putrescine and mycorrhiza showed the best mitigation effect by decreasing the average leaf length and width ratio in treatment T10 by 27.45%, 7.07% and 4.71% with respect to treatment T6 on proposed date of interval. When treatment T11 was compared with treatment T6 then significant leaf length and width ratio was decreased by 25.49%, 6.06% and 3.77% respectively. Similar effect was seen in the treatment (T16) with respect to treatment T12 and in this treatment the average leaf length and width ratio was found significant by the 38.23%, 11.11% and 6.60% respectively. The treatment T17 was found significant decreased by 58.82%, 17.17% and 10.37% with respect to T12. So the combination of putrescine and mycorrhiza showed the best combination for the mitigation of cadmium toxicity for the average leaf length and width ratio. The similar trends were found during the study made in the second year, subsequently. But the data was non significant. Kumar et al., 2018, reported that metal toxicity effect the plant growth and development. It also affects the plant metabolism. Cadmium absorption and growth of plant species was influenced by cadmium solution of different concentration (Kumar and Dwivedi, 2014)<sup>[1]</sup>.



Fig 3a & b: Leaf length and width ratio of sorghum during Kharif season of first year and second year (left to right)

where, DAS=Days after sowing. Data are in the form of Mean  $\pm$  SEM. S=Significance at P $\leq$ 0.05 and P $\leq$ 0.01, NS= Non Significant at  $P \le 0.05$  and  $P \le 0.01$  using Origin 6.1. TO= Control, T1=Control + Mycorrhiza, T2=Control + 2.5mM Putrescine, T3=Control + 5mM Putrescine, T4= Control + 2.5mM Putrescine + Mycorrhiza, T5=Control + 5mM Putrescine + Mycorrhiza, T6=0.07% Cd(NO<sub>3</sub>)<sub>2</sub>, T7=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + Mycorrhiza, T8=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine, T9=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T10=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T11=0.07% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza, T12=0.15% Cd(NO<sub>3</sub>)<sub>2</sub>, T13=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + Mycorrhiza, T14=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine, T15=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine, T16=0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% Cd(NO<sub>3</sub>)<sub>2</sub> + 5mM Putrescine + Mycorrhiza.

# Conclusion

It is concluded that the polyamines like putrescine and mycorrhiza *Glomus* impart significant mitigation of cadmium induced toxicity in sorghum mediated through their defensive role in plants.

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