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Role of Polyamines and Endo-mycorrhiza on Leaf Morphology of Sorghum Grown under Cadmium Toxicity

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ABSTRACT: The present study was carried out to evaluate the compatibility of polyamines and mycorrhiza in the mitigation of induced toxic effect of cadmium at 30, 60 and 90 DAS older of sorghum variety CSV15. The significant hazardous effects and oxidative damage of cadmium nitrate (70 ppm and 150ppm) were evidenced by decreased leaf length, width and area. The reverse responses were observed d by the external application of putrescine (2.5 and 5.0 mM) and mycorrhiza (Glomus; 150 inoculants per kg of soil).

Keywords: Abiotic, Biotic, Crop, Density, Economy, Foliar, Gap, Higher

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INTRODUCTION

Sorghum is one of the most important staple foods for the world's poorest and most food-unsecured people across the semi-arid tropics (Kumar *et al.,* 2016a). Heavy metal contamination threats the critical limit of alarm in most of the cultivated and periurban area around us. That's why it is considered as the major concern in India and abroad. Polyamine like Putrescine contents are altered in response to the exposure of heavy metals (Kumar *et al.,* 2011a, b, Kumar *et al.,* 2016a,b). Polyamines level in stressed plants have adjustive importance thanks to their involvement in regulation of cellular ionic atmosphere, maintenance of membrane integrity, interference of pigment loss and stimulation of supermolecule and protecting alkaloids (Kumar and Dwivedi, 2018a,b,c,d, Kumar *et al.,* 2018b). Interaction of polyamines with membrane phospholipids implicates membrane stability under stress conditions. Polyamines like Putrescine also protect membrane from oxidative damage as they act as free radical scavengers (Kumar *et al.,* 2018a, Pathak *et al.,* 2017). Response to abiotic injury and mineral nutrient deficiency is associated with the production of conjugated PAs in plants. We have tested many plant species for his or her capability of scavenging significant metals from soil and sludge and eventually we tend to reach on the conclusion that among the tested plants, *Sorghum vulgare* L is a lot of custom-made to grow on contaminated places with relation to alternative plant and ready to mitigate the significant metal toxicity from venturous waste site or cultivated site (Kumar and Dwivedi, 2018, Kumar *et al.,* 2012, Kumar *et al.,* 2013, Siddique *et al.,* 2018). Metallic element (Cd) may be an extremely deadly element and has been hierarchal seventh among the highest twenty toxins (Kumar and Dwivedi, 2018a). Metallic element may be a doubtless deadly metal and so its transfer from plants to humans is of major concern.

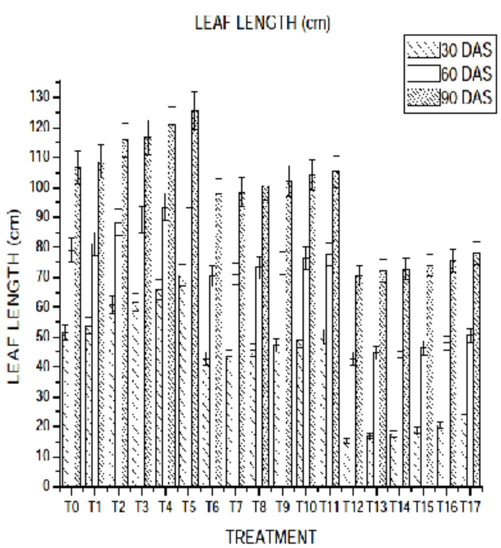
MATERIAL AND METHODS

The pot experiment was conducted within 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 board of directors of Sorghum Research Hyderabad, India. The pot size for the experiment was within the diameter of thirty cm and twenty five cm tall and every with capability of ten kilo soil, with atiny low hole at the underside. Pots containing soil combine (Soil + FYM in 3:1) are inoculated with seeds of *Sorghum vulgare* L. in step with arrange of labor, targeted pots were inoculated with Endomycorrhiza *Glomus* sp. and at that time significant metal stress was created in plant by the exogenous application of metallic element cadmium nitrate in soil. Two best concentrations of significant metals on the idea of initial screening were selected i.e., 0.07 % per 10 kilo and 0.15 % per 10 kilo of soil.

Putrescine was applied at the rate of 2.5 mM and 5.0 millimetre through foliar spray at the seven days of interval. The experiment was ordered go in CRD design. There have been eighteen treatments. Every treatment was replicated 5 times. All the numerical knowledge obtained were analyzed through applied stat package of Origin6.1-advance scientific graphing and knowledge analysis [OriginLab Corporation, One Round House Plaza, Northhampton, MA 01060]. Multivariate analysis was performed for interaction between mycorrhiza and metallic element treatments. One way multivariate analysis was performed.

RESULTS AND DISCUSSION

Effect of polyamine (putrescine), mycorrhiza and their combination on leaf length was studied in sorghum variety CSV15 during the two subsequent years under the cadmium stress. Data were recorded at 30, 60 and 90 days after sowing (DAS) (Fig.1a & b). During the first year, it is evident that the average leaf length was significantly reduced with 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 exposed to higher dose of heavy metal (T12) then its average leaf length was significantly reduced with 70.40%, 45.89% and 34.02% 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 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 was increases significantly with 3.39%, 2.21% and 1.64% on proposed date of intervals. In comparison to T6, the exogenous application of putrescine (T8) showed the mitigation of average leaf length with 5.56%, 3.62% and 2.69% on proposed date of interval. The average leaf length was significantly enhanced as compared to T6 with 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 with 4.69%, 3.05% and 2.27% on proposed date of interval. The average leaf length was significantly enhanced as compared to T12 with 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 by increasing the average leaf length in treatment T10 with 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 with 14.22%, 9.27% and 6.87% respectively.



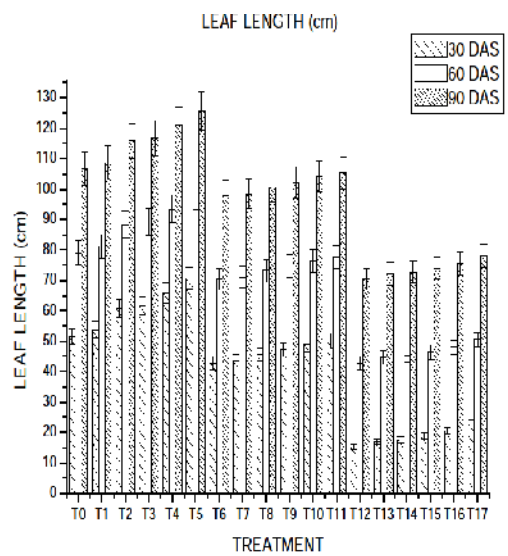


Fig. 1a & b. Leaf length (cm) of sorghum during *Kharif* season of two subsequent year (left to right).

where, DAS=Days after sowing. Data are in the form of Mean ± SEM. S=Significance at P≤0.05 and P≤0.01, NS= Non Significant at P≤0.05 and P≤0.01 using Origin 6.1. T0= 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% $Cd(NO_3)_2$, T7=0.07% $Cd(NO_3)_2$ + Mycorrhiza, T8=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine, T9=0.07% $Cd(NO_3)_2$ + 5mM Putrescine, T10=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T11=0.07% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza, T12=0.15% $Cd(NO_3)_2$, T13=0.15% $Cd(NO_3)_2$ + Mycorrhiza, T14=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine, T15=0.15% $Cd(NO_3)_2$ + 5mM Putrescine, T16=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza.

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 with 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 (cm). Kumar et al., 2018a,b,c, reported that, leaf length, width and area was increased by 100µM Cd but reduced by 200 µM Cd in mature maize leaves and reduced by both concentrations in aging leaves (Kumar, 2018; Kumar and Dwivedi, 2014, 2018a,b,c,d; Kumar *et al.,* 2011a,b, 2012, 2013, 2016a,b, Pathak, 2017). Low concentration of cadmium (0.05 and 0.1 µM) also has stimulating effect on chlorophyll synthesis and photosynthetic activity (Siddique *et al.,* 2018, Kumar *et al.,* 2018). It is evident that the average leaf width was significantly reduced with 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 (Fig. 2a & b). Similarly when plant exposed to higher dose of heavy metal (T12) then its average leaf width was significantly reduced with 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 with 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 was increases significantly with 0.39%, 0.25% and 0.19% on proposed date of intervals. In comparison to T6, the exogenous application of putrescine (T8) showed the mitigation of average leaf width with 10.75%, 6.81% and 5.38% on proposed date of interval. The average leaf width was significantly enhanced as compared to T6 with 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 with 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 with 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 with 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 with 1.59%, 1.01% and 0.79% with respect to T12. On the basis of above results, the combination of putrescine and mycorrhiza showed the best combination for the mitigation of cadmium toxicity for the average leaf width.

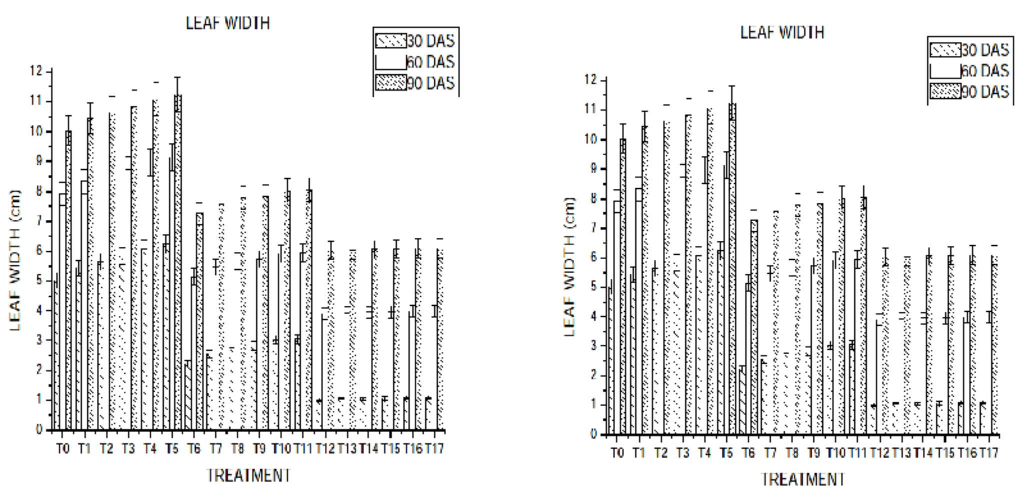
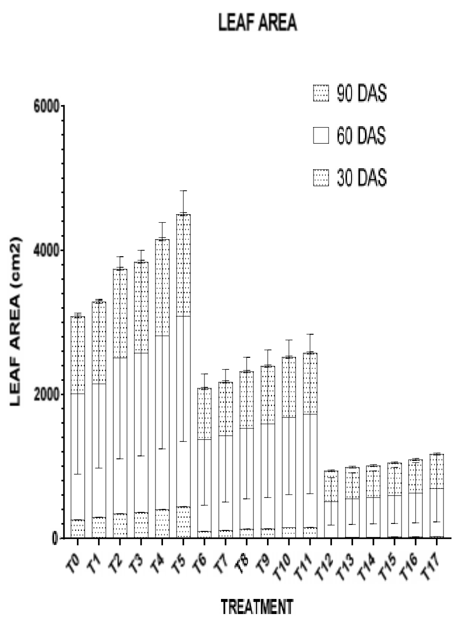


Fig. 2a & b. Leaf width (cm) of sorghum during *Kharif* season of two subsequent year (left to right).

where, DAS=Days after sowing. Data are in the form of Mean ± SEM. S=Significance at P≤0.05 and P≤0.01, NS= Non Significant at P≤0.05 and P≤0.01 using Origin 6.1. T0= 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% $Cd(NO_3)_2$, T7=0.07% $Cd(NO_3)_2$ + Mycorrhiza, T8=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine, T9=0.07% $Cd(NO_3)_2$ + 5mM Putrescine, T10=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T11=0.07% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza, T12=0.15% $Cd(NO_3)_2$, T13=0.15% $Cd(NO_3)_2$ + Mycorrhiza, T14=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine, T15=0.15% $Cd(NO_3)_2$ + 5mM Putrescine, T16=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza.

The similar trends were found during the study made in the second year. The similar trends were found during the study made in the second year. Pathak *et al.,* 2017, reported that, carotenoids which protect the chlorophyll from photo-oxidative destruction and a reduction in carotenoids could have serious consequences on chlorophyll pigments in presence of Cd (Kumar and Dwivedi 2016a, b; Kumar, 2018, Kumar *et al.,* 2012, 2013, 2018 a, b, c, d). In maize, Cd inhibits growth promoting factors of leaves (Pathak *et al.,* 2017). It reduces both the total length and the width, through the later decrease to a lower extent, thus leading to a drop in the leaf area ratio (Siddique *et al.,* 2018). The data on leaf area (cm^2) were recorded at 30, 60 and 90 days after sowing (DAS) and this is presented in fig.3a & b. During the first year, it is evident that the average leaf area (cm^2) was significantly reduced with 62%, 27.18% and 33.64% when exposed to cadmium 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 leaf area (cm^2) was significantly reduced with 94%, 71.55% and 60.37% 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 with 5.88%, 2.17% and 3.35% as compared to T6 on the dates of 30, 60 and 90 DAS of interval. Similarly when treatment T13 was compared to T12 the average leaf area (cm^2) was increases significantly with 0.81%, 2.09% and 1.11% on proposed date of intervals. In comparison to T6, the exogenous application of putrescine (T8) showed the mitigation of average leaf area (cm^2) with 12.0%, 7.19% and 7.02% on proposed date of interval. The average leaf area (cm^2) was significantly enhanced as compared to T6 with 14.56%, 10.36% and 8.62% when treated with higher dose of putrescine (T9) with respect to T8. Similarly when treatment T14 was compared with T12 the average leaf area (cm^2) was increases significantly with the 1.22%, 2.93% and 1.63% on proposed date of interval. The average leaf area (cm^2) was significantly enhanced with 1.87%, 4.49% and 2.47% as compared to T12 when it was 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 area (cm^2) in treatment T10 with 20.11%, 14.58% and 11.78% with respect to treatment T6 on proposed date of interval. When treatment T11 was compared with treatment T6 then significant average leaf area (cm^2) was increased respectively with 21.83%, 16.97% and 12.83%. Similar effect was seen in the treatment (T16) with respect to treatment T12.



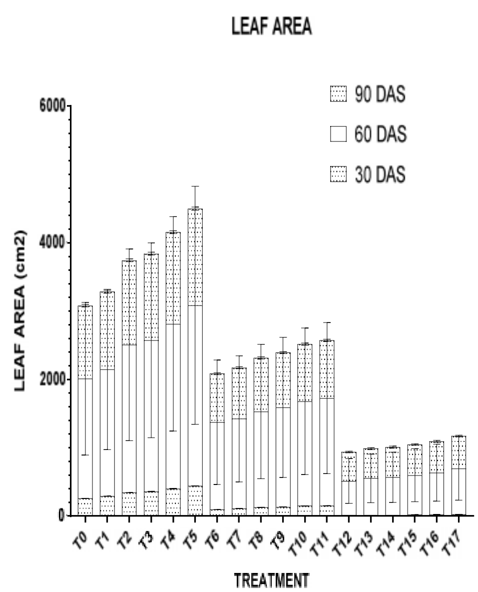


Fig. 3a & b. Leaf area (cm^2) of sorghum during *Kharif* season of two subsequent year (left to right).

where, DAS=Days after sowing. Data are in the form of Mean ± SEM. S=Significance at $P \leq 0.05$ and $P \leq 0.01$, NS= Non Significant at $P \leq 0.05$ and $P \leq 0.01$ using Origin 6.1. T0= 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% $Cd(NO_3)_2$, T7=0.07% $Cd(NO_3)_2$ + Mycorrhiza, T8=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine, T9=0.07% $Cd(NO_3)_2$ + 5mM Putrescine, T10=0.07% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T11=0.07% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza, T12=0.15% $Cd(NO_3)_2$, T13=0.15% $Cd(NO_3)_2$ + Mycorrhiza, T14=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine, T15=0.15% $Cd(NO_3)_2$ + 5mM Putrescine, T16=0.15% $Cd(NO_3)_2$ + 2.5mM Putrescine + Mycorrhiza, T17= 0.15% $Cd(NO_3)_2$ + 5mM Putrescine + Mycorrhiza.

In this treatment the average leaf area (cm^2) was found significant with the 2.58%, 6.45% and 3.41% respectively. The treatment T17 was found significant with 3.76%, 9.80% and 4.94% with respect to T12. Therefore, the combination of putrescine and mycorrhiza showed the best combination for the mitigation of cadmium toxicity for the average leaf area (cm^2).The similar trends were found during the study made in the second year of the experiment.

CONCLUSION

Polyamines like putrescine and mycorrhiza *Glomus* impart significant mitigation of cadmium induced toxicity in sorghum mediated through their defensive role in plants by increasing the length, width and area in the sorghum leaves.

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