Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 955-961
Received: 05-05-2020
Accepted: 07-06-2020

Khushbu Sharma
Department of Agronomy, School of Agriculture, Lovely Professional University, Punjab, India

Prasann Kumar
[a] Department of Agronomy, School of Agriculture, Lovely Professional University, Punjab, India
[b] Division of Research and Development, Lovely Professional University, Punjab, India

Corresponding Author:
Prasann Kumar
[a] Department of Agronomy, School of Agriculture, Lovely Professional University, Punjab, India
[b] Division of Research and Development, Lovely Professional University, Punjab, India

Mitigating the effect of biofertilizers on morphological and biochemical level in pearl millet grown under mercury toxicity

Khushbu Sharma and Prasann Kumar

Abstract
Heavy metals and metalloids are important naturally occurring components found in all soils. The bioavailability, toxicity and mobility of heavy metals in soil are strongly influenced by both natural and anthropogenic activities such as chemical complexions with clay minerals and oxides, desorption/ sorption, redox reactions, deliberation of inorganic and organic ligands etc. Their presence in soil rhizosphere leads to their entry in plant further they easily accomplish place in the food chain. Their occurrence in plant cause toxicity which is responsible for disturbance physiological activities of the ell and directly affects the quality and quantity of yield. Along with environment heavy metal toxicity also cause harmful effect on human health. Several remediation strategies were adopted to eliminate or minimize the toxicity of heavy metal in plant and soil. This research study was conducted to check the effect the ameliorating effect of trichoderma, rhizobium and mycorrhiza in mediated mercury stress under Pearl millet during Kharif season 2019 in Lovely Professional University under Department of Agronomy, School of Agriculture. A pot experiment was conducted to check the behaviour of all three biofertilizers on plant both on mthe molecular basis and morphological analysis. The average plant height was significantly increased with 45%, 16%, 18% and reduced by11.25% in treatment (T10) where all three biofertilizers are applied combined under mercury (100ppm) soil. The average leaf number was significantly decreased by 6.19%, 1.33%, 0%, 15.96% at all proposed dates of interval in treatment (T10). It is an evident in treatment (T1) mercury stress there was significant decrease in total soluble sugar content by 0%, 1.01%, 7.70%, 39.7% at 30,60,90 or 120DAS during comparison with control (T0).

Keywords: Bioavailability, contamination, heavy metal, stress, toxi

Introduction
Pearl millet (*Pennisetum glacum*) is commonly known by Bajra and one of the major coarse grain crop. Because Pearl millet there is a vast range of strains are cultivated out of all five are major (a) Pennicillaria, Eupennisetum (c) Hetrostachy (d) Gymnothria (e) Brevivavula. Cultivated species of Pearl millet is P.typhoides S and H.As C4 plant water use efficiency is also favourable to harsh weather condition. Pearl millet is more commonly growing crop of semi-arid and arid regions after rice, wheat, maize, sorghum it commonly grown in areas that are more susceptible to dry weather and high temperature. Among all millets Pearl millet occupies an area of 27mh with an annual production of 36lmozs Mt. Almost 60% of millet area is in Africa followed by 35% in Asia, 4% Europe and 1% North America. Total production of Pearl millet almost 93% is the only contribution of Africa and Asia in all over the world. 43% of total world production only from Asia itself. India is the second-largest producer of Pearl millet after china both in term of area (9.1mh) and production (7.3mt). Rajasthan is a largest producing state in India having 51% area under cultivation of P. millet followed by Maharashtra 15.3%, Gujrat 10.6%, Uttar Pradesh 9.2%, Haryana 6.2%etc based on ICRISAT –bred material. Pearl millet grain is rich in protein 11.6%, fat 5% and with very high carbohydrates 67%, commonly used as green fodder for animals and chapatti making in south India. It serves as a staple food for poor in relatively very short duration of time and also known as “poor man chapatti”.
PHB2884 genotype of variety is widely used in Punjab region as cultivar both for fodder and grain production it bears 2-3 tillers with the slate colour of the grain. This hybrid of P.millet has resistance against powdery mildew and ear cockle diseases of Bajra. This cultivar takes almost 95 days to attain maturity. Dry matter production is about 3-5 tonnes per/acre which could further utilize for mulching and for inter culture operation to minimise the nutrient requirement of preceding crop (Schoenbeck *et al*. 2006) [11]. The residue left after harvesting of the crop remains in soil having 60-80% K. (Rosolem *et al*. 2005) [6]. Grains of Pearl millet bears very high nutritive value it was estimated that it bears almost 1582KJ energy/100gm of grains and up to 8.5% fibre.

Reports submitted that the mercury is one of the most potentially harmful trace element. Soils in the world are contaminated by mercury toxicity, threat posses by mercury contaminated soils create a great loss to the soil, human beings, as well as environment. A major sector of agriculture is also affected by contamination of heavy metals in soils they directly enter our food chain and damage can be seen easily. Critically examine the cycle of, mercury in soil. There are various forms of mercury such as elemental mercury, organic mercury and inorganic mercury. It is observed that melting point of mercury is 300°C and boiling point up to 1000°c. So, it is very difficult to leach or volatilise its concentration remain constant in soil 0ver long years. Mercury causes a damageable threat to human and animal various diseases it gets to enter our food chain to increase ROS production in the cell.

Biofertilizers used to mitigate stress. Phytoremediation of Heavy metals is found very critical because of their density. The approach of using biofertilizers is found successful in P Pearl millet crop as the purpose of providing three different species of biofertilizers create interaction with mercury in the rhizosphere. Under sustainable agriculture integrated Nutrient Management use of Biofertilizers are considered as the most important component. Biofertilizers are the product of living microorganisms such as Trichoderma, Rhizobium and Mycorrihza. Use of these fertilizers maintains long term fertility of soil and crop productivity. Biofertilizers are considered a renewable source of nutrients in integrated nutrient management. These are products containing living cells of different types of living microorganisms After inoculation of these fertilizers to seed, plant surface, or soil they start growing in the rhizosphere or the inner cells of the plant leads to improving the growth of the plant through various metabolic processes, in soil converting essential nutrient from non-usable to usable form through a biological process such as nitrogen fixation and solubilization of phosphate (Rokhzadi *et al*. 2008) [8]. Biofertilizers enhance the adaptability of host plant towards pest and diseases attack. (El-yazeid *et al*. 2007) [2].

For the purpose to achieve maximum benefit of this microorganism it is necessary to select required species which is suitable to crop and microbial populations interaction both in contaminated and control treatment, ability to survive in the allocated rhizosphere. Phytoremediation in polluted soil is done by Rhizobium (Doty 2008; Zhuang *et al*. 2007) [13]. Fungus named Trichoderma are soil-borne, ascomycetes taken to improve the role of phosphate solubilizing bacteria and also improves antagonism towards phytopathogens (Rawat and Tewari *et al* 2011) [7]. It is free-living fungi most commonly isolated soil there are three species of Trichoderma genomes are four Trichoderma creates a three-way relationship in plant, roots and pathogens, also produced cell degrading enzymes or secondary metabolites. Colonization improves of Trichoderma spp.in roots of plants growth, development and resistance against abiotic stress (Harman *et al*. 2004) [5]. It was observed through various studies Trichoderma release several enzymes mainly chitinases ß-1,3 glucanases.

Methodology

The pot experiment was conducted at the terrace of 25th block of the School of Agriculture, Lovely Professional University, Jalandhar, Punjab with Pearl Millet. Pearl Millet variety (Moti Bajra) was taken from Punjab Agriculture University, Punjab. Pot size for the experiment was of diameter: 30 cm and height 25 cm. Mercury stresses were created in the plant by exogenous application of Hg in soil. One best concentration after initial screening within the range of 1-100 ppm of Hg was finally selected. There was 100 ppm concentration of heavy metals (after screening), was applied to soil for creating stress in Pearl Millet plant. Trichoderma, Rhizobium and Mycorrhiza were applied at the rate at the time of sowing of crops. The various measurements were made at four stages such as 30 day, 60 days, 90 days and 120 days.

Treatment Details

The detailed plan of treatments are; Control(T0), Mercury chloride (100ppm) (T1), (T2) Trichoderma, (T3) Rhizobium), (T4) Mycorriha, (T5), Mercury chloride (100ppm)+ Trichoderma (5g/pot), (T6) Mercury chloride(100 ppm)+Rhizobium (5g/pot), (T7 Mercury Chloride (100ppm)+ Mycorrhiza (T8), Mercury chloride (100ppm) +Trichoderma (5g/pot) + Rhizobium, (T9) Mercury chloride (100ppm) + Trichoderma (5g/pot) + Mycorrhiza, (T10) Mercury chloride (100ppm) + Rhizobium + Mycorrihza, (T11) Mercurychloride + Trichoderma + Rhizobium + Mycorrihza, (T12) Control + Trichoderma + Rhizobium + Mycorrihza. Basic nutrients to crop were applied at the time of sowing. The pots were watered at the interval of two days.

Observation was recorded

1. Plant Height (cm)

Plant height was measured at an interval of 30, 60, 90 and 120 DAS (Days after Sowing). Height of tagged plant was measured with a measurement scale from the ground to the topmost leaf of the plant.

Fig 1: Showing plant height of Pearl millet at 30 and 60 DAS

2. Leaf number

After a few days of sowing as the growth of plant continues and the number of leaves per plant was recorded. The total number of leaves present in the whole plant was counted in each treatment separately in all three replicates. The mean of each treatment was calculated as several leaves per plant.

3. Total soluble sugar (Anthrone method)

The total soluble sugar content in the plant sample was estimated following the method proposed by Sadasuvam and Manickam (1992).

Procedure

100 mg of leaf sample was homogenized with 10 ml of ethanol till all the leaf tissues were fully digested. Then extract of the sample was centrifuged at 5000 rpm for 15 min. Volume of the extract was made 100 ml by adding distilled water. One ml of the extract was taken in a test tube and 6 ml of the anthrone reagent were added to each test tube. The tube was then placed on a boiling water bath for 10 min, after which they were allowed to cool in running water. A blank was prepared similarly but without a leaf sample. After some time, a blue colour developed in the test tubes and the intensity of the blue colour was measured at 620 nm by a spectrophotometer. The amount of sugar in the leaf sample was calculated by the standard curve

Results and Discussion

1. Plant Height

In an experiment, the combined and individual effect of microbes (Trichoderma, Rhizobium and Mycorrihza) was studied in Moti Bajra Variety of Pearl millet during the year 2019-2020, in crop subjected to mercury stress. Changes in height of plant were observed at 30DAS, 60DAS, 90DASand 120DAS were shown in Table 1, Fig 1. Studies show a found average was significantly reduced with 4.48%, 16.129%, and 16.3% at 30, 60, 90 and 120DAS when exposed to mercury toxicity when the comparison was made between control (T0) and Mercury toxicity (T1). Similarly, when another comparison was made to examine the performance of microbes with mercury and it has been analyzed that the height of plant was found decreased in all the treatments (T5), (T6), (T7) and (T10) but there is variation in % decrease when (T0) was compared with (T5) there is a significant decrease in height by 4.53% at 30DAS and 21.629% at 60DAS, minor at 90DAS of 21.9% and get increased with 12.82% at 120DAS. Another more treatment was compared with control in which soil was exposed to mercury toxicity and for mitigation Rhizobium culture was inoculated in the pot (T0 and T6) there is a decrease in height with 1.4% at 30DAS, 35.48% at 60DAS, 51.05% at 90 DAS and increased with 3.4% at 120 DAS. Behaviour rhizobium was compared with control (T0) and (T6) initially there was mitigation of metal by rhizobium leads to increase in height by 10.44% then suddenly decrease at 60DAS interval by 35.48%, 51% at 90DAS but then increased at 120DAS by 3.4%. Under the treatment of mycorrhiza (T7) where the soil is also projected to mercury behaviour of mycorrhizal fungi was analysed as compared to other microbes mycorrhizal fungus treatment have better growth and tolerance to stress. A final comparison of all microbes together with mercury toxicity (T10) was compared with Control (T0) there was a decrease in height initially at the stage of 30DAS and then sudden rise by 45.16% at 60DAS again rise by 18% at 90DAS stage but decreased at 120DAS by 11.25%. Presence of mycorrhiza and rhizobium stimulates plant growth hormones such as auxin. The application of these microorganisms through seeds improves yield both in polluted and non-polluted soils (Anderson et al. 1993) [1].

Table 1: Plant height (cm) of Pearl millet

Treatments	30 DAS	60DAS	90DAS	120DAS
T0	11.16^{ab}±1.040	31.33 ^{d}± 4.16	38.33 ^{c}±2.08	127.33 ^{ab}±12.66
T1	11.16^{ab}±2.02	26.66 ^{e}± 3.05	38.00 ^{c}±4.58	106.66 ^{b}±1.55
T2	10.66^{ab}±1.154	26.00 ^{ef}± 2.00	36.33 ^{c}±3.51	110.33 ^{b} ±1.52
T3	9.83^{ab}±1.892	22.16 ^{fg}± 1.04	29.33 ^{d}±1.52	104.66 ^{b}±8.08
T4	8.66^{a}± .577	24.33 ^{ef}± .577	30.66 ^{d}±2.88	98.66 ^{b}± 7.023
T5	10.66^{ab}±73.05	20.33 ^{g}± 2.51	29.66 ^{d}±2.51	143.66 ^{a}± 2.08
T6	11.00^{ab}±1.00	16.00^{h}± 1.00	18.66 ^{f}±.577	31.66 ^{c}± 30.74
T7	10.00^{ab}±2.00	19.66^{gh}± 2.08	24.66 ^{e}±3.78	118.66 ^{ab}±1.52
T8	9.66^{ab}±1.154	38.33 ^{c}± 2.08	60.96 ^{a}±1.76	115.33 ^{ab} ± 4.72
T9	9.16^{b}±1.25	45.00 ^{a}± 2.64	56.33 ^{b}±1.52	113.66 ^{b}±2.081
T10	9.66^{ab}±.577	43.00 ^{ab}± 2.64	53.66 ^{b}± 2.51	122.66 ^{ab}± 2.88
T11	13.00^{a}±3.60	39.33 ^{c}±1.527	52.00 ^{b}±1.73	115.33 ^{ab}± 2.51
T12	10.44^{ab}±.509	33.33 ^{d}±1.527	53.00 ^{b}±3.00	113.66 ^{b}± 5.03

where, Data are in the form of Mean±SD at p<0.05, DAS signify days after sowing of crop where treatment are as follows: Control(T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercury chloride + Trichoderma, (T6) Mercury chloride+ Rhizobium, (T7) Mercury Chloride + Mycorrhiza,(T8) Mercury chloride + Trichoderma + Rhizobium, (T9) Mercury chloride + Trichoderma + Mycorrhiza, (T10) Mercurychloride + Rhizobium + Mycorrihza, (T11) Mercurychloride + Trichoderma + Rhizobium + Mycorrihza, (T12) Control + Trichoderma + Rhizobium + Mycorrihza.

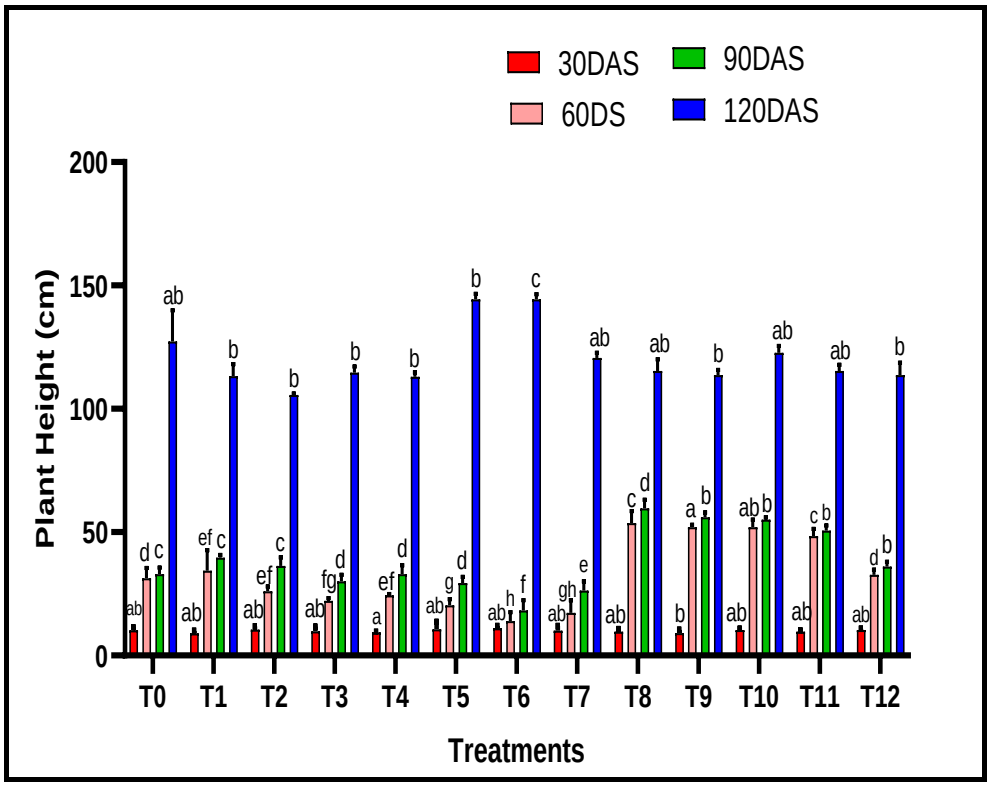

Fig 1: Showing plant height of Pearl millet

where, Data are in the form of Mean±SD at $p<0.05$, DAS signify days after sowing of crop where treatment are as follows: Control(T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercury chloride + Trichoderma, (T6) Mercury chloride + Rhizobium, (T7) Mercury Chloride + ycorrhiza, (T8) Mercurychloride + Trichoderma + Rhizobium, (T9) Mercury chloride + Trichoderma + Mycorrhiza, (T10) Mercurychloride + Rhizobium + Mycorrihza, (T11) Mercurychloride + Trichoderma + Rhizobium + Mycorrihza, (T12) Control + Trichoderma + Rhizobium + Mycorrihza.

2. Number of leaves (Plant^{-1})

In Moti Bajar variety of Pearl millet, grown under mercury toxicity with inoculation of different microbes morphological observation on several leaves at different stages of 30, 60, 90 and 120DAS were made to identify the effect of microbes under stress. The average increase or decrease in some leaves. Comparisons were made to analyze the effect of all microbe has been used in experiment trichoderma, rhizobium, mycorrhiza under soil subjected to mercury toxicity individually or the effect of all microbes together in mitigating stress. At 30days stage of growing number of leaves increases with 6.19% when comparisons made between treatment (T0) control or (T1) mercury toxicity as the plant reaches a stage of 60DAS number of leaves decrease with 30.36%, similarly decrease with 25.72% and finally at the stage of 120days little less decrease with 8.04%. Another treatment (T5) trichoderma + mercury toxicity was compared with control (T0) results shows an increase in leaves by 6.19% at the initial stage then decrease by 3.09% at 60 and no change in several leaves at 90days has been observed and at 120days leaf number has been found increased with 3.96%. Next comparison, was made between another microbe rhizobium bacteria(T6) grown under mercury toxicity compared with control there was a usual increase in many leaves due to mitigating effect then decreased by 3%, no changes have been observed at 90days and finally get increased by 15.96% at 120days after growing. The behaviour of mycorrhiza fungi was also compared with control to select the best microbe among all three applied (T7) grown under toxicity there is a huge increase in many leaves as compared to others by 12.57% at 30days, decreased by 6.09% at 60days and then get increased by 3.96% at the stage of 120DAS. Finally combined behaviour of all microbes grown under mercury-contaminated soil(T10) was compared with a plant grown under the normal condition as treatment (T0) where results show that performance of all microbes (trichoderam + rhizobium + mycorrihza) under stress was more promising than other treatments or grown individually such as T4,T5,T6 and T7. Undertreatment (T10) there was a rise in leaf number by 6.19% then there has been no effect of metal at 60days but get decrease with 1.33% at 90days and increased by 15.96% at 120DAS.

Table 2: Leaves number in Pearl millet

Treatments	30DAS	60DAS	90DAS	120DAS
T0	$5.33^{a} \pm .577$	$11.00^{a} \pm 1.00$	$11.66^{a} \pm .577$	$8.33^{bcd} \pm .577$
T1	$5.66^{a} \pm .577$	$7.66^{b} \pm .577$	$8.66^{b} \pm .577$	$7.66^{cd} \pm 1.15$
T2	$5.33^{a} \pm .577$	$11.00^{a} \pm 1.00$	$11.66^{a} \pm .57$	$7.66^{d} \pm 1.15$
T3	$5.66^{a} \pm .577$	$11.00^{a} \pm 1.00$	$11.66^{a} \pm .577$	$9.33^{abcd} \pm .577$
T4	$5.66^{a} \pm .577$	$9.66^{a} \pm 577$	$11.33^{a} \pm 1.15$	$7.33^{d} \pm .577$
T5	$5.66^{a} \pm .577$	$10.66^{a} \pm .577$	$11.66^{a} \pm .57$	$8.66^{bcd} \pm 1.52$
T6	$5.66^{a} \pm .577$	$10.66^{a} \pm .577$	$11.66^{a} \pm .57$	$9.66^{abc} \pm .577$

T7	6.00 ^{a} ±.000	10.33 ^{a} ±1.527	11.66 ^{a} ±.57	8.66^{bcd}±.577
T8	5.66 ^{a} ±.577	10.66 ^{a} ±1.527	11.66 ^{a} ±.57	11.00^{a}±1.73
T9	5.66 ^{a} ±.577	10.33 ^{a} ±.5773	11.66 ^{a} ±.57	9.66^{abc}±.577
T10	5.66 ^{a} ±.577	11.00 ^{a} ±1.00	10.33 ^{a} ±1.52	9.66^{abc}±2.30
T11	5.66 ^{a} ±.577	9.66 ^{a} ±.577	11.66 ^{a} ±.57	10.0^{ab}±1.73
T12	6.00 ^{a} ±.000	10.00 ^{a} ±1.00	11.66 ^{a} ±.57	9.00^{abcd}±.00

where, Data are in the form of Mean±SD at $p<0.05$, DAS signify days after sowing of crop where treatment are as follows: Control(T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercury chloride + Trichoderma, (T6) Mercury chloride+ Rhizobium, (T7) MercuryChloride + Mycorrhiza, (T8) Mercurychloride + Trichoderma + Rhizobium, (T9) Mercury chloride + Trichoderma + Mycorrhiza, (T10) Mercurychloride + Rhizobium + Mycorrihza, (T11) Mercurychloride + Trichoderma + Rhizobium + Mycorrihza, (T12) Control + Trichoderma + Rhizobium + Mycorrihza.

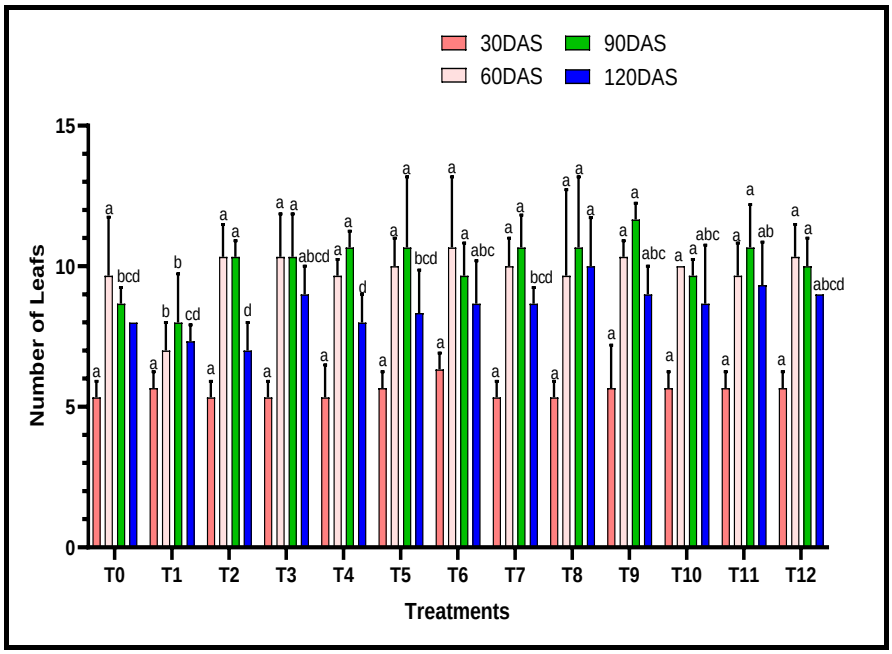

Fig 2: Internodal length of Pearl millet crop

where, Data are in the form of Mean±SD at $p<0.05$, DAS signify days after sowing of crop where treatment are as follows: Control (T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercurychloride + Trichoderma, (T6) Mercurychloride + Rhizobium, (T7) MercuryChloride + Mycorrhiza, (T8) Mercurychloride + Trichoderma + Rhizobium, (T9) Mercury chloride + Trichoderma + Mycorrhiza, (T10) Mercurychloride+Rhizobium+Mycorrihza,(T11)Mercurychloride+Trichoderma+Rhizobium+Mycorrihza,(T12)Control+Trichoderma+Rhizobium + Mycorrihza.

3. Total soluble sugar

Effect of biofertilizers (trichoderma, rhizobium and mycorrhiza) and their combination on total soluble sugar (mg g-1) FW was deliberated in Moti Bajra variety of Pearl millet crop during 2019 when subjected to mercury stress. Data were recorded at interval of 30, 60, 90, 120DAS(days after sowing) (Table 3 & Fig 3).It is an evident in treatment (T1) mercury stress there was significant decrease in total soluble sugar content by 0%, 1.01%,7.70%,39.7% at 30,60,90 or 120DAS during comparison with control (T0).When treatment (T5) trichoderma was applied to mercury stressed soil was compared with treatment (T0) there was a significant decrease in sugar content at 30days interval by 81.77% and increased continuously by 9.85%,11.58%,63.91% at all proposed dates of interval. There was frequently decreased by 34.69%, 11.78% and increased by 63.91% at 60,90 or 120DAS in treatment (T6) rhizobium culture was inoculated to mercury stressed soil compared with control (T0). Mycorrhizal treatment (T7) grown under mercury stress was continuously decreased at all proposed days of the interval but initially decreased by 67.13% at 30days then increased by 16.86%, 1.94% and 60.20%. Final treatment (T10) combination of all biofertilizers under mercury stress was compared with control (T0) there was a significant decrease in total soluble sugar content by 53.18%, 27.9%, 3.31% and 48.15%. Gill *et al*. 2015: this study is focused on the impact of abiotic stresses on growth and development of plant and physiological changes adopted by a cell during stress like production of ROS reactive oxygen species. ROS production in a cell during stress is endowed by certain enzymes like SOD superoxide dismutase. SOD protects the cell from cytotoxic metal compounds through the conversion of oxygen into hydrogen peroxidase. SOD provides direct defence against abiotic stress. This review discusses the introduction, role, significance and modulation of SOD enzyme in a cell under abiotic stress. It highlights major researches done on genetic improvement of SOD enzyme. All post-transitional modification of SOD regulation asis highlighted in this review with aims to improve the future approach for generating tolerance of plant Species under abiotic stresses. The selection criteria for wheat resistance species were made after analysing a range of resistance coefficient and heritable variability which lies between 0.31-0.68.

Table 3: Total soluble sugar (mg g^{-1} fresh weight) of Pearl Millet

Treatments	30DAS	60DAS	90DAS	120DAS
T0	11.41^{ab}±8.37	185.66±.144	131.38^{c}±6.02	38.77^{abc}± .25
T1	2.08^{c}±.363	183.72^{b}±.47	121.27^{f}±.77	23.41^{bc}±15.66
T2	2.16^{c}±.220	186.33^{b}±.58	125.50^{e}±.54	6.44^{c}± 1.85
T3	1.69^{c}±.708	244.3^{ab}±3.14	122.0^{f}±.85	9.36^{c}± .94
T4	12.13^{a} ±9.80	188.38^{b}±.55	138.22^{b}±1.16	32.13^{abc} ± 39.0
T5	3.25^{bc} ±2.31	203.94^{b}±.64	116.16^{g}±.79	63.58 ^{a}± 24.48
T6	5.36^{abc}±3.02	250.02^{ab}±8.37	115.91^{g}±.58	49.75 ^{ab}± 23.74
T7	3.75^{bc}±3.21	216.91^{b}±5.28	128.83^{cde}±1.37	62.11 ^{a}± 23.04
T8	3.61^{bc}±2.59	204.66^{b}±.433	137.86^{b}±2.06	33.50 ^{abc}± 3.83
T9	4.25^{abc}±3.46	330.19^{a}±192.3	136.72^{b}±.54	27.36 ^{bc}± 2.64
T10	5.52^{abc}±3.07	237.52^{ab}±1.19	127.02^{ed}±.88	20.61^{bc} ±5.08
T11	5.00^{abc}±2.34	229.27^{ab}±32.9	158.02^{a}±.473	22.26^{bc} ±14.32
T12	7.70^{abc}±.64	184.91^{b}±.707	129.70^{cd}±.766	36.25 ^{abc}±.35

where, Data are in the form of Mean±SD at $p<0.05$, DAS signify days after sowing of crop where treatment are as follows: Control (T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercury chloride + Trichoderma,(T6) Mercury chloride+Rhizobium,(T7)MercuryChloride+Mycorrhiza,(T8) Mercurychloride+Trichoderma+Rhizobium,(T9)Mercury chloride+ Trichoderma+Mycorrhiza,(T10)Mercurychloride+Rhizobium+Mycorrihza,(T11)Mercurychloride+Trichoderma+Rhizobium+Mycorrihza,(T12)Control+Trichoderma+Rhizobium + Mycorrihza.

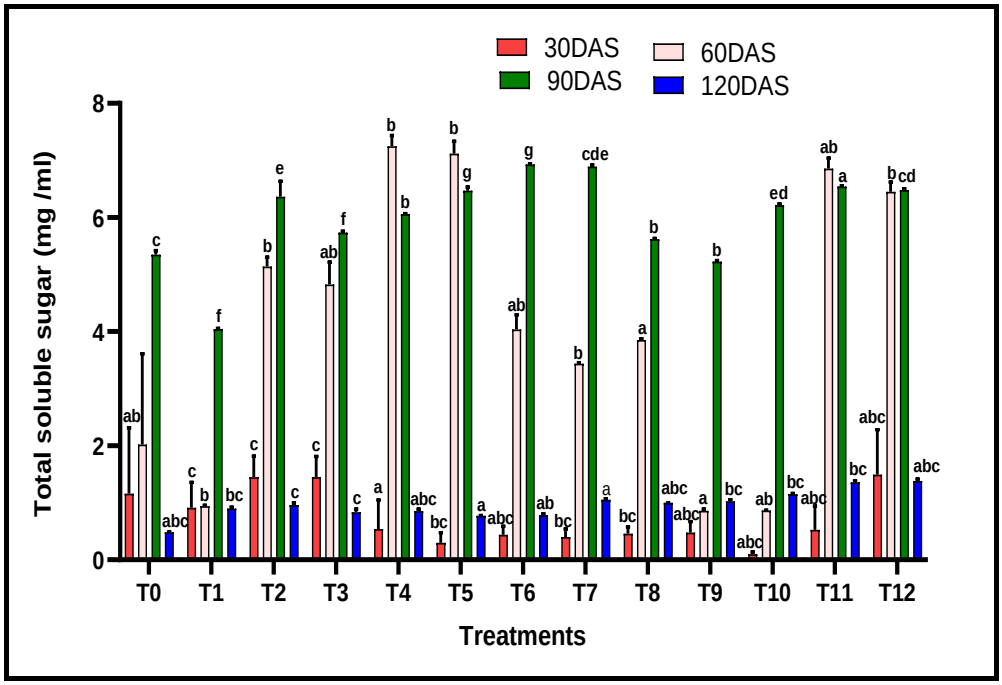

Fig 3: Total soluble sugar (mg g^{-1} fresh weight) in Pearl Millet

where, Data are in the form of Mean±SD at $p<0.05$, DAS signify days after sowing of crop where treatment are as follows: Control(T0), Mercury chloride (T1), (T2) Trichoderma, (T3) (Rhizobium), (T4) Mycorriha, (T5) Mercury chloride + Trichoderma, (T6) Mercury chloride+Rhizobium, (T7) Mercury Chloride + Mycorrhiza, (T8) Mercury chloride + Trichoderma + Rhizobium, (T9) Mercury chloride + Trichoderma + Mycorrhiza, (T10) Mercurychloride + Rhizobium + Mycorrihza, (T11) Mercurychloride + Trichoderma + Rhizobium + Mycorrihza, (T12) Control+Trichoderma+Rhizobium + Mycorrihza.

Conclusion

Overall results of this study cconclude that exogenous application of mycorrihza under mercury treated soils shows better plant growth in terms of Plant height and number of leaves. Number of leaves and Plant height was decreased in treatment (T1) mercury chloride as compare to (T0) control. Total soluble sugar content was decreased more frequently in in treatment (T1) mercury chloride when compare with treatment (T0) control and it is an evident that total soluble sugar content was increased in treatment (T7) mycorrihza applied to mercury treated soil compared to treatment (T0) control.

Acknowledgement

K.S. and P.K gratefully acknowledge the support provided by Department of Agronomy, School of Agriculture, Lovely Professional University, Punjab, India

References

1. Anderson TA, Guthrie EA, Walton BT. Bioremediation in the rhizosphere. Environmental Science & Technology. 1993; 27(13):2630-2636.
2. El-Yazeid AA, Abou-Aly HA, Mady MA, Moussa SAM. Enhancing growth, productivity and quality of squash plants using phosphate dissolving microorganisms (bio phosphor) combined with boron foliar spray. Res. J Agric. Biol. Sci. 2007; 3(4):274-286.
3. Gadd JM. Transformation and mobilization of metals, metalloids, and radionuclides by microorganisms. In: A. Violante, P.M. Huang, G.M. Gadd. (eds). Biophysico-Chemical Processes of Metals and Metalloids in Soil Environments. Wiley-Jupac Series, John Wiley & Sons, Hoboken, NY 2008; 1:53-96.
4. Gill SS, Anjum NA, Gill R, Yadav S, Hasanuzzaman M, Fujita M, Tuteja N. Superoxide dismutase — mentor of abiotic stress tolerance in crop plants. Environmental Science and Pollution Research. 2015; 22(14):10375-10394.
5. Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. Trichoderma species-opportunistic, avirulent plant symbionts. Nature reviews. Microbiology. 2004; 2(1):43-56. https://doi.org/10.1038/nrmicro797
6. Rosolem CA, Calonego JC, Foloni JS. Potassium leaching from millet straw as affected by rainfall and potassium rates. Communications in Soil Science and Plant Analysis. 2005; 36(7-8):1063-1074.
7. Rawat R, Tewari L. Effect of abiotic stress on phosphate solubilization by biocontrol fungus *Trichoderma* sp. Current microbiology. 2011; 62(5):1521-1526.
8. Rokhzadi A, Asgharzadeh A, Darvish F, Nourmohammadi G, Majidi E. Influence of plant growth-promoting rhizobacteria on dry matter accumulation and yield of chickpea (*Cicer arietinum* L.) under field condition. Am-Euras. J Agric. Environ. Sci. 2008; 3(2):253-257.
9. Rosas SB, Andre´s JA, Rovera M, Correa NS. Phosphate-solubilizing Pseudomonas putida can influence the rhizobia-legume symbiosis. Soil BiolBiochem. 2006; 38:3502-3505.
10. Rosolem CA, Calonego JC, Foloni JSS. Potassium leaching from millet straw as affected by rainfall and potassium rates. Commun. Soil Sci. Plant Anal. 2005; 36(7-8):1063-1074. doi: 10.1081/CSS200050497.
11. Schonbeck M, Morse R. Cover crops for all seasons. Virginia Assoc. for Biological Farming. Lexington, VA. Information Sheet #3-06, 2006.
12. Violante A, Cozzolino V, Perelomov L, Caporale AG, Pigna M. Mobility and bioavailability of heavy metals and metalloids in soil environments. Journal of soil science and plant nutrition. 2010; 10(3):268-292.
13. Zhuang X, Chen J, Shim H, Bai Z. New advances in plant growth-promoting rhizobacteria for bioremediation. Environment international. 2007; 33(3):406-413.