EFFECT OF HEAVY METAL ON Brassica Juncea GROWTH EXPOSED TO DIFFERENT LEAD TREATMENTS

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Abstract— General effect of heavy metal is worldwide problem that posed and render environment polluted by causing destruction to both biotic and abiotic substances due to the human activities both Industrial as well as Agricultural practice. The effect of lead (Pb) on growth of Brassica juncea (Indian mustard) was analyzed by mix contamination of 1kg of soil mechanically using variable concentration of lead as (0.3g, 0.6g and 0.9g) and (0.0) contained no external lead as control in the experimental garden. During plantation period of one month the plants was watered with deionised water throughout the experimental period in an alternative days to ensured maintenance of soil moisture near to the field capacity which followed by harvest at developmental stage. Shoot length, root length and fresh plant weight biomass was recorded.

Two different species of Indian mustard were used as M1 and M2 the result obtained showed that root length of M1 decreased at the range of (0.3-0.6) g/pot and for M2 it decreased at the range of (0.6-0.9) g/pot (Fig.1). Shoot length for M1 decreased with the increase in heavy metal concentrations, but for M2 it decreased at the range of (0.6-0.9) g/pot (Fig.2). Plant biomass decreased at the range of (0.3-0.6) g/pot for M1 and at the range of (0.6-0.9) g/pot for M2.
The root and shoot length of the two varieties exposed to 0.3 g/pot Pb was greater than the control, this showed that low concentration of Pb does not show a significant effect but plant length decreased with increased concentrations. There are no significant changes in fresh weight of the two species, M1 treated with 0.3 g/pot showed a weight higher than the control but M2 treated with 0.3 g/pot showed a weight lower than the control. From the present study it may be concluded that the decreased in shoot and root length of the mustard resulted from the Pb accumulated by the two plant varieties, and this clearly shown that both the two varieties can be use for remediating heavy metal polluted soil.

Index Terms—Biomass, Brassica juncea, Heavy metals, Lead and Varieties

INTRODUCTION

Soil contains trace levels of many heavy metals and most of these heavy metals are essential elements for living organisms, but their excess amount is generally harmful to plants, animals and human health.[1-4]. Many anthropogenic activities pollute the soil ecosystems with heavy metals resulting in conditions which are toxic for living organism [5,6].Soil contamination by industrial effluents loaded with toxic heavy metals has raised a new threat to agriculture. These effluents and wastes contain heavy metals in sufficient amount to cause toxicity to crop plants. Excessive accumulation of heavy metals like copper, cobalt, chromium, nickel, cadmium, zinc, lead etc. in soil as a result of mining, processing and other technological activities of man have been reported[7-8]. There are several studies emphasizing the influence of heavy metals such as Ni, Co, Cu, Mn, pb and Zn on plant growth and function[5,7,10,11].However, underlying all these studies, there is are requirement to expose plants to toxic, but appropriate, concentration of the trace metal in order to study heavy metal tolerance in plants[10].

Heavy metals derived from various anthropogenic sources (industrial effluents and wastes, urban runoff, sewage and inhibition of photosynthetic activity [21, 22]. The effect of Pb depends on concentration, type, and properties of soil and plant species [23].

treatment plants, boating activities, agricultural fungicide runoff, domestic garbage dumps, and mining operations) have progressively affected the environment and ecosystems [11-12]. Major concerns with respect to plant exposure (as well as the human food-chain) are the metalloids: arsenic (As), selenium (Se), and the metals cadmium
(Cd), mercury (Hg), and lead (Pb) [14]. Heavy metals can influence the physical and chemical processes in living organisms by directly inducing reactive oxygen species (ROS) production (Fenton reaction), by blocking functional groups of proteins and glutathione, and by displacing essential metals – like zinc or selenium from proteins and zinc from zinc-finger motifs of transcription factors [15-17]. Lead (Pb) exists in many forms in natural sources throughout the world. According to the U.S. Environmental Protection Agency (EPA), Pb is the most common heavy metal contaminant in the environment [20]. Lead concentration over 30 $\mu g \cdot g^{-1}$ dry biomass is toxic to most plant species. Pb toxicity leads to inhibition of seed germination root and shoot growth, disturbed mineral nutrition.

Although heavy metals are naturally present in the soil, geologic and anthropogenic activities increase the

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concentration of these elements to amounts that are harmful to both plants and animals. Some of these activities include mining and smelting of metals, burning of fossil fuels, use of fertilizers and pesticides in agriculture, production of batteries and other metal products in industries, sewage sludge, and municipal waste disposed [24-26].

Growth reduction as a result of changes in physiological and biochemical processes in plants growing on heavy metal polluted soils has been recorded [27-28]. Continued decline in plant growth reduces yield which eventually leads to food insecurity. Therefore, the remediation of heavy metal polluted soils cannot be overemphasized.

Heavy metals are elements that exhibit metallic properties such as ductility, malleability, conductivity, cation stability, and ligand specificity. They are characterized by relatively high density and high relative atomic weight with an atomic number greater than 20 [25]. Some heavy metals such as Co, Cu, Fe, Mn, Mo, Ni, V, and Zn are required in minute quantities by organisms. However, excessive amounts of these elements can become harmful to organisms. Other heavy metals such as Pb, Cd, Hg, and As (a metalloid but generally referred to as a heavy metal) do not have any beneficial effect on organisms and are thus regarded as the "main threats" since they are very harmful to both plants and animals.

Metals exist either as separate entities or in combination with other soil components. These components may include exchangeable ions sorbed on the surfaces of inorganic solids, nonexchangeable ions and insoluble inorganic metal compounds such as carbonates and phosphates, soluble metal compound or free metal ions in the soil solution, metal complex of organic materials, and metals attached to silicate minerals [26]. Metals bound to silicate minerals represent the background soil metal concentration and they do not cause contamination/pollution problems compared with metals that exist as separate entities or those present in high concentration in the other 4 components [27].

Soil properties affect metal availability in diverse ways. Harter [28] reported that soil pH is the major factor affecting metal availability in soil. Availability of Cd and Zn to the roots of Thlaspi caerulescens decreased with increases in soil pH [29]. Organic matter and hydrous ferric oxide have been shown to decrease heavy metal availability through immobilization of these metals [30]. Significant positive correlations have also been recorded between heavy metals and some soil physical properties such as moisture content and water holding capacity [31].

Conversely, heavy metals may modify soil properties especially soil biological properties [32]. Monitoring changes in soil microbiological and biochemical properties after contamination can be used to evaluate the intensity of soil pollution because these methods are more sensitive and results can be obtained at a faster rate compared with monitoring soil physical and chemical properties [33]. Heavy metals affect the number, diversity, and activities of soil microorganisms. The toxicity of these metals on microorganisms depends on a number of factors such as soil temperature, pH, clay minerals, organic matter, inorganic anions and cations, and chemical forms of the metal [34, 35, and 36].

There are discrepancies in studies comparing the effect of heavy metals on soil biological properties. While some researchers have recorded negative effect of heavy metals on soil biological properties [31, 32 and 35], others have reported no relationship between high heavy metal concentrations and some soil (micro) biological properties [36]. Some of the inconsistencies may arise because some of these studies were conducted under laboratory conditions using artificially contaminated soils while others were carried out using soils from areas that are actually polluted in the field. Regardless of the origin of the soils used in these experiments, the fact that the effect of heavy metals on soil biological properties needs to be studied in more detail in order to fully understand the effect of these metals on the soil ecosystem remains. Further, it is advisable to use a wide range of methods (such as microbial biomass, C and N mineralization, respiration, and enzymatic activities) when studying effect of metals on soil biological properties rather than focusing on a single method since results obtained from use of different methods would be more comprehensive and conclusive.

The presence of one heavy metal may affect the availability of another in the soil and hence plant. In other words, antagonistic and synergistic behaviours exist among heavy metals. Salgare and Acharekar [37] reported that the inhibitory effect of Mn on the total amount of mineralized C was antagonized by the presence of Cd. Similarly, Cu and Zn as well as Ni and Cd have been reported to compete for the same membrane carriers in plants [38]. In contrast, Cu was reported to increase the toxicity of Zn in spring barley [39]. This implies that the interrelationship between heavy metals is quite complex; thus more research is needed in this area. Different species of the same metal may also interact with one another. Abedin et al. [40] reported that the presence of arsenite strongly suppressed the uptake of arsenate by rice plants growing on a polluted soil. The heavy metals that are available for plant uptake are those that are present as soluble components in the soil solution or those that are easily solubilized by root exudates [41]. Although plants require certain heavy metals for their growth and upkeep, excessive amounts of these metals can become toxic to plants. The ability of plants to accumulate essential metals equally enables them to acquire other nonessential metals [42]. As metals cannot be broken down, when concentrations within the plant exceed optimal levels, they adversely affect the plant both directly and indirectly.

Some of the direct toxic effects caused by high metal concentration include inhibition of cytoplasmic enzymes and damage to cell structures due to oxidative stress [43, 44]. An example of indirect toxic effect is the replacement of essential nutrients at cation exchange sites of plants [45]. Further, the negative influence heavy metals have on the growth and activities of soil microorganisms may also indirectly affect the growth of plants. For instance, a reduction in the number of beneficial soil microorganisms due to high metal concentration may lead to decrease in organic matter decomposition leading to a decline in soil nutrients. Enzyme activities useful for plant metabolism may also be hampered due to heavy metal interference with activities of soil microorganisms. These toxic effects (both direct and indirect) lead to a decline in plant growth which sometimes results in the death of plant [42-46].

It is important to note that certain plants are able to tolerate high concentration of heavy metals in their environment. Baker [44-47] reported that these plants are able to tolerate these metals via 3 mechanisms, namely, (i) exclusion: restriction of metal transport and maintenance of a constant metal concentration in the shoot over a wide range of soil concentrations; (ii) inclusion: metal concentrations in the shoot reflecting those in the soil solution through a linear relationship; and (iii) bioaccumulation: accumulation of metals in the shoot and roots of plants at both low and high soil concentrations. Indian mustard or Brassica juncea (Brassicaceae), an oil-seed crop, is the well-known plant for phytoremediation [45-47]. Its biochemical and genotype (expression of metallothionine genes) favours the hyperaccumulation of heavy metals [47-48]. It is a high biomass producing crop plant even in the presence of heavy metals [48-49]. Possible mechanism involved in metal accumulation is the uptake of metals in the root via solubilizing the metal from soil matrix and transported to the leaves where it is detoxified or chelated and finally sequestered and volatilized [49]. Thus, Indian mustard has the capacity to take up and accumulate to very high levels metals such as Cd, Cu, Ni, Zn, Pb and Se from the contaminated sites.

Plants in the mustard family, Brassica, are often effective at phytoremediation [41-53]. *Brassica rapa*, also known as field mustard, is very versatile and can grow in many different soil textures, pH levels, and amounts of shade. The species used for this study, known as Wisconsin Fast Plants, has a rapid growth rate because it has been breed to withstand constant light.

1. The objective is to compare the effect of two plant species by measuring the performance of plant at different lead concentration and
2. Finally to observed the effect of heavy metals on the analyzed plant.

Materials and Methods:

Garden house experiments:
A garden house experiment was conducted to find out the effect of (Pb) on Growth of Brassica juncea (Indian mustard) exposed to different lead treatment and find out the performance of the plant at different concentrations of (Pb).

Experimental soil:
Soil samples were collected from the top 0-15 cm profile of the Garden land from Greater Noida UP, India. Soils were air dried and passed through 2 mm sieve and used for cultivation of plants. Experimental design and treatments:
The experiment was carried out in garden house with one kg (1kg) polythene bags which filled with soil and the bags were arranged in a completely randomized factorial design with three replicates each.
Soil portions equivalent to 1 kg of dried soil were individually contaminated (by mechanical mixing in Polythene bags) with four treatments Viz., TC (Control, no external pb added), T3, T6 and T9 (0.3, 0.6 and 0.9g kg-1 of pb as pb (NO3)2 dissolved in deionised water). Control and polluted soil were equilibrated for one week. Soil and plants with four treatments and three replicates, giving a total of 24 bags.

Plant cultivation:
Seeds were sown at a rate of 3 bags –1 and thinned to one seedling in each bags 2 weeks to the sowing time. Deionised water was added on alternative days throughout the experiment to keep the water content near to the field capacity.

Harvest: Plants were harvested at developmental stage which marks 30 days to the time of sowing.
Harvested Plants were washed with running tap water to remove adhering soil particles, then rinsed twice with deionised water, blotted with tissue paper and their fresh weight, root length, shoot length and total length was record.

RESULTS

Soil contamination by heavy metals is a worldwide environmental problem which causes plants destruction. When heavy metals are present in higher quantity, they became toxic and cause reduction in plant growth. Pb is one of the heavy metals which contaminates soil and causes structural and biochemical changes in plants. Effect of Pb was studied in this experiment. Decreased in morphological characteristics such as shoot/root lengths, fresh weight of shoot and root was seen in the plants treated with Pb.

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From the result obtained, it was shown that root length of M1 decreased at the range of (0.3-0.6) g/pot and for M2 it decreased at the range of (0.6-0.9) g/pot (Fig.1). Shoot length for M1 decreased with the increase in heavy metal concentrations, but for M2 it decreased at the range of (0.6-0.9) g/pot (Fig.2). Plant biomass decreased at the range of (0.3-0.6) g/pot for M1 and at the range of (0.6-0.9) g/pot for M2 (Fig.3).

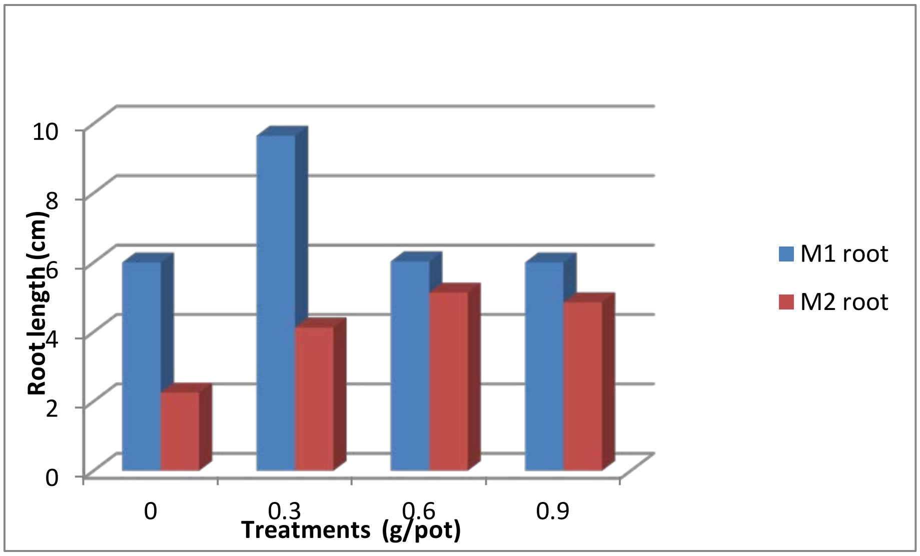

Fig 1: Root length of mustard varieties under Pb stress,
M1=Pm-26 (NPJ-113) & M2=pusa saag-1

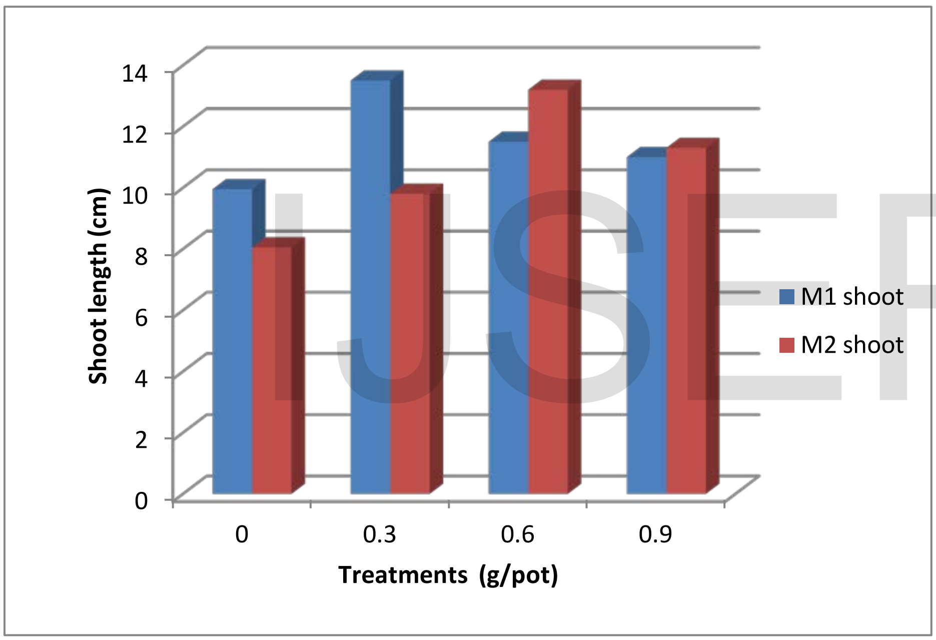

Fig 2: Shoot length of mustard varieties under Pb stress, M1=Pm-26 (NPJ-113) & M2=pusa saag-1

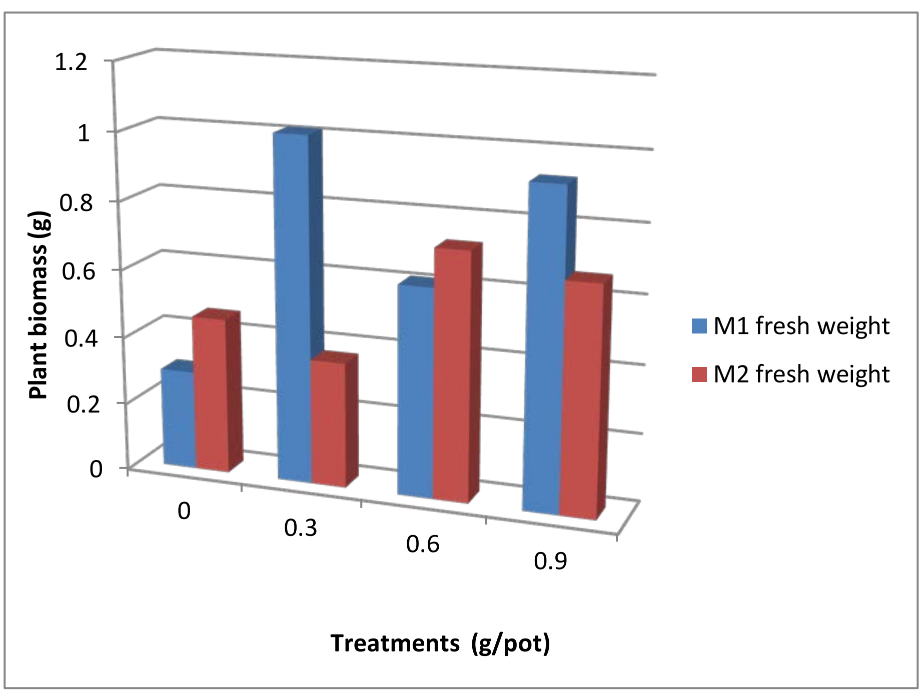

Fig 3: Fresh weight of mustard varieties under Pb stress, M1=Pm-26 (NPJ-113) & M2=pusa saag-1

CONCLUSION AND DISCUSSION

Soil contamination by heavy metals is a worldwide environmental problem which causes plants destruction [54].

In this experiment, it was found that Pb inhibits plant morphological parameters such as root length, shoot length and plant biomass. These findings are similar to another study in which there was also reduction in shoot length of wheat due to Pb contaminated soil [55]. The root and shoot length of the two varieties exposed to 0.3 g/pot Pb was greater than the control, this showed that low concentration of Pb does not show a significant effect but plant length decreased with increased concentrations. There are no significant changes in fresh weight of the two species. M1 treated with 0.3 g/pot showed a weight higher than the control but M2 treated with 0.3 g/pot showed a weight lower than the control.

From the present study it may be concluded that the decreased in shoot and root length of the mustard resulted from the Pb accumulated by the two plant varieties, and this clearly shown that both the two varieties can be use for remediating heavy metal polluted soil.

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