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Bioremediation of Match Industry Waste Using Fungal Isolates and its Impact on the Growth of *Vigna radiate* Linn.

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Abstract: In the bioremediation study, different concentrations of match industry waste soil (10%, 30% and 50% (w/w) was inoculated with 10^8 spores/ml concentration of M_1 and M_2 fungi isolates individually on and the seedlings were analyzed on the 21st day. The growth characteristics such as shoot length, root length, fresh weight, dry weight and leaf area of the plants were analyzed and found to be increased compared to the plants treated with match industry waste soil alone.

Key words: *Vigna radiate* · Fungal isolates · Match industry waste

INTRODUCTION

In India many industries are using heavy metals in their process and exiled out without proper treatment. Metals are released into the environment leads to wide spectrum of anthropogenic activities such as smelting of metallic ores, industrial fabrication and commercial application of metals, which are polluting our aquatic bodies. Though, several metals are essential for biological systems these must be present in a certain concentration range. Too low concentrations lead to a decrease in metabolic activity and at too high concentrations lead to toxicity. Non essential metals are tolerated at very low concentrations and inhibit metabolic activity at higher concentrations [1]. Uses of heavy metals in several applications lead to their wide distribution in soil, silt, waste and waste water. Such a pollution of the environment by toxic metals and radionuclide arises as a result of many human activities, largely industrial, although sources such as agriculture and sewage disposal also contribute. Zinc (Zn) was the most abundant pollutant creating phytotoxicity, while public health was mostly endangered by the presence of the toxic metal Cadmium (Cd). Besides Zinc (Zn), Nickel (Ni) and Cadmium (Cd) the metals Copper (Cu) and Lead (Pb) were also present in the contaminated sandy soils. Heavy metals are toxic to plants. Toxic heavy metal concentration has increased in ground water to change physiological and genetic characters in plants, animals, insects, earthworms, fishes, birds and animals [2,3] and the industrial waste generally spoiled the quality of water by their physico chemical and microbiological characteristics. Heavy metals may originate from a variety of sources including the nuclear power defence and fuel reprocessing industries. These metals are serving as nutrients for animals and plants at low level concentration but toxic at higher level [4].

The uses of conventional technologies, such as ion exchange, chemical precipitation, reverse osmosis and evaporative recovery for this purpose is often inefficient and / or very expensive [5]. There is a need for innovative treatment technologies for the removal of heavy metal ions from wastewater. Different microbes have been proposed to be efficient and economical alternative in removal of heavy metals from water [6].

Microbial populations are known to affect trace metal mobility and availability to the plant through release of chelators, acidification and redox changes [7]. The presence of rhizosphere bacteria has been reported to increase the concentrations of Zn, Cu, Pb or Cr in plants [8,9]. Improvement of the interactions between plants and beneficial rhizosphere microorganisms can enhance biomass production and tolerance of the plants to heavy metals and is considered to be important components of phytoremediation technologies[10].

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Hence in the present study an attempt was made to assess the quality of match industry waste soil, isolation of fungi from match industry waste soil and its impact on the growth characteristics of *Vigna radiata*, Linn.

MATERIALS AND METHODS

Isolation of Fungi: Five fungi were isolated from the sample of match industry waste soil by serial dilution using Rose Bengal agar medium and pour plate technique. The pure cultures were made on PDA plates and identified by their morphological and colony characteristic and the slants was sub cultured once a month [11].

Impact of Match Industry Waste Soil on the Chosen Plant Seed Source: Seeds of *Vigna radiate* Linn was procured from the Seed Protection Department, Sattur, Virudhunagar district, Tamil Nadu.

Seed Treatment: Healthy and viable seeds of *Vigna radiate* Linn were surface sterilized with 0.1% mercuric chloride for one minute and washed with running tap water, followed by rinsing with distilled water. The seeds were soaked in distilled water for two hours.

Raising of Cultivars: Pellets of fungal mycelium were collected by centrifuging at 3000 rpm for 5mins. The crude pellets of M_1 and M_2 were coated on the sterilized seeds of *Vigna radiata* individually. The garden soil (sand, loam and red soil 1:1:1) and the match industry waste soil was mixed with garden soil to get 10, 30 and 50% w/w. Then the fungal inoculated seeds were sown in different pots containing 10, 30 and 50% w/w, respectively. The individual pots were inoculated with 10ml 0f PD broth having M_1 and M_2 fungi, respectively for the respective concentrations of the match industry waste soil. Then control pots were maintained with the seed of *Vigna radiata* which devoid of fungal isolates. The experimental pots were kept in diffused light at room temperature. Both experimental and control sets were maintained in triplicates all the pots were watered regularly. On the 21th day the seedlings of *Vigna radiata* were taken for analysis.

Growth Parameters: For all the growth characteristics, *viz*., shoot length, root length, fresh weight, dry weight, three seedlings has been taken from both experimental and control sets were analyzed.

RESULTS AND DISCUSSION

Soil microorganisms are ubiquitous in soils to which hyper accumulators are native, even in those soils containing high concentrations of metals [12]. Soil microorganisms can produce iron chelators and siderophores that ensure iron availability, reduce soil pH and / or solubilize metals phosphates [7].

The seedlings were individually grown in various concentrations of match industry waste soil such as (10, 30 and 50% (w /w)) up to 21st day. Proper control set with water was maintained. On the 21st day, various growth parameters were analyzed on the seedlings.

The length of the seedlings was significantly reduced in the *Vigna radiata* grown in match industry waste soil and the reduction was found to be increased with increasing the concentration of the match industry waste soil. Fresh weight of the seedlings also showed similar declining trend as the length of the seedlings (Table 1).

In the present study, it has been noted that the match industry waste soil adversely affects the growth of *V. radiatae.* The plants grown in different concentrations of match industry waste soil resulted in the retardation of growth expressed in terms of shoot and root lengths, leaf area and plant biomass. Growth reduction in plant system is very complex including toxic effects from the excess of micro nutrients, heavy metals, decomposition products, salt toxicity as well as effect on soil structure, porosity and aeration [13,14] and also observed that the toxic effluent might have affected the seedling vigour through a decrease in the root shoot ratio.

The reduction in growth may be due to the excess amount of solid materials and soluble salts in the effluent which could cause injuries to plant [15]. They reported that nitrate, phosphate, potassium, sodium and chloride contents in the soil by increasing the addition of wastewater. According to Sahai *et al*. [16], the retardation of plant growth was due to excess quantities of micronutrients and other toxic chemicals.

It was observed that the higher concentration of sulphate, chlorate and total dissolved solids are the factors which caused reduction in seedling growth [17].

Similar reduction in the growth of paddy, maize, cotton, black gram and tomato crops were reported due to irrigation with paper mill effluent [18]. The reduction may be attributed to high amounts of dissolved solids resulting in the osmotic imbalance of the root system. In the present study, it has been noted that the vigor of

Table 1: Effect of Various Concentrations of Match Industry Waste Soil on the Growth of *Vigna radiate* Linn

S. No.	Parameters	Control	10% (w/w)	30% (w/w)	50%w/w)
1	Shoot length (cm)	20.0 (100%)	18.5(92.5%)	17.5(87.9%)	16.0(80%)
2	Root length (cm)	3.01(100%)	2.88(95.68%)	2.72(90.36%)	2.70(89.70%)
3	Fresh weight (g)	3.62(100%)	3.5(96.68%)	2.98(82.32%)	2.5(69.06%)
4	Dry weight (g)	0.06(100%)	0.006(100%)	0.05(83.33%)	0.04(66.66%)
5	Leaf Area (cm^2)	2.98(100%)	2.95(98.99%)	2.72(91.27%)	2.33(78.18%)

Table 2: Bioremedial effect of M1 fungi on the Various Concentrations of Match Industry Waste Soil on the Growth of *Vigna radiata* Linn

S. No.	Parameters	Control	10% (w/w)	30% (w/w)	50% (w/w)
1	Shoot length (cm)	20.0(100%)	19.5(97.5%)	17.98(89.9%)	16.98(84.9%)
2	Root length (cm)	3.01(100%)	2.98(99%)	2.82(93.68%)	2.75(91.36%)
3	Fresh weight (g)	3.62(100%)	3.5(96.68%)	3.0(82.87%)	2.98(82.32%)
4	Dry weight (g)	0.06(100%)	0.06(100%)	0.06(100%)	0.05(83.33%)
5	Leaf Area (cm^2)	2.98(100%)	2.94(98.65%)	2.68(89.93%)	2.42(81.20%)

Table 3: Bioremedial effect of M2 fungi on the Various Concentrations of Match Industry Waste Soil on the Growth of *Vigna radiate* Linn

S. No.	Parameters	Control	10% (w/w)	30% (w/w)	50% (w/w)
1	Shoot length (cm)	20.0(100%)	19.8(99%)	18.52(92.6%)	18.04(90.2%)
2	Root length (cm)	3.01(100%)	2.99(99.33%)	2.85(94.68%)	2.79(92.69%)
3	Fresh weight (g)	3.62(100%)	3.5(96.68%)	3.2(88.39%)	3.05(84.25%)
4	Dry weight (g)	0.06(100%)	0.06(100%)	0.06(100%)	0.05(83.33%)
5	Leaf Area (cm^2)	2.98(100%)	2.96(99.32%)	2.73(91.61%)	2.52(84.56%)

the seedlings was decreased and resulted in succumbing of seedlings when treated with above 50% concentration of Match industry waste soil.

The wilting of young seedlings may be due to the presence of calcium and magnesium in the effluent that caused higher osmotic pressure [19]. Similar observations were reported by Gomathi and Oblisamy [20] and Kumran Suresh [21], who observed that when *Phaseolus aureus* was irrigated with paper mill effluent, the lower concentration was in favour of germination and seedling growth while there was a gradual decrease in germination and seedling growth on higher concentrations.

The present study revealed that there was a very high reduction in both the fresh and dry weight of the plant in different concentrations of match industry waste soil on the experimental plants. The pronounced inhibition of shoot and root lengths and reduction in leaf area are the main causes for the decrease in fresh weight and dry weight of the seedlings. Similar observations were reported with tailings water irrigation on the biomass of some crop plants [22]. The reduction in root length and chlorophyll content, associated with the dry matter reduction in stressed plants have also been reported byThukral [23]. Hence, it was suggested that bioremediation would be a suitable alternative and conventional remediation technology; especially for soil.

In the bioremediation study, different concentrations of match industry waste soil (10, 30 and 50% (w /w)) was inoculated with 10^8 spores /ml concentration of M_1 and M_2 fungi individually on *Vigna radiata* and the seedling were analyzed on the 21st day (Tables 2 and 3).

After the inoculation of M_1 and M_2 fungi individually to the match industry waste soil, their growth was enhanced and compared to control plants of *Vigna radiate* Linn.

The increase in growth parameters in the M_1 and M_2 inoculated soil may be attributed to the multiple effects of M_1 and M_2 fungi such as their ability to suppress pathogenic micro-organisms production of growth promoting substances and its role in detoxification of heavy metals (Tables 2 and 3). Similar results were reported in maize when *Azotobacter* was inoculated with tryptophan [24].

The enhancement of growth in the experimental plants may be due to the efficient effect of M_1 and M_2 fungi on the match industry waste soil degradation. *Azotobacter* is tolerant to high salts, improves soil fertility and enhances nutrient uptake and water uptake in deficient soils, thereby aiding in better establishment of plants [25].

In the present study, the match industry waste soil caused osmotic stress on the experimental plant. The resulting adverse effect such as osmotic stress, reduction of leaf area and senescence are diminished by the inoculation of of M_1 and M_2 fungi on the match industry waste soil. *Azospirillum* inoculated *Sorghum bicolor* plants to an osmotic stress in water culture systems have diminished adverse effects of osmotic stress [26].

The M_1 and M_2 fungi isolates on the match industry waste soil recovered plants from stress induced by the chlorate ions of match industry waste soil may be due to tolerance of these fungi towards high concentrations of chlorate ions. This is correlated with those obtained by Hartman *et al.* [27], who stated that *Azospirillum* recovered plants from stress and it was due to the tolerance towards high concentrations of sodium chloride, sucrose and polyethylene glycol. It is to be pointed out that among the two bio remediants used in the present study for the bioremediation of match industry waste soil, it was found that the M_2 fungi effect is higher for the match industry waste soil followed by M_1 fungi respectively. It was observed that the toxic effects of the match industry waste soil can almost be nullified by the inoculants used.

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