MANAGEMENT STRATEGIES TO RESCUE TRANSPLANTABLE VEGETABLES IN AND AROUND YAMUNA RIVER BELT AGAINST HEAVY METALS CONTAMINATION AND SOIL BORNE HIDDEN ENEMIES.-A MATTER OF GREAT CONCERN TO HUMAN HEALTH

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Abstract
Yamuna river belt in Delhi suffers from industrial pollution due to factory effluents and toxic pesticides being indiscriminately used by the farmers causing produces unfit for human consumption. A systematic survey during 2015-2016 around farmer’s field at Yamuna river belt showed yield losses of tomato and brinjal by major soil borne fungi caused by root knot nematodes and wilt/rot both alone and together resulting disease complex with synergistic effect on the common hosts. On close interaction with the growers, it was learnt that over use of toxic chemical pesticides caused detrimental effect on human health. All the hidden maladies are expressed as symptoms by patchy growth of the affected crops referred as hot spots. To combat the above problem, an indigenous, integrated, pest and pollution management (IIPPM) techno-package containing sustainable components was applied at nursery and field to the transplantable crops i.e., tomato, brinjal. The package contains specific fungal bio-agent against respective pathogens, three species of Brassica namely B. juncea, B. napus and B. rapa against bioremediation, Eclipta alba and Phyllanthus niruri as bio-fumigant botanicals. The three species of Brassica also served as trap crops, trapping the heavy metals from environment. The treatment proved to be highly successful as it decreases the nematode level to less than 2 larvae/gram soil (ETL) and simultaneously reducing the heavy metal of soil to significant level. B. juncea having proven to be the most effective among three species under investigation and is recommended for crop rotation with other vegetables.

Key words : Industrial pollution, root knot nematodes, hot spots, bioremediation.

Introduction
Green revolution in India has welcomed large scale production of hybrid varieties and focused only on crop production but have neglected crop protection issues. As a result, the uneducated growers in India being unaware are still using a large dose of banned pesticides and fertilizers i.e., Endosulfan. In addition the same field has also become victimized by the ingress of heavy metals coming from industries. The seriousness of the contamination was highlighted in a study undertaken by TERI in 2012 sponsored by UNICEF. It showed how despite government efforts industrial effluents and untreated sewage continue to choke the river. In fact, the toxins have polluted the ground water and soil. It has entered our food chain through the vegetables grown on the belt and continues to affect the people living on the belt. Most of the vegetables being sold at Delhi’s wholesale markets are washed in the toxic water of the Yamuna. Others are grown in the bed of trash along it and both kinds pose danger to our health. The vegetables growing in this soil absorb the contaminants. “Vegetables contaminated with such toxins can impact normal health quite seriously. It can cause a range of conditions including cancers, heart disease, brain, kidney and liver diseases, muscle and general weakness,” Dr. S.P. Byotra, Head of Internal Medicine at Sir Ganga Ram Hospital said.

Vegetables contaminated with such toxins have a huge negative impact on human health. It can cause a range of conditions including cancer as well as lung, heart, brain, kidney, liver diseases, reproduction failure (partial sterility/full sterility), muscle and general weaknesses as said by
Dr. S. P. Byotra, head of internal medicine, Sir Ganga Ram Hospit also quotes a 2012 study by National Reference Trace Organics Laboratory and Central Pollution Control Board (CPCB) in association with the environment ministry that found Lindane, a carcinogenic insecticide in Yamuna water. In 2012, a study by National reference trace organics laboratory and Central pollution control Board in association with environment ministry was done and a carcinogenic insecticide, Lindane was found in Yamuna water.

A systematic survey was conducted on 2015-2016 at the grower’s field in the Geeta Colony site of River Belt. Growers were facing yield-losses of Solanaceous crops viz., Tomato, Brinjal, Chilli by soil borne fungi causing wilt, rot along with root knot nematodes.

Soil borne fungi along with RKN are certain hidden enemies in the soil for which growers are suffering huge yield loss. Interaction between fungi and nematodes having been recognized since 1892, when Atkinson reported Fusarium wilt of cotton and it was found to be more severe in presence of root-knot nematodes (Meloidogyne sp.) than in their absence. Several workers have been reviewed the work on interaction of plant parasitic nematodes with fungi on various crops (Castillo et al., 2003; Goswami et al., 2007). Root knot nematode (Meloidogyne sp.) is reported by the above mentioned authors to predispose the attack of root wilt (Fusarium sp.) and attack of root rot (Rhizoctonia sp.) and form disease complex which goes very deep in the soil showing synergistic interaction and reduces the soil quality and yield. Being totally ignorant, the growers keep on increasing the doses of chemical pesticides mainly organophosphates and carbamates which are very toxic with high residual effect creating potential hazard to the environment and finally the health of higher animals including human beings wrecking their immune systems.

Scanning of literature clearly reveals no safe and cost effective solution for the above mentioned maladies including soil borne ones and environmental pollution posing a continuous threat to human health. It is therefore, felt desirable to investigate a safe and cost effective Indigenous integrated pest and pollution management package (IIPPM).

Components of IIPPM

Vermi-compost

Vermi-compost has been found to effectively enhance the root formation, elongation of stem and production of biomass in vegetables, ornamental plants etc. (Grappelli et al., 1985; Bano et al., 1993; Atiyeh et al., 1999). The nutrient level in the vermi-compost, especially the macro- and micronutrients were found to be always higher than the compost derived from other methods. One of the unique features of vermi-compost is that during the process of conversion of various organic wastes by earthworms, many of the nutrients are changed to their available forms in order to make them easily utilisable by plants. Therefore, vermi-compost has higher levels of available nutrients like nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes (Buchanan et al., 1988). These distinctive properties can be utilized in considering vermi-compost as a suitable carrier for the bio-formulation and as a significant component of the proposed package.

Neem oil seed cake

Neem (Azadirachta indica) is widely used for management of root knot nematodes infecting vegetables, pulses and soil borne fungus causing wilt, root rot etc (Sharma and Bedi, 1988). It has also a strong insecticidal property.

Biopesticide

As potential antagonistic fungal bio-agents, the filamentous Deuteromycetes fungi, Trichoderma harzianum, Paecilomyces lilacinus (Khan & Goswami, 2002) and Aspergillus niger (Zuckermann, 1994) have attracted attention due to their multi prolonged action against various soil borne pathogens including root knot nematodes. The species of Trichoderma have been evaluated against wilt, root rot fungi, and root knot nematode under glass house and field conditions and found to give results (Goswami et al., 2005). Several isolates of Paecilomyces showed antagonism against root knot nematode (Goswami et al., 2005) and the application of several isolates of Trichoderma and Paecilomyces against pathogenic soil borne fungi and root knot nematode showed outstanding results in combating soil borne diseases. Local botanicals i.e., Phyllanthus niruri and Eclipta alba grown as weeds are also components of the package as they are reported to have nematicidal as well as fungicidal property (Goswami et al., 2013).

Besides in the present work, three species of Brassica namely Brassica juncea, Brassica napus and Brassica rapa have been included. These plants are reported to eliminate heavy metals i.e., Cd, Pb, Ni, Zn from soil and environment and known as good metal accumulators having high biomass and fast growing property and have been evaluated as potential phyto-extraction plants (Akhtar et al., 2013). These above plants have also been reported to exhibit bio-fumigant property against soil borne fungi and nematodes.
Management Strategies to Rescue Transplantable Vegetables

Apart from being phyto-extractor, the functional groups present in plant biomass viz. acetamido, alcoholic, carbonyl, phenolic, amido, amino, sulphonyl groups etc. have affinity for heavy metal ions to form metal complexes or chelates. The mechanism of bio-absorption process includes chemi-sorption, complexation, adsorption on surface, diffusion through pores and ion exchange etc which make it suitable to add as dried botanicals in the package (Sud et al., 2008).

The major components of IIPPM package showing multifarious activities are given in table 1.

<table>
<thead>
<tr>
<th>Components</th>
<th>Bio-remedant</th>
<th>Bio-fumigants</th>
<th>Bio-pesticides</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fungicides</td>
</tr>
<tr>
<td>Azadirachta indica</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Trichoderma harzianum</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paecilomyces lilacinus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspergillus niger</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phyllanthus niruri</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eclipta alba</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brassica juncea</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brassica napus</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brassica rapa</td>
<td>√</td>
<td></td>
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</tbody>
</table>

(Ravichandra, 2014). Effects of polluted land, water and usage of chemical pesticides for the management of pests and diseases including root knot nematodes and convincing them about the present proposed IIPPM package at selected hot-spots.

5. After illustration of the weeds namely Phyllanthus niruri and Eclipta alba and the other botanicals namely Brassica juncea, Brassica napus and Brassica rapa growers will be engaged for collection of all the botanicals, shed drying and crushing to prepare powder to be used in package.

6. Selecting potential strains of fungal bio-agents Trichoderma harzianum and Paecilomyces lilacinus and Aspergillus niger from the lab consortium, wide range of commercially available products to combat the soil borne hidden enemies. Since, these vegetable crops are transplantable, treatment was done at nursery level:

**At nursery level**

a. Soil treatment: Fungal bio-agents (Trichoderma harzianum + Paecilomyces lilacinus + Aspergillus niger @50g each/kg) was applied two weeks prior to sowing with about 500g of Vermi-compost containing 50g each of botanicals.

b. Two weeks prior to sowing mixture of fungal bio-agents powder (Trichoderma harzianum + Paecilomyces lilacinus + Aspergillus niger @50g each) of fungal colonized grains and also 500g of Vermi-compost containing 50 g of each of botanicals was added to nursery bed.

c. Seed treatment: Seeds to be sown after treating with 0.001% HgCl₂.

d. Bare root dip treatment: Prior to transplantation of 20-30 days old healthy seedlings in a slurry
containing Jaggery @ 50g+fungal bio-agents (@ 50g each/lit.) dipped for 30 minutes followed by transplantation with about 500g of Vermi-compost containing 50g of each of botanicals.

Transplantation of 4 weeks nursery healthy seedlings (Tomato and Brinjal) to the ‘hot-spots’ on micro-plot (2*2 sqm) keeping 30 cm distance between the seedlings prior to which deep ploughing along with application of a mixture of fungal bio-agents 50g + 10kg Farm Yard Manure + 5kg neem oilseed cake in powdered form for as spot treatment.

Indigenous mass production on starch rich grains

For the indigenous mass production of fungal bio-agents, overnight soaking of starch rich grains (sorghum) in water was followed by draining out and filling about 100-150gm of the same soaked grains in autoclavable polypropylene bags. The bags was sealed with thread followed by sterilization in pressure cooker on LPG burner for about 4-5 whistles. On cooling, around 10-15 pre-mycelium collected from lab consortium was introduced in fresh packets containing grains by transferring near flame of the lamp followed by prompt sealing. Inoculated poly bags was incubated for 10-12 days at ambient

Fig. 1 : Patches of vegetable crop showing symptoms of hotspots.

Fig. 2 : Disease complex symptoms showing root knot nematodes, wilt and rot.
temperature till profuse growth following which they will be ready to apply in the fields (fig. 4).

Field (2×2 sq.m) trial was carried out by Randomized Block Design (RBD).

The observations in respect of plant growth parameters, disease incidences and quality in respect to pollution as well as yield of the produces were systematically recorded all through the investigation period. Simultaneously, the interactive session with the concerned growers was maintained and their response was taken into account.

Soil samples and trap plants were collected and tested for evaluating content of heavy metal using Atomic Absorption Spectrophotometer (AAS). Soil sample was also tested for evaluating nematode load per gram soil. Collected plants were rinsed thoroughly in water before kept for drying in blotting sheets. Both plant and soil samples were dried in the oven at 60°C for three days. Dried soil was sieved through 0.2 mm size sieves prior to processing for digestion. Before digestion to analyze heavy metals, each sample was dried at 60°C for 48 h. The process of digestion was carried out in closed system. 2 g of plant and 0.5 g of soil was weighed for digestion. The samples were treated with concentrated HNO₃ and HCl (6:1, v/v) (Mohammed et al., 2012). Samples were heated up at 300°C for 45 min by microwave to digest samples and evaporate solvent followed by cooling at room temperature (24 ± 2°C). The final volume was made up to 25 ml by diluting the digested samples with Milli-Q water. Samples were filtered through Whatman No. 42 filter paper (GE Healthcare Life Science). These solutions were then used for metal analysis.

**Results and Discussion**

The treatments did not show any negative effects on plant growth. There were significant differences in the height and yield of Tomato and Brinjal plants treated with IIPPM package (fig. 5). Pb and Ni were found to be significant in the selected hot spots (table 2). *B. juncea* was found to be maximum accumulator of heavy metal viz. Pb and Ni (table 3) among the three species.

### Table 2: Heavy metal content of hot spot soil before and after treatment (IIPPM package and phyto-remediation by three species of Brassica) analysed by AAS.

<table>
<thead>
<tr>
<th>Metals</th>
<th>Initial conc. of metals in soil before treatment (mg/kg)</th>
<th>Final conc. of metals in soil after treatment (mg/kg)</th>
<th>Decline in metal content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>789.22 ± 6.11</td>
<td>230.12 ± 2.8</td>
<td>70.84%</td>
</tr>
<tr>
<td>Ni</td>
<td>588.01 ± 4.8</td>
<td>95.09 ± 2.4</td>
<td>83.84%</td>
</tr>
</tbody>
</table>

### Table 3: Heavy metal content in the harvested *B. juncea* before and after the treatment (Analysed by AAS).

<table>
<thead>
<tr>
<th>Metals</th>
<th>Metal conc. in (mg/kg) in <em>B. juncea</em> harvested from green house</th>
<th>Metal conc. in (mg/kg) in <em>B. juncea</em> harvested after phyto-remediation treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>Nil</td>
<td>230.12 ± 2.8</td>
</tr>
<tr>
<td>Ni</td>
<td>Nil</td>
<td>95.09 ± 2.4</td>
</tr>
</tbody>
</table>

### Table 4: Heavy metal content in the harvested *B. rapa* before and after the treatment (Analysed by AAS).

<table>
<thead>
<tr>
<th>Metals</th>
<th>Metal conc. in (mg/kg) in <em>B. rapa</em> harvested from green house</th>
<th>Metal conc. in (mg/kg) in <em>B. rapa</em> harvested after phyto-remediation treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>Nil</td>
<td>190.12 ± 2.8</td>
</tr>
<tr>
<td>Ni</td>
<td>Nil</td>
<td>78.09 ± 2.4</td>
</tr>
</tbody>
</table>

### Table 5: Heavy metal content in the harvested *B. napus* before and after the treatment (Analysed by AAS).

<table>
<thead>
<tr>
<th>Metals</th>
<th>Metal conc. in (mg/kg) in <em>B. napus</em> harvested from green house</th>
<th>Metal conc. in (mg/kg) in <em>B. napus</em> harvested after phyto-remediation treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>Nil</td>
<td>165.12 ± 3.8</td>
</tr>
<tr>
<td>Ni</td>
<td>Nil</td>
<td>65.09 ± 3.5</td>
</tr>
</tbody>
</table>
Decline in metal content was found after the treatment. Pb was found to be 70.84% lower and Ni was found to be 83.84% lower in the soil after the treatment. The treatment proved to be successful as it decreases fungal disease occurrence confirmed by substantial reduction of the spore count in the rhizosphere soil and the nematode level to less than 2 larvae/gram soil (ETL).

From the present study, it is amply clear that IIPPM package along with three trap species of *Brassica* reduces the soil borne hidden maladies and thus improvement in plant height and yield were observed. The package along with the trap plants efficiently up took Pb and Ni from polluted soil at Yamuna belt and so it act as good hyper-accumulator. Although, polluted Yamuna is the main source of contaminated vegetables in Delhi, nothing could be done to safe the vegetables of Yamuna belt as yet. The treatment proved to be highly successful as it decreases the nematode level to less than 2 larvae/gram soil (ETL) and soil borne pathogens and simultaneously reducing the heavy metal of soil to significant level. *Brassica juncea* having proven be the most effective among three species under investigation and is recommended for crop rotation with other vegetables.

References


