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A review on the effect of herbicides on the earthworms

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Abstract
The herbicides, used to fight against the weeds in the agriculture are very toxic to soil biota. To some extent, these herbicides are unrestrainedly used by farmers without considering the long or short term effects in soil medium. It is evident that most of these herbicides may cause the reduction of sensitive populations of certain groups of biota in soil medium. It is believe that in cases where these herbicides are used to treat soils, they are considered harmful to nematode, earthworms and other biological organisms. Studies on this aspect are important because earthworms are the common prey of many terrestrial vertebrate species such as birds and small mammals, and thus they play a key role in the biomagnifications process of several soil pollutants. It is now emphasized that, whereas higher concentrations of a pollutant can easily be assessed with the acute (mortality) test, contaminated soils with lower pollutant concentrations require more sensitive test methods such as reproduction test in their risk assessment. The aim of this paper was to provide a synopsis review of the effects of some herbicides to soil biological community.

Keywords: herbicides, acute test, contaminated soil and pollutant concentartion

Introduction
Earthworm play a valuable role in organizing and enhancing the supplements of soil, serve as a greater percentage (>80%) of biomass of terrestrial invertebrates. Hence, earthworm can be provide an early warning of degradation in soil quality as they act as an applicable bioindicators of chemical contamination of the soil in terrestrial ecosystem[1-3]. Earthworm show many sensitive reactions towards environmental influences and they also act as decomposers, due to this they generally used as test organisms. Earthworms are ecologically very important as many substances are responsible for the risk of secondary poisoning through feeding on worms. It can be possible that worms themselves suffered from much adverse effect [4-5].

The excessive use of herbicides or pesticides is responsible for the degradation of agro ecosystem sustainability [6]. Weeds and pests are responsible for degradation in agricultural crops [7]. To minimize weeds problems in crop production, the herbicide application should be on a regular practice [8].Various studies have showed that the qualitative and quantitative change in enzyme activity occurs due to the use of herbicides. The interactions between the herbicides and soil biota have practical significance by the reason of possible inhibition in microbial action increasing to soil fertility [9-12]. The fate of herbicides in soil is responsible for the distressed of earthworm. For the estimation of lethal and sub lethal consequences of chemical contaminated pollutant earthworm have been used. Hence earthworms are helpful to determine the contaminant fractions which may operate on all creatures assimilating in touch with soil [5]. Earthworms play a role in constitution and eradication of the soil fragments along with the organic matter transfer. Therefore they can affect the soil properties (pH, organic matter, nitrogen, granulometry, etc.). When the ingested soil passes through the gut of earthworm, it (soil) undergoes some chemical and microbial changes [13]. The main concept is that, these herbicides can affect soil and soil creatures through both direct and indirect way. Herbicides can direct affect the soil organisms or indirectly they can expose their effect on supporting plant communities. Generally herbicides had significant effect on earthworms and other soil organisms. Butachlor has been revealed to be greater toxicity on earthworms. On the other hand, herbicides can also alter the enzyme activities. In a laboratory study, Glyphosate was exposed to inhibit the phosphatase activity by up to 98% [14]. Besides, glyphosate and atrazine both are responsible for the stimulation of urease activity. Therefore, this study reviews in brief; the effect of herbicides on growth and reproduction of earthworms.

Herbicides and soil biota
Microorganisms (like bacteria and fungi) and soil fauna (like microscopic and macroscopic animals) are considered in a term that is called soil biota [15]. Soil biota play an important role in various biogeochemical cycles and litter decay which consequently alters soil productivity and plant growth [16-19]. Hence, the entire soil system can be affected by the use of these organophosphate herbicides [20]. The growth of unwanted plants and vegetation is suppressed by the use of these organophosphate herbicides which are the major groups of pesticides [21-22]. The debris of these pesticides is the reason for ecological destruction as they cause some side effects to the ecological habitat and the productivity; simultaneously destruct the soil biota as the non-target agent [23-28]. The performance of the essential soil functions along with soil character and soil productivity developments can be decreased by these effects [29-30].

Herbicides and behavior of earthworm

Soil community structure and functions can be affected by herbicides in two ways:-1.) Effect of herbicides on soil creatures and 2.) Through effect on supporting plant communities [31]. Growth, breeding and fitness of earthworm being increasingly scared by the heavy use of herbicides to soil. (Table 1) [32]. Earthworm precisely changes the persistence of pesticides through carrying herbicides to bottom and proliferating the soil bound portions in soil; or through consuming herbicide debris in their tissues [33-34].

Table 1: Summary of Effect of Herbicides on Earthworms

Herbicides	Parameter (s) affected	References
Butachlor	<Cocoon production	Muthukaruppan *et al*. 2005
Paraquate	>nuclear swelling(2fold)	Fisher and Molnár 1992
Glyposate	<chromatin,loss of epithelium cell structure, lacking regeneration of the cells	Morowati 2000
1-methyl-3-octylimidazolium bromide	> Catalase activity > glutathione content < malondialdehyde levels > superoxide dismutase activity	Li *et al*.2010
1-methyl-3-octylimidazolium bromide	> Oxidative stress	Lio *et al*. 1989
Acetochlor	Glutathione-S-transferase activity	Xiao *et al*. 2006
Mecoprop and dicamba	< Biomass	Parfitta 2010
Acetochlor	> Growth rates, >numbers of juveniles per cocoon	Xiao *et al*.2006
Isoproturon	> Total soluble protein	Mosleh *et al*. 2003
Butachlor	< Cocoon production, < clitellum development	Gobi and Gunasekaran 2010
Paraquate	Nuclear swelling	Fischer and Molnar 1992

Value denotes (>) Increase; (<) decrease

When the sub lethal level of atrazine is exposed to *Eisenia fetida*, the growth and cocoon production were exceedingly decreased [35]. Earthworm activity is drastically decreased when the agrochemical concentration increase in soil surface [36-37]. Chemoreceptors are distributed on the whole body surface of earthworms so earthworms are sensitive towards the presence of chemicals in soil [38]. The feeding activities of earthworms affected by herbicides which was reveal in the weight loss and the reproductive capability[39-40], decrease cocoon production, owing to decrease of coelomic epithelium and gametes[41]. The biomass of *Aporrectodea caligenosa* was noticeably lesser when treated with herbicide Mecoprop and Dicamba [42].

Effect on growth

A number of researches have been carried out on the standard worm *Eisenia fetida/andrei*. The weight of the earthworms was a more susceptible index when evaluated with mortality in signifying toxic effects of acetochlor and methamidophos [43]. When Malathion and Parathion were tested on the same earthworm species, both observed reduction in the body weight of treated worms [44, 3]. Various analyzers has been reported the negative impact of pesticides on earthworm growth. The toxicity of acetochlor on earthworm, growth may be a sensitive parameter [45].The effect of copper oxychloride has been tested in laboratory and examined the shock of carbendazim, glyphosate and dimethoate on *Eisenia fetida* and found a cogent degradation in the earthworm growth in a prescribed amount manner [46, 47]. Parathion has an effect on growth of *Eisenia andrei* [48]. The effect of two organophosphates, chlorpyrifos and diazinon and the toxicity of aldicarb, cypermethrin, profenofos, chlorfluazuron, atrazine and metalaxyl in the earthworm *Aporrectodea caliginosa* examined and they observed a reduction in growth rate in all pesticide treated worms [49, 50]. The effect of endosulfan and aldicarb on *Lumbricus terrestris* studied [53] and advised growth rate as essential biomarkers for contamination by endosulfan and aldicarb [51-52]. It was found that chlorpyrifos had negative effect on growth in earthworm when exposed to 5mg/kg chlorpyrifos after eight weeks. Some investigations have demonstrated that growth of earthworms looked to be more critically distressed at juvenile stage as compared to adult stage [54-55].

Effect on reproduction

The exposure time of herbicide to earthworm is also responsible for the mortality of earthworm. According to it, if the exposure time for any given concentration of acetochlor has been increased, the mortality of earthworm also increased. It was described that if the concentration of acetochlor increased up to 6 day exposure was 296 kg/mg than there were no death of the tested earthworm took place [56]. The rate of weight change of earthworm was very susceptible as compare to the rate of mortality change towards the toxic effect of acetochlor. The LC50 value for chlorpyrifos was slightly higher than atrazine and cyanozine [57]. The cocoon production was decreased with an increasing in the herbicide concentration likewise a reduction in the mean biomass of earthworm reported with enhancing the concentration of herbicide [58]. The application of butachlor to *Eisenia fetida* resulted in the reduction of growth, cocoon production and clitellum development [59]. The application of glyphosate to *Eisenia fetida* showed a destructive effect on the viability of cocoons and biodiversity of earthworm population [60]. A cogent reduction in the incubation rate of cocoons (17% to 43% for *Lumbricus terrestris* and 32% to 71% for *Aporrectodea caliginosa*) after the appliance of glyphosate has been observed [61]. The effect of application to commercial parathion on the reproductive parameters like sperm and cocoon production and genotoxicity on male germ cells of *Eisenia fetida* have been done and found that variation in reproductive parameters were noticeable with reference to the number of sperm, cocoon and worms born [3]. The cocoon production in *Aporrectodea trapezoids* was constrained with

endosulfan and fenamiphos at normal application rates and methiocarb at 10 times normal rate [62]. On the application of organophosphate insecticide melathion to *Eisenia fetida*, *Espinoza-Navarro and Bustos-Obregon*.2005, noticed that melathion decreased the spermatic viability in spermatheca, changing the cell propagation and modifying the DNA structure of spermatogonia [63]. The Acetochlor showed sub lethal toxicity to *Eisenia fetida* at a higher (20-80mg/kg) concentration [64]. The cypermethrin affect the reproduction of earthworm more severely at juvenile stage than at adult stage. At a dose of 20mg/kg cypermethrin induced a serious toxic effect in reproduction of worms [65].

Enzymes as biomarkers in earthworms

The efficiency of biomarkers in earthworms is constantly suitable for the estimation of impact of pesticides in soil organisms. Enzymes play a vital role in the neurocholinergic transportation and in cell stability hindering the toxic effect of chemicals; hence various classes of enzymes are known as biomarkers [66-68]. The protein profile, cellular enzyme system as well as the testicular histomorphology of *Eisenia kinneari* had been toxically affected by the use of dimethoate which is an organophosphate pesticide [52, 69, 70]. Acetylcholinesterase is an important enzyme which plays an important role in the transportation mechanism of nervous system. Acetylcholine hydrolyzed into choline and acetate, responsible for the neurotransmission that occurs at cholinergic synapses [71]. Generally the activity of AChE suppressed by two pesticides that are organophosphorus and carbamate. Mainly, organophosphorus hindered the activity of acetyl cholinesterase through covalently phosphorylating the serine debris inward the active site group [72]. A cytosolic enzyme, glutathione-s-transferase (GST), acts in the detoxification and biotransformation in matter of electrophilic compounds by destruction of glutathione. The disclosure of pesticides may accelerate to the variations in the enzymatic activities that follow the metabolic interruptions and cell destruction in the specific tissues [73, 74]. GST can be used as biomarkers for observing pollution because the increased level of GST may result into sophisticated protection in contrast to harmful effects of pesticides [75]. The formation of glutathione acetanilide conjugates helps in the detoxification of many widely used herbicides like alachlor, metolachlor, propachlor or fenoxaprop from biological systems [76]. The current information reveals that the microflora lodging in the gut of the earthworm. Many enzymes are present in the gut of earthworms like cellulase, endoglucanase, amylase, pectinase, acid phosphatase, alkaline phosphatase and nitrate reductase. All these enzymes can diminish the complex organic compounds (cellulose, pectin etc.) into their simpler forms. When earthworms bring to contact with deltamethrin it decrease the cellulase activity of earthworm, while lindane increase the activity of cellulase enzyme inside earthworm. Hence, the exposure of deltamethrin to worms is harmful while lindane shows the beneficial effects on worms [77].

Conclusions

It is concluded by this review that the use of herbicides can affect the biological parameters of earthworms. The present article explains that there is a precise impact on biomass and cocoon production after the application of herbicides at different concentrations. The extensive use of herbicides has progressively turned into a matter of environmental concern modifying the soil productivity status and the population of biota. Herbicides almost show high toxicity against earthworms, despite some exceptions. The review highlighted that some herbicides are harmful and are highly toxic to earthworms.

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