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Adverse Impacts of Commonly Used Herbicides on Different Plants

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ABSTRACT

Herbicides are the chemicals used to control weeds in crop plants. Low concentration of herbicide helps to increase the growth of plant whereas high concentration affects the growth of plant as it destroys microbes present in the soil and affects different photosystems and ultimately photosynthesis

INTRODUCTION

Herbicides are the group of chemicals which promotes the growth of the plants [1]. Herbicides are used to destroy weeds. Weeds are the unwanted plants species that grows along with the desired crop [2]. These chemicals at low concentration stimulate the growth of the plant and this phenomenon was called hormesis by Southam and Erlich in 1943 [2] [3]. This phenomenon was earlier called Arndt and Schulz law. [3]. Higher concentration of these chemicals proves to be toxic or lethal for the plant [3]. The commonly used herbicides are the glyphosate, metribuzin, fluchloralin, Sulfonylurea, 2,4-Dichlorophenoxy acetic acid, Isoproturon [4]. Herbicides are also used for controlling weeds in leguminous plants [5]. Herbicides have great effect on nodulation and nitrogen fixation in legumes. The *Rhizobium* bacteria play an important function in growth of plants and protect the crop from pathogens and stress. These bacteria can become

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metabolically inactive by more spray of herbicide. The toxic effect of various herbicides is reported. The effect of toxicity depends upon the concentration and type of herbicide. However, reports of herbicidal effect on pea and its symbiont show a significant reduction in rhizobial growth. The growth of plant depends upon the nodule formation which is favoured by *Rhizobia* present in the soil. All these processes get adversely affected by excess herbicide application.

METRIBUZIN

Metribuzin (4-amino-6-tert-butyl-4,5-dihydro-3 methythio-1,2,4-triazine-5-one) belongs to triazine family of herbicides. It can be used as post emergence as well as pre emergence herbicide. Pre-emergence herbicide can applied immediately after sowing of seeds whereas post-emergence herbicide is applied after germination of seeds. Metribuzin directly affects the photosynthesis by inhibiting PSII. Herbicide binds to the proteins that inhibit the transfer of electrons in Hills reaction of PSII [6]. It can be degraded with the help of micro organisms.

ISOPROTURON –

Isoproturon (3-(4-isopropyl phenyl)-1,1-dimethylurea). Isoproturon can be used to control broad leaf weed species. It can also be used as both pre-emergence and post- emergence herbicide and it also inhibits photosystem II. It is non-biodegradeable which contaminates water and soil, often found in groundwater [7].

Some commonly used herbicide

S.NO	COMMON NAME	CHEMICAL NAME	AFFECTED SYSTEM	USE	REFERENCE
1.	Glyphosate	(N-phosphonomethyl glycine)	Inhibits synthesis of amino acids by inhibiting shikimic acid pathway	Post-emergence	[8][9]
2.	Metribuzin	(4-amino-6-tert-	Inhibit	Pre-emergence	[10]

		butyl-4,5-dihydro-3 methythio-1,2,4-triazine-5-one).	photosystem II	Post-emergence	
3.	Isoproturon	(3-(4-isopropyl phenyl)-1,1-dimethylurea.	Inhibits photosystem II	Pre-emergence Post-emergence	[11]
4.	Sulfonylurea		Inhibits amino acid synthesis	Post- emergence	[12]

EFFECT OF HERBICIDES ON SOIL MICROBES AND NITROGEN FIXATION

Nitrogen fixation is a process of conversion of atmospheric nitrogen into ammonia. Conversion of dinitrogen into ammonia is carried out by some prokaryotic species eg- Rhizobia and it is an oxygen sensitive process. Root nodules of legumes (*Pisum sativum*) forms a symbiotic association with Rhizobia. Low concentration of herbicides for a desired period of time especially during the early stages of growth when nodulation is restricted by some environmental factors proves to be beneficial for the plant. [13]

Herbicides are widely used which not only affect the growth of the plant but also to the associated microbes. Microbes degrade herbicides and also act as bioindicators of soil. [14]. Many species such as *Azotobacter* can be used as bioherbicides. Bioherbicides are the living species which can be used as herbicides or which can be used for controlling weeds. *Azotobacter* can decreased in number significantly after 7-14 days of herbicidal application. Young plants require adequate amount of Nitrogen supply for proper vegetative and reproductive growth [15]. The excessive application of herbicide can destroy the *Azotobacter* species, due to which nitrogen content in the soil also decreases and plant growth is affected.

A brief tabulated report of impact of various herbicides on different plants

S.No	EXPERIMENT	EXPLANT	METHOD	RESULT	REFERENCES
1.	Differential varietal	Pea	Metribuzin was mixed with	Application of herbicide	[16]

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	response of green pea *(Pisum sativum)* to Metribuzin.	plant	soil before sowing of seeds and then fertilized with K, N and P. In second experiment plants were grown under greenhouse conditions.	Metribuzin significantly decreases the growth of plant.	
2.	Physiological responses of Soybean (Glycine max) to Metribuzin	Plants	Seeds were grown and the seedlings were treated with Hoagland's solution. After 7 days plants were treated with Metribuzin. Metribuzin treatment is given through roots.	Plants treated with more concentration of Metribuzin shows sharp decrease in photosynthesis and chlorophyll.	[17]
3.	Dry matter production of green pea influenced by herbicide.	Plants	Plants were treated with five different pre-emergent herbicides with different mode of action, immediately after sowing the seeds.	Pivot herbicide helps to increases the plant growth whereas Metribuzin will decreases the plant gowth more rapidly as compared to other herbicicdes.	[18]
4.	Effect of Metribuzin and Trifluralin on Faba bean development, growth and symbiotic nitrogen fixation.	Plants	Trifluralin and Metribuzin are applied to plants. Both treatments are given individually and in combination with fertilizer or rhizobia and with both fertilizer and rhizobia.	Plants only treated with Metribuzin show greater reduction in the Nitrogen fixation, growth and development.	[10]
5.	Effect of herbicide on the growth, nodulation, symbiotic nitrogen fixation and yield	Plant	Pre-emergence and post-emergence herbicides are used. Treatment of pre-emergence is given immediately after sowing	Pre-emergence herbicide decreases the growth parameters. As the concentration of herbicide increases its negative affect	[19]

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	of *Pisum sativum*.		whereas treatment of post-emergence herbicide is given 25 days after sowing and then the dose of herbicides is doubled of the recommended rate. The rate of photosynthesis, nitrogen content and nitrogenase activity is measured.	on plant also increases.	
6.	Plant growth stimulated by herbicide.	Plant	Two plants were taken. One plant is inoculated in media and in media itself herbicide was added and on other, plant was sprayed with herbicide of different doses. After that detection of growth and dry weight was evaluated.	Herbicide like gylphosate, sulfonylurea, or some herbicide can stimulate plant growth when applied in low concentration. All herbicides can't promote the growth of plant.	[3]
7.	Effect of 2, 4-Dichlorophenoxy acetic acid on the oxidative metabolism and growth on pea.	Plant	Seeds were grown and when seedlings are 10 days old, the treatment of 2, 4-D is given at different concentrations. The analysis of antioxidant enzyme activity, growth parameters, proline and protein were done.	Higher concentration of 2, 4- D affect the growth of plant by affecting ROS metabolism. It decreases the chlorophyll content whereas antioxidant activity is increased.	[20]
8.	Growth stimuted by low doses of glyphosate	Plant	10 days after sowing when plant is at two leaf stage glyphosate is sprayed at different concentrations. After one week plants were	There is increase in dry weight when treated with low dose of glyphosate	[3]

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			harvested and analysis of leaf area and dry weight was done.		
9.	Low dose application of glyphosate can stimulate plant growth	Plant	Application of Glyphosate is given by using microsyringes or by sprayer to both glyphosate resistance seeds and non resistance seeds. Concentration ranging from 0 to 2880g AE $ha^{-1.}$ The analysis of dry weight is done.	There is no significant change in the plants of glyphosate resistance seeds whereas plants non-resistance seeds show that growth increases at low doses.	[21]
10.	Role of Shikimate accumulation and Glyphosate mode of action in nodular metabolism	Plants	When plants were 5 weeks old foliar spray of glyphosate is given at concentration ranging from 0 to 10Mm. Analysis of nitrogenase, starch and protein content was done after 1,2,3,4,5 and 7 days of herbicide spray.	Each herbicide treatment decreases nitrogenase activity even at lowest dose due to inhibition of shikimate pathway.	[22]
11.	Effect of herbicide on the microbiological properties of soil.	Plants	Different concentrations of atrazine, alachlor and dimethenamide were applied to plants and microbes present in soil are tested after herbicide application.	Herbicides are degraded by microbes present in the soil and can be used as bioindicators. *Azotobacter* is found to be more sensitive to herbicide.	[14]
12.	Glyphosate inhibits the site of Shikimate pathway		Cells of *B.mollugo* can culture on B5 medium and herbicide glyphosate is added in the medium itself as glyphosate is heat labaile. Autoclaved medium is used for the	Glyphosate is strong inhibitor of Shikimate acid pathway which later synthesis amino acids.	[23]

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			inoculation of cells under sterile conditions. Analysis of exogenous Shikimate content, anthraquinone content is done		
13.	Glyphosate reduced seeds and leaf concentrations of calcium, manganese, magnesium and iron in non-glyphosate resistant seeds.	plants	13 days after the sowing of seeds the plants were treated with glyphosate. Both young and old leaves were harvest after 21 days of herbicide application for analysis of mineral nutrient concentration and dry weight. Analysis was done by inductively coupled plasma optical emission spectrometry.	Application of glyphosate adversely decreases the dry weight in young leaves. Amount of mineral nutrient concentration was not much affected but the concentration of P and Cu is increased by application glyphosate.	[24]
14.	Glyphosate reduced seeds and leaf concentrations of calcium, manganese, magnesium and iron in non-glyphosate resistant seeds.	Plants	The plants were allowed to grow till maturity. Glyphosate at different concentration was applied to plants at different stages of growth and along with glyphosate treatment appropriate amount of N, P and K fertilizer is given to plants at early stages of growth. Analysis of mineral nutrient concentration was done by inductively coupled plasma optical emission spectrometry.	Higher concentration of glyphosate reduced the dry weight by chlorosis in leaves and seed yield. In seeds, the amount of N, Zn, Cu, K, increase with application of glyphosate in comparison with control and decreases as glyphosate conc increases.	[24]
15.	Application of	Plants	Seeds were surface sterilized	Metribuzin application	[25]

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	post-emergence herbicide induced strees in Wheat.		before sowing and 35 days after sowing plants were divided into groups one as a control and other with foliar spray of Metribuzin. After 7 days analysis of samples were done. Analysis of water soluble carbohydrates was done by using phenol-sulfuric acid method and protein by Bradford method.	reduces the shoot length. It is having no effect on glutathione reductase and oxidative stress is get induced.	
16.	Nitrogen fixation, nodulation and growth of Chickpea is affected by herbicide application.	Plants	Seeds were grown in polythene bags before inoculation with rhizobial strain. Herbicide fluchloralin was applied before sowing to soil whereas Metribuzin and pendimethalin were applied to soil after sowing. Analysis was done at 30, 45, 60 and 75 days after sowing.	All the three herbicide used reduced the growth in some cases. Nitrogen fixation is increased. Nodulation is not affected.	[26]
17.	Isoproturon treatment in maize caused alterations in antioxidants and kinetics of glutathione-S-transferase.	Plants	Seeds were sown and when seedlings are of 10 days, it gets divided into two parts one served as control and other with herbicide treatment. Isoproturon treatment is given by foliar spray at different concentrations. Analysis was	Isoproturon reduced the dry weight, chlorophyll and carotenoid and GST activity.	[27]

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			done after 0, 2, 4, 8, 12, 16 days after herbicide application.		
18.	Effect of Glyphosate on metabolism of aromatic amino acid in *Cyperus rotundus.*	tubers	Tubers were allowed to grow and when 5 to 9 leaves came foliar spray of 14.4mM Glyphosate is given to leaves and analysis was done at 0, 3, 5, 7, 9, 12 days after treatment.	There is rapid accumulation of shikimic acid in Cyperus rotundus which is toxic to plants	[28]

CONCLUSION

This review highlights that herbicide proves to be toxic for plants as well as for soil. Low concentration of herbicide stimulated the growth of plants but at higher concentration it is toxic. Metribuzin and Isoproturon both inhibited the PSII of photosynthesis and also contaminate the soil. Isoproturon is non-biodegradeable and also found in contaminated ground water. However, Metribuzin shows higher phytotoxicity than Isoproturon in plants. So, use of herbicides should be reduced and use of bio-fertilizers and manures should be done to enhance the fertility of soil and weeds should be removed by hand.

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