The Pharma Innovation Journal 2022; SP-11(4): 1774-1777

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(4): 1774-1777

www.thepharmajournal.com
Received: 04-02-2022
Accepted: 06-03-2022

Aditya Prakash
B.Sc (Hons), Under Graduate Student, Department of Agriculture, SHUATS, Prayagraj, Uttar Pradesh, India

Rashmi Kumari
M.Sc., Graduate Research Assistant, Department of Horticulture, Oklahoma State University, Oklahoma, United State of America

Pranav Raj
B.Sc (Hons), Under Graduate Student, Department of Agriculture, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author
Aditya Prakash
B.Sc (Hons), Under Graduate Student, Department of Agriculture, SHUATS, Prayagraj, Uttar Pradesh, India

Challenges in weed management in India

Aditya Prakash, Rashmi Kumari and Pranav Raj

DOI: https://doi.org/10.22271/tpi.2022.v11.i4Sw.12233

Abstract
The widespread use of various herbicides in India has made weed control a difficult task. The weed spectrum is increasing each year. The increased use of herbicides has led to increased exposure of users to this class of compounds and the associated hazards. This also poses a great challenge to researchers and practitioners to develop new herbicides and to make them available to farmers. The use of crop rotation in weed management, along with effective, timely and judicious use of herbicides and other agro-inputs should be practised. The current study evaluates the current herbicides used in India and impact of these herbicides on soil biome and plant health.

Keywords: Glyphosate, weed control, weed management, India

Introduction
The global population is expected to double by the year 2100, while the resources available to produce food will remain constant. According to studies, 70% of the world's food production comes from the top 30 countries, with India, Brazil and China as the major producers (FAO, 2012). To keep pace with the growing world population, the demand for food is also expected to rise. It should, however, be noted that demand is not limited to the food demand alone. In a recent study, it was estimated that in 2013 the world's energy demand would increase by 35% and the global population would be about 7.3 billion people.
The need for sustainable food production to supply the global population while conserving limited natural resources cannot be overemphasised. The use of agro-inputs is expected to play a significant role in this challenge, as crop yields increase with the adoption of agro-inputs. The world of agriculture is evolving to find solutions to a changing environment. While much work has been done to explore and design better crop varieties, it is now important to develop and implement management practices that are efficient in the use of land and agro-inputs. The challenge is to combine and use the best existing technologies to reduce the application of inputs (e.g. pesticides, fertilisers, hybrid seeds) with better management of crops and weeds (Kim, K. H., *et al.*, 2017) [1].
Herbicides are used extensively in modern agriculture, where they are applied to protect crops from weed infestation. The extensive use of herbicides has not only reduced the weed populations but also given control over the weeds that would have otherwise proliferated. Despite the benefits, however, the indiscriminate use of herbicides has also brought with it several hazardous consequences including resistance to the herbicide, toxicity to humans and other animals and contamination of surface and groundwater. This has led to serious concern worldwide over herbicide-induced environmental problems. As far as India is concerned, the use of herbicides has always been restricted to a few crops for pest control. Despite this, the use of herbicides has increased by more than 20% in the last five years (Joseph & Raj, 2011) [2].

Glyphosate use in India
Glyphosate, is the most popular herbicide in the world. It is the only active ingredient in the most popular herbicide used in India, the Roundup Ready® weed killer. It was developed in the U.S. by Monsanto and is now manufactured and marketed by Monsanto India (formerly Zeneca India Limited), a joint venture company of India's largest pesticide manufacturing group, Bharat Organics Limited.
Glyphosate is highly toxic to plants. It depletes the amino acids in plants which leads to damage to the cell membrane and eventually cell death. Glyphosate is a broad-spectrum herbicide. It is toxic to a large variety of weed species. It can be used effectively for selective control of noxious weeds at all growth stages.

Various mechanisms for resistance to glyphosate have been studied at the molecular level. Many weed species have evolved tolerance to glyphosate and its nonselective mode of action. Most notably in soybeans and cotton, the dominant crops in India, weeds have evolved mechanisms to become highly resistant to glyphosate.

Glyphosate has been registered for use in India under the label Monsanto® Roundup®, following evaluation by the Environment and Standards Authority (ESA) of India. It is applied using the following sprayers: conventional sprayers for use in a garden centre/greenhouse, airblast sprayers for use in parks, playgrounds, nurseries and garden centres, and broadcast sprayers for use in roads, highways and agricultural lands. The herbicide is available in three formulations-RoundUp Original® 250×, RoundUp Original® 350×, and RoundUp Original® 450×. The use of glyphosate in Indian agriculture has increased from 5,000 tons in 1997 to more than 9,000 tons in 2005 (Borggaard, O. K., & Gimsing, A. L., 2008) [3]. As compared to other herbicides, its use is relatively high in Indian agriculture. However, studies show that it was responsible for only 0.6% of all crop injuries and that it is used for only 25% of the crop injuries caused by herbicides.

Herbicides are the leading cause of crop loss. Over 40% of the crop loss can be directly attributed to the use of these agrochemicals (Mueller, 2005) [4]. Glyphosate was introduced in the Indian market in 1995 and is the world's most widely used herbicide. The herbicide is used in the treatment of more than 30 crops and weeds throughout the world. The widespread and unregulated use of glyphosate is the primary factor driving the development of glyphosate-resistant weeds. The current regulatory response to the widespread weed problems associated with glyphosate has been to increase the label use rates of glyphosate and to provide limited opportunities for the farmer to use post-emergent herbicides (Glyphosate.Misery in a Bottle!).

Degradation of glyphosate in water and soil

Glyphosate is degraded in soil, water and in the body, and is considered relatively non-toxic. In soil, it is quickly degraded to aminomethylphosphonic acid (AMPA) by both non-specific microbial metabolism, and by metabolism specifically initiated by the enzyme glyphosate-acyl hydrolase (GlyA). However, AMPA is not immediately available in the soil to plants, because it is very stable, and has low water solubility. When glyphosate-containing herbicides are applied to soil, AMPA is released in solution, and rapidly hydrolyzed in the soil to glyphosate, which then enters the food chain.

AMPA can be hydrolyzed to form either N-acetyl-AMPA (AMPA-N) or phosphonic acid (PA). AMPA-N is not available to plants in solution and it accumulates in the soil. PA is more readily available to plants than AMPA-N, so is less persistent, and it is more readily hydrolyzed in plants to glyphosate, and also than AMPA-N. Hence, when glyphosate-containing herbicides are applied to soil, the glyphosate present is rapidly hydrolyzed by soil microorganisms to form inorganic (N-acetyl) phosphonates, phosphonic acids, and ultimately, free phosphorous (as phosphoric acid).

AMPA-N is not only an intermediate in the biodegradation of glyphosate, but it also degrades glyphosate. In the environment, AMPA-N also rapidly degrades to inorganic phosphorous. These factors mean that AMPA-N in soil rapidly leaches from the soil matrix to the groundwater. AMPA-N is a major transformation product in the environment, and so is a major source of P pollution. Indeed, the soil phosphorus (P) recovery efficiency of glyphosate-based herbicides, when applied to soil in conventional doses, is often less than 50%.

In conventional herbicide use, phosphonates and phosphonate derivatives of glyphosate are formed in the soil, and this is a major source of P pollution. Soil phosphorus losses occur as ammonium phosphonate, phosphonic acid, and phosphate esters (organic and inorganic), but also as phosphate salt or ion. As phosphate salt, it is an immobile source of P and, where P is available in sufficient concentrations, will leach from the soil. Most conventional herbicides contain phosphate salts.

Ammonium phosphonate, phosphonic acid, and phosphate esters of glyphosate are more mobile than the corresponding salts of phosphorous in the soil environment. Because they have a net positive charge, phosphonates are attracted to the soil and can leach to the groundwater. Inorganic phosphate salts, including phosphate esters and phosphate ions, tend to be bound by the clay mineral surfaces in soil, and so are also immobile. Glyphosate-based herbicides contain high concentrations of inorganic phosphate salts.

Conventional herbicides that contain phosphate salts result in large amounts of P being present in surface water and groundwater, where they act as contaminants. Phosphate salts are immobile and can contaminate drinking water supplies.

This means that in conventional glyphosate use, leaching of P into water supplies is inevitable. Because glyphosate-based herbicides contain the phosphonate transformation product, AMPA-N, the soil P lost to leaching is different to that of conventional herbicides.

In terms of the potential risks to human and environmental health, the situation is clear. Although glyphosate is the active ingredient in conventional herbicides, the presence of phosphonate has been known to contaminate human and environmental water supplies in India.

Conventional herbicides such as glyphosate-based herbicides, because of their high phosphonate content, should also be considered toxic to groundwater supplies. It is therefore highly likely that exposure to phosphonate from glyphosate-based herbicides has also been documented in India

In the countries like the UK, however, there are no environmental water regulations covering glyphosate-based herbicides, and this is likely to be the case in many other countries. There are, therefore, reasons to consider glyphosate-based herbicides as highly toxic to human and environmental health, on the same basis as conventional herbicides. While no toxicological studies have been conducted on AMPA-N, in a similar way, conventional herbicides containing phosphonates, also have no testing on their toxicological impact, even though these conventional herbicides, because they are toxic, have been banned for many years.

Herbicide Resistance

Herbicide resistance is a complex phenotype, and it can arise via a range of different mechanisms. While resistance to herbicides from the same chemical class is usually the same, cross-resistance to herbicides in different chemical classes varies from case to case. The phenomenon of herbicide resistance in weeds has gained momentum, particularly with the introduction of new, more powerful herbicides with residual effects that give little chance to "come out of nowhere" to develop resistance.

Resistance to herbicides can occur because the weed has developed resistance to the active ingredient or because the herbicide is degrading slowly. The former may be due to the plant developing a specific enzyme that breaks down the active ingredient; the latter may be due to the plant lacking a metabolic enzyme needed to activate the herbicide.

Herbicide resistance has recently been seen in corn, sugar cane and alfalfa. Herbicide resistance, which can be detected by a test such as the agar diffusion test, is also possible in weeds when they are treated with a combination of chemicals.0With the herbicide in question, a test can be used to look for a 'superbug' in the mixture. Herbicide resistance in weeds can be monitored by measuring the herbicide concentration in samples of treated soil and weed.

Many of the commercial herbicides in India contain one or more glyphosate-type compounds or one or more of the herbicides known as 'glyphosate-based herbicides' (GBH) or herbicides based on the active ingredient 'glyphosate'. A significant number of commercial herbicides have been formulated with one or more GBH or other active ingredients. It is important to note that GBH may contain the active ingredients known as 'amides', or N-(phosphonomethyl) glycine, or simply 'glyphosate'

The use of herbicides for weed control in India is widespread. Weeds become resistant to herbicides if a gene, termed the 'gene to be eliminated', becomes present in the plant that encodes a protein ('enzyme') that is needed to activate the herbicide, or when an enzyme ('metabolic enzyme') that is needed to activate the herbicide is not present in the plant. If either of these conditions is met, the weed is resistant to the herbicide. This resistance, or the presence of an enzyme that can activate the herbicide but which is absent from the weed, can be determined by growing plants under controlled conditions. Such tests are typically conducted *in vitro*, i.e. in controlled experiments on the growth medium, under laboratory conditions, using test plants that have been grown under controlled conditions for several generations to ensure that the gene is present at a level of about 20-50% in the plants. This ensures that the plants are homozygous for the gene.

Herbicide resistance is also a concern because it often results in the need to use herbicides that are more toxic to crops or other non-target crops, such as soybeans. This may require using more agrochemicals overall. This situation is particularly noticeable with the newer herbicides that have led to the development of several resistance management strategies such as trying to identify and document resistance before it gets into the weed population, manage the herbicide resistance when identified, and finally, develop new weed control strategies that do not rely on herbicides to control weeds.

Reliance on Herbicide-Resistant Crops

There is an increase in the use of herbicide-resistant crops across the globe, especially in the United States and some developed countries. This has been seen to be because of the ease of use of herbicide-resistant crops over conventional crops. However, the use of herbicide-resistant crops has led to an increase in public concern about the health effects associated with it and its environmental impact. There is now a growing concern about the potential environmental impact of herbicide-resistant crops, as it is being seen to lead to the use of more herbicides in agriculture. The major herbicide-resistant crops include glyphosate-tolerant soybeans and herbicide-tolerant corn. Herbicide-tolerant crops reduce the need for herbicides but still have the potential to threaten other crops. The concerns surrounding the use of herbicide-resistant crops in India and its likely effect on India's economic growth.

The use of herbicide-resistant crops is becoming a major part of American agriculture. In the United States, it has been predicted that the use of herbicide-resistant crops will increase from about 30 million acres in 2004 to as much as 55 million acres in 2014 and that up to 10% of corn and soybeans may be grown on those acres.

Most the herbicide-resistant crops are developed by introducing a single herbicide-resistant gene into the crop plants using genetic engineering. Herbicide-tolerant crops use a dominant "T" gene (herbicide-tolerant gene) which is linked to the crop plant. This herbicide-tolerant gene is capable of "swallowing" herbicides that normally would kill the crop plants. However, these herbicide-tolerant crops still need to be sprayed with chemicals (called herbicides) such as glyphosate, glufosinate, glufosinate, and 2,4-D (2,4-dichlorophenoxyacetic acid), which have the potential to affect humans, animals, and the environment.

The development of herbicide-tolerant crops

There has been an increasing number of crop seeds released with resistance to herbicides. Such crops are usually developed by using traditional breeding and biotechnology. Many different types of herbicide-tolerant crops have been developed, including soybeans, maize and cotton, and there is a growing concern that these could eventually replace all traditional crops (Singh, 2012). In the United States, glyphosate-tolerant crops have become increasingly common in recent years. In particular, Monsanto developed herbicide-resistant cotton in 1996 and has been marketing it commercially since 2002 (Singh, 2012). However, there is a growing concern about the potential environmental impact of these crops and their long-term economic impacts.

Glyphosate is the main herbicide used in the production of herbicide-tolerant crops and is considered a highly effective herbicide because of its non-toxicity to other organisms. Although glyphosate kills most of the plants that are susceptible to it, some weeds still can detoxify it and survive (Herbicide Tolerant Crops, www.beyondpesticides.org). This has led to the development of herbicide-tolerant crops, which use a second herbicide that targets the weeds that can survive the first herbicide (Zhang, R., *et al.*, 2019) [7].

Several studies have been conducted to examine the effectiveness of different herbicide-tolerant crops in reducing pesticide usage in the United States. One study found that the use of herbicide-tolerant soybean was associated with a significant increase in total annual pesticide use. This was attributed to the increased use of herbicides used in the production of crops, and of herbicides used on the weed that escapes the glyphosate, as well as to increased herbicide usage in the control of weeds.

However, other studies suggest that the growth of herbicide-tolerant crops may result in significant reductions in pesticide usage in the areas where the crops are used (Fitt and Seralini, 2011). Glyphosate is one of the most widely used pesticides in the United States. One study estimated that the use of glyphosate in the United States increased from 1.3 million to 6.5 million pounds from 1997 to 2009, in addition to a 1.9 million pound increase in the total amount of pounds of insecticides applied to agriculture in that period (Hellerstein,

D., & Vilorio, D. 2019) [9].
It is important to note that other studies have used a different measure of herbicide use, suggesting that glyphosate use has significantly increased over the past several decades and that this has led to an increase in the amount of time that people spend working on their farm (Herbicide Tolerant Crops, www.beyondpesticides.org). While increased use of herbicides is one measure of agricultural pesticide use, increased use of pesticides has been linked to increased rates of cancer and other chronic diseases

A sustainable approach to controlling weeds
Weeding in India is often an afterthought due to a high cost and a lack of understanding of the control techniques. This results in a continuous and uncontrolled state of weeds. There are various problems associated with weeds and no efficient or sustainable means of weeding are currently practised in India. Weeds are a real problem and a constant menace. They are not only detrimental to agriculture and the farmers but also an obstacle to animal production, urban landscaping and infrastructure construction.
One of the reasons for India's rapid growth is attributed to its food, energy and infrastructure needs. India has a massive requirement for its growth, the total resources used by the country, its population and its per capita income are much greater than the major industrialised countries (Ministry of Health & Family Welfare, GOI 2007, p. 10). Hence, it is not surprising that the country is also facing an increasing ecological burden and, in response, the government has set up several departments and institutions for better management.
In the agriculture sector, weeds are an inevitable phenomenon and a cause of crop loss. In India, as in most of the world, weeding is done by mechanical means using hoes or hand picks. This practice is not only inefficient but also unsustainable. Besides that, weeds are a great obstacle to the farmers' agricultural practices. It not only impedes their success but also reduces the quantity and quality of their harvest. Hence the Indian government has set up the National Service Project on Weed Control (NSPWC) and National Green Technology Mission (NGT-MoEF/GAP-I). NSPWC (2012) helps the farmers with the proper use of weed control agents, seed and soil, etc. NGT-MoEF/GAP-I (2012) addresses the use of environment-friendly and sustainable practices for sustainable agriculture. The programmes under NGT-MoEF/GAP.

Conclusion
To sum up, herbicides have been playing a major role in weed management across the globe. As the farmers have used an array of herbicides like glyphosate, MCPA, alachlor, and 2, 4-D. The impact of herbicide use has been witnessed on various levels of the environment and agro-ecosystem. The use of these herbicides has resulted in many negative side effects. Moreover, the continuous use of these herbicides has put pressure on the soil and its functions. The use of herbicides has resulted in soil degradation. As such, the application of these herbicides has shown harmful impacts on the soil properties like nitrogen and phosphorus content, microbial population, pH, and biological activity. In addition, the soil's chemical and physical properties like soil structure, density, moisture content, aeration, and porosity have been observed to decline. Likewise, it has been observed that the use of these herbicides has caused heavy damage to the environment, resulting in a decrease in biodiversity, and an increase in the pest population in crops. Moreover, there has been an increase in crop damage due to the use of these herbicides. This damage further increases the dependency on the use of pesticides. The increased use of pesticides and the increase in the production of genetically engineered crops have led to higher production costs and higher environmental load.

References

1. Kim KH, Kabir E, Jahan SA. Exposure to pesticides and the associated human health effects. Science of the total environment. 2017;575:525-535.
2. Joseph B, Raj SJ. Impact of pesticide toxicity on selected biomarkers in fishes. International Journal of Zoological Research. 2011;7(2):212.
3. Borggaard OK, Gimsing AL. Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. Pest Management Science: formerly Pesticide Science. 2008;64(4):441-456.
4. Mueller TC, Mitchell PD, Young BG, Culpepper AS. Proactive versus reactive management of glyphosate-resistant or-tolerant weeds. Weed Technology. 2005;19(4):924-933.
5. Frantz SC, Says WC, Croft W, Says BD, Davenport B, Says CD Judy. Glyphosate. Misery in a Bottle!, 2015 Nov 24. Retrieved from https://www.laprogressive.com/glyphosate/
6. Tsaftaris A. The development of herbicide-tolerant transgenic crops. Field Crops Research. 1996;45(1-3):115-123.
7. Zhang R, Liu J, Chai Z, Chen S, Bai Y, Zong Y, *et al*. Generation of herbicide tolerance traits and a new selectable marker in wheat using base editing. Nature plants. 2019;5(5):480-485.
8. Herbicide Tolerant Crops. (n.d.). Retrieved from https://www.beyondpesticides.org/resources/genetic-engineering/herbicide-tolerance
9. Hellerstein D, Vilorio D. Agricultural resources and environmental indicators, 2019, 1476-2019-1679.
10. Chauhan BS. Grand challenges in weed management. Frontiers in Agronomy. 2020;1:3.
11. Gharde Y, Singh PK, Dubey RP, Gupta PK. Assessment of yield and economic losses in agriculture due to weeds in India. Crop Prot. 2018;107:12-18. DOI: 10.1016/j.cropro.2018.01.00
12. Singh V, Bagavathiannan M, Chauhan BS, Singh S. Evaluation of current policies on the use of unmanned aerial vehicles in Indian agriculture. Curr. Sci. 2019;117:25-29. DOI: 10.18520/cs/v117/i1/25-29.
13. Rao AN, Singh RG, Mahajan G, Wani SP. Weed research issues, challenges, and opportunities in India. Crop Protection. 2020;134:104451.