Paraquat factsheet and Integrated Pest Management

What is Paraquat?

Paraquat is a commonly used, but highly toxic, herbicide. Despite the herbicide's cost effectiveness and efficiency in controlling weed and grass growth, Paraquat poisoning poses a variety of human health hazards such as seizures, comas, and heart, kidney and liver failure if the chemical is ingested. [1] In addition to lung scarring and respiratory failure, other symptoms of poisoning include damage to the adrenal glands, central nervous system, muscles and spleen. [2] Poisoning normally occurs through ingestion or exposure to damaged skin. It is also corrosive to human skin.

The chemical normally comes in a liquid form that contains an active ingredient concentration of anywhere from 5 to 44 percent. [2] This is further diluted for herbicide spraying purposes. However, there have been fatal incidences involving accidental ingestion or contact with damaged skin when handling dilute spray solutions. [2] The usage of Paraquat is particularly dangerous in developing countries, where it is widely used, because sprayers are often subjected to unsafe working conditions such as a lack of protective gear, faulty equipment and inadequate medical facilities. [2] Ingesting more than a tablespoon of 20 percent concentrate can be fatal, especially since there is no antidote. [2]

Due to all these risks, its use is restricted in the USA and banned in many countries, including those in the European Union. Pesticide and herbicide-related suicides are also prevalent in several countries in Asia. Studies have shown a correlation between a ban on these toxic substances and a drop in overall suicide rates in affected countries such as Sri Lanka and South Korea. [3] [4]

Alternatives to Paraquat/chemical weed management

Paraquat is a fast-acting herbicide that is effective against a large variety of weeds. But it is also much more acutely toxic than other commonly used herbicides. [2] Chemical alternatives to Paraquat may not be as cost effective or comprehensive, but there are a number of weed-specific herbicides that are potent on particular species.

Furthermore, prolonged and extensive use of the same chemical results in the development of resistance towards it. This renders it ineffective in the long run and shows the importance of diversification in chemical use. About 30 weed species have already developed a resistance to Paraquat. [5] While completely stopping the use of Paraquat may not be immediately feasible, phasing it out of operations presents a much more realistic target.

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[1] Centers for Disease Control and Prevention. <http://emergency.cdc.gov/agent/paraquat/basics/facts.asp>

[2] Neumeister, L. & Isenring, R. (2011): Paraquat. Unacceptable health risks for users. 3rd Edition. Berne Declaration, Pesticide Action Network UK, PAN Asia and the Pacific. <http://www.pan-uk.org/attachments/364_Paraquat_UnacceptableHealthRisk_3rdEdition_2011_6%20website.pdf>

[3] Myung W, Lee G-H, Won H-H, Fava M, Mischoulon D, Nyer M, et al. (2015) Paraquat Prohibition and Change in the Suicide Rate and Methods in South Korea. PLoS ONE 10(6): e0128980. doi:10.1371/journal.pone.0128980 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4452788/>

[4] "Shaping suicide prevention initiatives." University of Bristol. http://www.bristol.ac.uk/research/impact-stories/2015/shaping-suicide-prevention-initiatives.html

[5] Heap, I. "The International Survey of Herbicide Resistant Weeds." Online. Internet. Wednesday, January 27, 2016. <http://weedscience.org/graphs/activebyspecies.aspx>

As a contact herbicide, Paraquat only affects plant matter that comes into direct contact with it, i.e. foliage or matter that is above the soil. This is different from systemic herbicides, which are absorbed and transported throughout the plant. This includes parts below the soil such as the roots. An example of a systemic herbicide is Glyphosate, which is the most widely used herbicide in the world. However, according to the International Agency for Research on Cancer (IARC), glyphosate is "probably carcinogenic to humans." [6] The risk with systemic herbicides is that desirable plants may be unintentionally affected too. Therefore, this is another important criterion when choosing a chemical substitute to Paraquat.

Alternatives to chemical weed management also exist, but these are largely control mechanisms that are not meant to eliminate, but rather control, pest populations. Chemical intervention is still important, especially as a short term measure, during pest outbreaks. Therefore, a more practical aim would to reduce and promote responsible chemical use rather than eliminate it. Using herbicides when necessary rather than employing prophylactic spraying methods is one way to reduce development of resistance and reliance on chemical use. This can also be done by viewing chemical use as part of a larger overall weed management plan rather than the sole contributing factor.

Integrated Pest Management (IPM)

In terms of long term sustainability and soil quality, IPM offers a possible solution. IPM is a multi-approach method that emphasizes prevention and control of pest populations, and reduction of pesticide use. In essence, IPM requires one to consider various environmental factors so as to create unfavourable conditions for a particular pest. As such, pest identification and monitoring play an important role when implementing IPM. In order to maximise the benefits of IPM, a combination of the methods listed below is recommended, depending on the situation.

- **Bioherbicides** are specific plants that are lethal to certain kinds of weeds. An example of this would be mycoherbicides – weed-killing fungi that can be used as a bioherbicide. [7]
- **Weed-killing insects** only attack a particular weed, thereby aiding in the control of a weed population. [8] Grazing animals, such as cattle and goats, have also been used, but they tend to bring their own set of problems in terms of management of the animals. [9]
- **Organic herbicides**, which are derived from plants, offer another alternative. These include vinegar and pine oil based herbicides, which result in the dehydration of plant matter. Vinegar (acetic acid) has been effective against broadleaf weeds and grasses. An acetic acid concentration

[6] "Glyphosate and Cancer Risk: Frequently Asked Questions." Center for Food Safety. <http://www.centerforfoodsafety.org/files/glyphosate-faq_64013.pdf>

[7] "Inundative Control Using Bioherbicides." Landcare Research. <https://www.landcareresearch.co.nz/__data/assets/pdf_file/0014/20525/Inundative_Control_Using_Bioherbicides.pdf>

[8] Seastedt, Tim. "Biological Control of Noxious Weeds." Beyond Pesticides. <https://www.beyondpesticides.org/assets/media/documents/weeds/publications/Insects_weed_management.pdf>

[9] Popay, I. & Field, R. "Grazing animals as biological control agents." Council of Australasian Weed Societies. <http://caws.org.au/awc/1992/awc199212731.pdf>

of about 10 percent is required to be effective, while vinegar only consists of about 5% acetic acid. However, a 10 percent concentration may cause skin irritation, and eye irritation or damage. [10]

- **Reduced tillage**: Excessive tillage may cause soil erosion, reduce soil fertility and may require extensive use of fossil fuels, among other things. Reduced tillage systems can help diminish these pitfalls, while also maintaining the benefits of tilling, e.g. disrupting weed growth, especially among less mature plants. [11]
- **Mulching**: spreading a 2 to 3-inch layer of organic (e.g. compost, dried leaves, empty fruit bunches, coconut husk, etc.) or inorganic (e.g. stones, rocks, etc.) matter on top of the soil in order to prevent weed growth by depriving their seeds the light required for germination. Among other benefits, the decomposition of organic mulches also helps maintain soil moisture and improves soil condition. [12]
- The growing of **cover crops** to outcompete weeds for nutrients and water can also increase the yield of a crop by helping fix nitrogen, retaining moisture in the soil and preventing soil erosion, especially in hilly areas. These crops may also later be used as a mulch or manure (green manure). [13]
- **Intercropping**, i.e. growing 2 compatible crops simultaneously or successively, may also be a viable weed management solution for small holders, in addition to providing an economic advantage. Weed suppression occurs because there is more competition for resources. However, due to yield considerations, larger scale operations have shied away from this method. [14]
- In addition to this, **preventative measures** such as selecting high quality seeds, maintaining cleanliness, monitoring crops regularly and applying fertilizer immediately after weeding (when the crop has optimum access to it) can be helpful in weed management. Some weeds only grow in certain soil types, while others don't have this limitation. Hence, proper soil management may be another option used to create unfavourable conditions for weeds. [10]
- **Flame and steam weeding** are two methods of weeding that utilize heat in the form of a direct flame, infrared burner or steam. Steam is said to be the more effective of two, but both are costly and the usage of a flame can become a fire hazard. Another option is the usage of heat from ultraviolet rays, but this is still in the experimental stage. [15]

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[10] "Alternatives to Chemical Weed Control." Goolwa to Wellington Local Action Planning Association. <http://www.gwlap.org.au/wp-content/uploads/2015/11/Alternatives-to-chemical-weed-control_info-for-field-day.pdf>

[11] "Weed Management Options Which Reduce Pesticide Risk." Agriculture and Agri-Food Canada. <http://www.umanitoba.ca/outreach/naturalagriculture/weed/files/nonchemical/tillage_e.htm>

[12] "How to Grow Crops without Paraquat." Pesticide Action Network (PAN) Germany. <http://www.oisat.org/downloads/field_guide_without_paraquat.pdf>

[13] Samedani, B., A.S. Juraimi, S.A.S. Abdullah, M.Y. Rafii, A.A. Rahim and M.P. Anwar, 2014. Effect of cover crops on weed community and oil palm yield. Int. J. Agric. Biol., 16: 23–31 <http://www.fspublishers.org/published_papers/41353_..pdf>

[14] Nchanji, Y. K., Nkongho, R. N., Mala, W. A. & Levang, P. (2015). "Efficacy of oil palm intercropping by smallholders. Case study in South-West Cameroon." <http://www.cifor.org/publications/pdf_files/articles/ALevang1501.pdf>

[15] Collins, M. "Thermal weed control, a technology with a future?" Council of Australasian Weed Societies. <http://caws.org.au/awc/1999/awc199910251.pdf>