Hazard classifications which qualify paraquat as a Highly Hazardous Pesticide

Paraquat is one of the 296 pesticide active ingredients identified by PAN International as an HHP. The table shows for which of the three hazard groups it qualifies and for which particular hazard criteria.

Active ingredient	CAS # *	Pesticide type	HHP: Acute toxicity to human health classifications	HHP: Chronic human health classifications	HHP: Environmental concerns
Paraquat dichloride	1910-42-5	Herbicide; defoliant; desiccant	**GHS/EU 'Fatal by inhalation'** operator hazard (H330 code)		

*CAS # = Chemical Abstracts Service unique identifying code for individual chemicals Source: PAN International List of Highly Hazardous Pesticides (June 2015 version). *Via: http://pan-international.org/wp-content/uploads/PAN_HHP_List.pdf*

This broad-spectrum, non-residual herbicide is highly soluble in water and persistent. It is classified as 'very persistent' in soils, with a degradation half-life in field conditions of 365 days. Paraquat exhibits high acute toxicity to birds and moderate toxicity to mammals, fish, aquatic invertebrates and honeybees. Toxicity to earthworms and other soil dwelling invertebrates is moderate to low. There is no data on ecotoxicity to key natural enemies in FOOTPRINT.

For health concerns, paraquat is a known irritant to skin, eyes and the respiratory tract. It may damage lungs if inhaled and can be fatal (hence its H330 code for operator exposure hazard). It is also a potential liver, kidney, stomach, intestine and respiratory system toxicant, although it is only classified as WHO Class II 'moderately hazardous' for acute toxicity (a classification long questioned by PAN and others). Swallowing paraquat can often be fatal, hence its renown as a cheap, readily available way to commit suicide.

EU status: Paraquat started to become increasingly restricted in the European Union from 2004, due to operator safety concerns and environmental hazard to certain bird and herbivorous mammal species. Before all uses of paraquat were withdrawn in 2007, all product labels had to carry the words 'Very toxic by inhalation'.

***Paraquat and the international chemical conventions*:** In 2010 Burkina Faso's government discovered from health monitoring surveys that paraquat products were one of the leading causes of occupational poisonings in the country, particularly via skin contact and inhalation. The government nominated paraquat products (containing 20% concentration or stronger) as candidate for the Rotterdam PIC list, which was then recommended by the convention's Technical Review Committee for inclusion as a Seriously Hazardous Pesticide Formulations. To date, this recommendation has been blocked by a tiny number of countries. However, several food companies and standards have made unilateral decisions to prohibit in their supply chains.

Information on use, health and environmental impacts from Central America: Paraquat occupied the fourth largest volume of pesticide active ingredients imported into the Central American region during 2000-2004 and ranked eighth in Costa Rican imports over the period 1977-2006 (5,034 tons total). A worrying 30% increase in Costa Rican paraquat imports has been identified by the IRET project team in the last two years from national import statistics, with 505,458kg active ingredient imported in 2014 and 459,942kg in 2015, compared with 350,000kg in 2012 and 387,000kg in 2013.

Paraquat is renowned in the region for being the most frequent pesticide reported as the cause of pesticide acute poisonings and fatalities. Costa Rican Ministry of Health data highlighed paraquat as the most frequent pesticide (34%) of poisonings documented during 1996 to 2002. Skin and eye lesions and respiratory damage are occupational exposure problems. Costa Rican studies have shown paraquat to be responsible for subclinical respiratory abnormalities in workers on banana, coffee and oil palm plantations. Research on childhood leukaemia has linked this disease with parental exposure to paraquat. In Panama, paraquat has been shown to trigger contact dermatitis and was one of the 12 pesticide active ingredients reported as causing the most pesticide poisonings during 1992-2000.

Environmental fate studies in Costa Rica in 1987-1988 documented paraquat in samples of surface water from Lake Arenal in the Caribbean coast región and its tributaries and high levels were also reported in soils of coffee farms.

[1] *As per hazard data and interpretation in the 'FOOTPRINT' Pesticide Properties Database managed by Univ. Hertfordshire.*

[2] *Information translated from the database in IRET's Pesticide Manual for Central America, via http://2 www.plaguicidasdecentroamerica.una.ac.cr/*

[3] *Paraquat. Unacceptable health risks for users. 3rd edition (2011). Berne Declaration, PAN UK & PAN Asia Pacific. Via: http://www.pan-uk.org/attachments/364_Paraquat_UnacceptableHealthRisk_3rdEdition_2011_6%20website.pdf*

[4] *Effects of pesticides on health and environment in Costa Rica. Pan-American Health Organisation and Ministry of Health, Costa Rica (in Spanish).*

Alternatives to Paraquat for Pineapple Foliage Treatment

Lab-based studies on microbial biodegradation of pineapple foliage, Costa Rica, August 2016

Background

Pineapple cultivation in Costa Rica produces about 300 tons of crop waste (stubble) per hectare, in the form of plant foliage, once the fruits have been harvested. This crop waste needs to be treated quickly or removed from the field, to prevent the spread of the stable fly Stomoxys calcitrans. This stable fly can attack and harm livestock by feeding on blood meals. Badly affected animals become weakened and stressed and can quickly lose weight and therefore economic value for dairy and beef cattle ranchers. Very high levels of stable flies have become a serious problem and persistent concern for livestock owners in parts of Costa Rica in recent years, coinciding closely with the rapid expansion of pineapple cultivation. One of the factors behind these stable fly increases is the ready availability of huge volumes of suitable egg laying sites in the post-harvest residues of pineapple, which consists of thick, fibrous, fleshy plant stems and leaves, with a very high moisture content. Rotting foliage is highly attractive to stable fly for egg-laying and if poorly managed can soon become a breeding ground for this livestock pest.

Treatments For Speeding Up Pineapple Foliage Breakdown or Physical Destruction

Current pineapple grower practice may comprise one or more of the following treatments to speed up the foliage breakdown process:

- **Application of a 'burn down' desiccant herbicide, commonly paraquat (HHP status, see Annex) at 12 litres/ha**
- **Physical burning of fields post-harvest to kill the plants**
- **Up to four tractor passes using 38" (950cm) disc harrows to mechanically chop foliage**
- **Incorporating dying, chopped material into the soil using an inversion plough**

These practices can have negative health or environmental effects as well as risking soil erosion. Several end up wasting what could be a valuable resource for soil improvement, livestock fodder or other recycling. Some practices, especially with mechanical methods alone, do not decompose the foliage quickly enough to prevent the rotting tissues becoming an attractive breeding ground for the stable fly, which can fly up to 20km in search of suitable sites for reproduction. This then entails applications of insecticides, including the HHP chlorpyrifos, adding a 40% higher insecticide load to the pineapple cultivation cycle. Slow rotting material also tends to favour conditions for soilborne diseases of pineapple, e.g. Phytophthora rots. Some growers report anecdotally that mechanical destruction alone is five times more expensive than using paraquat because of the additional use of insecticides and fungicides for disease control. Others, however, recount that they are able to manage waste foliage effectively without resorting to herbicides or insecticides to kill the stable fly larvae

With the frequent heavy rains typical of Costa Rican pineapple zones, mechanical measures for crop residue management are limited by how often heavy machinery can be driven across the bare, open fields of typical large scale pineapple production. Digging large pits to bury uprooted plants has been tried but causes more soil erosion.

The Study

This briefing summarises one small, lab-based exploratory study conducted at Costa Rica's National University (UNA) during 2015 as a first 'snapshot' look at the potential of using microbial mixtures to speed up pineapple foliage breakdown post-harvest.

Microbes known to break down lignin and cellulose compounds in tough, fibrous tissues were selected. The experiments tested the effectiveness of a 'consortium' made of up two bacteria (*Lactobacillus* sp. and *Bacillus subtilis),* a fungus (*Pleurotus ostreatum)* and a yeast *(Saccharomyces cerevisiae*) to break down small quantities of chopped up pineapple stem and leaves in test-tube conditions over a 60 day period. The degradation process was assessed by looking at:

- the physico-chemical characteristics of the pineapple foliage before and after treatment, compared with an untreated control
- measuring content of lignin, whole and 'digested' cellulose and polysaccharide compounds and activity of degradation enzymes
- electron microscope imagery of the physical condition and fragmentation before and after treatment

Key results: *The microbial association was able to start the breakdown process more quickly than the untreated control. By 60 days, over 40% of the cellulose compounds had been degraded.*

Implications of The Findings and Questions Arising

Q: What is the maximum required speed/duration of foliage breakdown producers need to avoid stable fly problems?

A: Breakdown duration varies a lot, according to production zone, weather, soil conditions, farm scale, cropping system and to the grower's production aims and when he aims to replant. Larger farms that have many production fields will clean up extensive areas when weather conditions permit, so they can prepare enough land to plant up new fields. They may leave some fields fallow for 2-3 months post-harvest. Smaller producers tend not to leave temporary fallows because their limited production area means they need to clean up and incorporate crop waste and then replant within 1 - 2 months after harvest. But if the weather is not favourable for machinery to enter fields, they may have to wait 2-3 months until the field condition is suitable.

Large, monoculture farms aiming to produce large volumes of fruit year round face the biggest challenges in rapidly cleaning fields post-harvest before re-planting. They aim to replant within 45-50 days of harvest and certainly within 3 months maximum. Farms with wider crop rotations and/or less commercial pressure to produce 'non-stop' fruit for the fresh markets have more options, and may leave 2-3 months before planting the following crop.

Q: How useful could this method be for producers?

A: Difficult to say at this stage but definitely worth studying further, including in the field with small trial plots. The results from this experiment are only very preliminary indications of feasibility. Different microbial species could be selected which might break down the fibres more quickly. Microbial degradation is being used with some success in other cropping systems (e.g. sugar cane). There have been trials in pineapple combining fungal decomposers with a half dose of paraquat, with good results. Likewise, combining microbial degradation (by other species than in this study) with mechanical destruction has delivered halfway reasonable results.

Q: Any other alternatives available?

A: Some farms (a small minority) uproot the plants during the harvesting period, remove from the field (hence avoiding the stable fly problems), mechanically chop and use the crop waste as fodder, either via silage or feeding the green crowns and leaves straight to cattle.

Two other herbicides are registered in Costa Rica for pineapple desiccation: bispyribac sodium and trichlopyr. Neither qualifies as an HHP. Anecdotal grower reports suggest that bispyribac sodium works quite well but trichlopyr is not so effective and is also expensive.

Some large farms conduct detailed monitoring of harvested fields to assess stable fly larvae numbers and then decide whether insecticide applications are needed (usually with chlorpyrifos at 8 litres/ha). Note there have been no studies on ways to disrupt the stable fly lifecycle, only on reducing (i.e. speeding up) the duration when rotting foliage is exposed in the field. However, at least one large farm of 2,000ha is trying out biological control tactics, in this case rearing and releasing parasitic wasps known to parasitize Stomoxys spp. larvae, and combining with insecticide application on threshold-based decision making.

Trapping of adult stable flies in the field with simple sticky traps is another tactic increasingly used to help reduce population levels. White plastic bags painted with adhesive are mounted on wooden stakes and placed in pineapple fields and surrounding cattle pasture every 10-20 metres, when fruit cutting has finished and crop waste is chopped mechanically. These traps do collect many flies, either immigrating adults looking for breeding sites and/or new adults as they emerge from eggs laid in pineapple crop waste. However, it is unclear how effective these traps are to manage stable fly outbreaks and research is underway to look at improved designs and biodegradable materials.

Sources:

(a) In-vitro evaluation of a consortium of fungi and bacteria on the degradation of pineapple foliage. Dorell Rojas Fonseca, undergraduate research thesis for BSc in Environmental Management, with emphasis on clean technologies, National University of Costa Rica (UNA), 2016

Abstract: Pineapple cultivation in Costa Rica produces about 300 tons of stubble per hectare which must be treated quickly to prevent the spread of the stable fly Stomoxys calcitrans, which affects livestock. The post-harvest residue of pineapple consists of plant stems and leaf litter once the fruit has been cut. This investigation aimed to evaluate quantitative changes in the chemical characteristics of pineapple post-harvest residue, in the presence of a consortium of bacteria, yeast and fungi (Pleurotus ostreatus, Lactobacillus sp, Bacillus subtilis, and Saccharomyces cerevisiae).

This information is essential to develop more environmentally sustainable solutions for the pineapple producers, reducing the amount of pesticides applied to residues, while taking advantage of the biomass generated by decomposing pineapple plants for soil fertilization.

The starting material was characterized, for which holocellulose insoluble lignin, ash, moisture, polymerization degree, sugar profile was determined. The material was subsequently exposed to a consortium of fungi and bacteria specialized in the degradation of lignin and cellulose. The efficiency of treatment with the microbial consortium on the degradation of the lignocellulosic material was evaluated by measuring the contents of cellulose, calculated according to the quantity of glucose present in the material, degree of polymerization of cellulose and insoluble lignin content.

With the results generated in this study, we seek to contribute to the generation of best agricultural practices, a decrease in pesticide use and better management of solid waste, in order to benefit the human and ecosystem health.

(b) Personal communications with Dorell Rojas, UNA, and Fernando Ramirez, IRET.

(c) Biodegradación de rastrojo de piña por medio de un consorcio de hongos y bacterias. Rojas D, et al. (in press)

(d) Biology and Trapping of Stable Flies (Diptera: Muscidae) Developing in Pineapple Residues (Ananas comosus) in Costa Rica. J-A Solorzano, J Gilles, O Bravo, C Vargas, Y Gomez-Bonilla, GV Bingham & DB Taylor (2015) Journal of Insect Science 15(1) 145 DOI: 10.1093/jisesa/iev127

For more information, contact:

Stephanie Williamson, Staff Scientist, PAN UK. stephanie@pan-uk.org

Fernando Ramírez, Project Coordinator, IRET. fernando.ramirez.munoz@una.cr
www.iret.una.ac.cr (English pages)

Ms Dorell Rojas, agronomist and post-grad researcher, School of Environmental Sciences, National University UNA dorell14@gmail.com