GM soya expansion fuels endosulfan use in Argentina

Widespread adoption of herbicide-resistant soya in Argentina has had unintended and unexpected consequences. It is intensively cultivated in monocultures limiting crop rotation and consequently reducing the number of beneficial insects. Farmers respond to pest pressures by using more insecticides, particularly endosulfan. In fact, endosulfan use has more than doubled in the past decade mainly due to GM soya plantings. ***Javier Souza*** *of the Centre for Research on Appropriate Technologies in Argentina (CETAAR) describes the many impacts of GM soya in Argentina.*

Throughout the main soya producing countries in South America (Argentina, Brazil, Paraguay, Uruguay) soya cultivation is associated with deforestation and loss of biodiversity. Intensive monoculture cultivation, mainly of genetically modified soya varieties resistant to the herbicide glyphosate, is based on heavy use of synthetic fertilisers and pesticides and reduced (or absent) crop rotation, which contributes to further impacts on soil health and ecosystem biodiversity [PN67 pp10-11]. More recently attention has been drawn to serious socioeconomic and political issues around soya expansion and the impacts on rural farming communities, with violence and repression particularly in Paraguay [PN74 pp6-7].

Soya now occupies around half of Argentina's agricultural land, with an estimated 16.8 million hectares (ha) sown in the 2007/08 season[1]. Monsanto's Roundup Ready GM soya makes up 98% of the varieties planted and is primarily responsible for the growth in use of agrochemicals in Argentina. The soya processing plants can process over 100,000 tonnes per day, more than the national cultivation capacity, and they therefore import and process soya grown in neighbouring countries, especially Bolivia and Paraguay. Each year soya is taking over from cattle ranching and crops such as wheat, vegetables and potato, as well as encroaching on fragile ecosystems of the dry foothills and the Patagonian steppe. A further three million ha are projected to come under soya by 2012.

The expansion of soya has been closely followed by an increase in agrochemical use and an almost identical technological 'package' across the country. Nevertheless, soya yields are closely linked to sowing date and weather, especially rainfall. As land prices rise with growing market demand for soya, producers must pay careful attention to crop husbandry in order to maintain yields and income and have responded by intensifying soil exploitation, reducing rotations and sowing more crops per unit area and over the year. In some areas, soya is grown twice a year; in others it is grown before a winter crops of oats, wheat, oil seed rape or barley. Although soya monoculture is expanding, research shows that four years of continuous soya growing reduces yields by up to 400 kg/ha, while rotating soya achieves yields over 270 kg/ha higher than when grown without rotation[2].

Pesticides and pest management

The cultivation package of intensive soya generally involves reduced fallow period, careful timing of sowing, precision no-till sowing, partial intercropping with wheat or

Table 1 Major pesticides used in soya bean production

Active ingredient	Target pest/disease	Formulation/Conc.	Dose (ml/ha)
alphamethrin	Bollworm; *Helicoverpa gelotopoeon*	E10%	100
	Fall armyworm; *Spodoptera frugiperda*	E10%	50
chlorpyrifos	Bean shoot borer; *Epinotia aporema*	L48%	1,300
	Southern green stink bug; *Nezara viridula*	E48%	900
	Grey looper caterpillar; *Rachiplusia* spp.	E50% (+E5%)	300 (+ cypermethrin)
cypermethrin	Fall armyworm; *Spodoptera frugiperda*	E25%	100
	Bollworm; *Helicoverpa gelotopoeon*	E25%	100
	Southern green stink bug; *Nezara viridula*	E25% (+E35%)	50 (+ endosulfan)
deltamethrin	Bollworm; *Helicoverpa gelotopoeon*	E5%	100
endosulfan	Bollworm; *Helicoverpa gelotopoeon*	E35%	1,500
	Southern green stink bug; *Nezara viridula*	E35%	1,200
	Grey looper caterpillar; *Rachiplusia* spp	E35%	1,200
	Fall armyworm; *Spodoptera frugiperda*	E35%	1,800
lambda-cyhalothrin	Grey looper caterpillar; *Rachiplusia* spp	E8.3%	50
	Fall armyworm; *Spodoptera frugiperda*	E8.3%	50
methamidophos	Bean shoot borer; *Epinotia aporema*	E60%	1,200
monocrotophos	Bean shoot borer; *Epinotia aporema*	L60%	1,000-1,200
	Southern green stink bug; *Nezara viridula*	L60%	700
permethrin	Grey looper caterpillar; *Rachiplusia* spp	E50%	50-60
strobilurin + triazole fungicide products	Soya bean rust Late season diseases	–	300
triazole fungicides	Soya bean rust Late season diseases	–	400

sunflower, seed inoculation with nitrogen-fixing bacteria, fertilisation with phosphates and sulphates, application of herbicides (glyphosate, 2,4-D and atrazine), insecticides (notably endosulfan, especially in dry years) and fungicides to control late season diseases and soya bean rust.

The reduction in crop rotation and reliance on chemical control has affected the survival of beneficial insects and triggered insecticide resistance in some key soya pests. Beneficial insects which prey on, or parasitise, insect pests can be extremely valuable in controlling pest levels - research shows that natural enemies can get rid of up to 65% of sucking bugs. Parasitic wasps are also important and may attack 70-90% of bugs and caterpillars on soya. Increased pesticide use, however, has greatly reduced the numbers of these natural enemies and the changes in natural vegetation and reduced diversity in field crops reduces the plants they need for nectar or shelter. Increased reliance on pesticides is also related to higher populations of insect pests associated with wide availability of their food source and with milder winters, such as sucking bugs and inchworm caterpillars. Key soya pests also feed on sunflower, one of the usual rotation crops. Table 1 lists the main insecticide and fungicide active ingredients used in soya and their application doses.

Weed control has been reduced to reliance on chemical control alone with the massive adoption of GM soya varieties. Producers mainly use glyphosate (Roundup and other brands) at concentrations from 3-10 litres/ha in two to four applications per season. The appearance of herbicide-resistant weeds has led to larger application volumes, higher doses and herbicide rotation. Major problematic weeds *Chenopodium album, Sorghum jalapense* and *Eleusine indica* have become resistant to glyphosate. As weeds have developed resistance to the recommended glyphosate rates, farmers have shifted to spraying 2,4-D herbicide at doses of 2-3 l/ha. Argentina's National Institute for Agricultural Technology's (INTA) recent study on weed resistance noted that just 40% of weeds were affected by a dose of 3 l/ha and even a dose of 12 l/ha was insufficient to destroy all the weeds in the field[3]. By 2006, some 120,000 ha were affected by herbicide-resistant weeds, causing production costs to rise and yet more use of herbicides. In Cordoba province an estimated extra 25 million litres of non-glyphosate herbicides are needed to combat *Sorghum jalapense* alone and may double farmers' herbicide costs[4].

The rise of endosulfan

Although endosulfan qualifies as WHO Class II for acute mammalian toxicity, this persistent organochlorine compound is extremely toxic to fish and label instructions restrict it from being applied close to water courses. It is also moderately toxic to bees and birds. In Argentina it is classified as a very dangerous Class Ib product but despite this it is used not only in soya but also on cereals, alfafa, cotton, flowers, vegetables, sunflower, flax, peanuts and tobacco.

Statistics show an upward trend in sales and use of endosulfan, making it not only the most commonly used insecticide on soya in Argentina, but the country's most widely sold insecticide. Endosulfan dependency in soya is characteristic of the growth of soya monoculture, without a comprehensive pest management strategy. Sales of endosulfan increased from 1.9 million litres of formulated product in 1999 to 4.2 million litres by 2006. Several endosulfan products are sold in Argentina, all as emulsifiable concentrate formulations, including DuPont's Agar Cross; Bayer's Thiodan and numerous products manufactured locally.

A trend towards higher dependency on pesticides, especially endosulfan, has also been observed in horticulture in Argentina, associated with a shift to greenhouse production systems and the development of pest resistance to recommended insecticide doses. Recent research links increased pesticide use with strong pressure from consumers for 'clean' vegetables, i.e. free of insect damage[5].

Toxicology and health issues

Unfortunately, pesticide health impacts receive scant attention in Argentina's health service, due to serious underestimations of poisoning cases. There are several reasons for this, for example, affected persons may not realise that their symptoms are linked with exposure to toxic products. Case studies revealed that what a medical professional would describe as symptoms of an acute health incident, farm workers describe merely as 'feeling bad, not being able to work, vomiting'. Even when affected people can find the time and money to access the health services, they may be assessed by medical staff only in terms of their symptoms and not their causes. These factors contribute to the low rate of incidence reporting and hence to the obstacles in recognising pesticide-related illness as a real health problem. The author's research in horticulture systems revealed that 67% of farmers interviewed had experienced poisoning during their work or via accidental ingestion or spray exposure[6]. Poisoning incidents mainly involved those spraying pesticides, generally males over 15 years old.

One epidemiological study in Entre Rios province revealed an increasing frequency of congenital abnormalities in boys, including undescended testicles (cryptorchidia), small penis size and abnormal urethra openings (hypospadia). In zones where endosulfan and other pesticide use is high, higher incidence of cryptorchidias was reported[7]. In Santa Fe province, one of the main soya production areas, rural populations' health was assessed in relation to national averages. Hypospadia and cryptorchidia incidence was significantly higher than average, as were hormone-dependent cancers and certain cancers of the digestive system, especially of the stomach, liver and pancreas[8].

Environmental impacts of soya pesticides

Several field and laboratory studies in Argentina demonstrate adverse impacts on wildlife, either via spray drift reaching water courses or contamination by soil particles containing endosulfan. Studies in the Pampas region on aquatic invertebrates noted that endosulfan concentrations were highest in soil particles, concluding that soil erosion is an important source of water contamination by endosulfan[9]. In Buenos Aires province, research in rivers found high levels of general fish mortality 24-72 hours after endosulfan application in nearby fields. Mixtures of pesticides proved especially harmful, with survival rates only around 17% for one fish species following application of endosulfan with glyphosate[10]. Another study in the same province highlighted the role of pesticide mixtures on amphibians, with non-lethal impacts having consequences for later growth and development of immature stages[11].

Field studies and the scientific literature agree that the main impacts observed in amphibians and fish are associated with aerial spraying, of single pesticide compounds or in mixtures, conducted close to water courses[12]. Crop spraying in general appears to be affecting the owl population, which has fallen dramatically in recent years. Owls hunt rats, keeping the population levels down, but villagers now report rat epidemics. In 2007 a major outbreak of the virus Leptospirosis, carried in rat urine, occurred in Entre Rios province, infecting animals and causing a number of human deaths[13]. Evidence also shows that partridge and herons have been affected by soya pesticides and beekeeping traditionally found in what are now soya areas is in decline due to biodiversity reduction[14]. Further studies since 2005 found concentrations of soya pesticides in the fat of amphibians, snakes, birds and mammals found in ponds and fields in soya growing areas. In 2007 INTA published a report recognising that the 'increasing and out of control use of agrochemicals within the province is the major cause of fish mortality'[15].

Alternatives and organic production

Alternatives to endosulfan certainly exist. However, replacing it with any of the insecticides listed in Table 1 is merely 'jumping out of the frying pan into the fire', as several are equally or more acutely toxic to mammals and most are extremely harmful to aquatic organisms and bees. River fish is an important protein source for many rural communities and conservation of clean and healthy water resources should be a priority. Less toxic pesticides could be used, but only under an appropriate integrated management plan, and not as mere substitutes. Such an approach would need to be accompanied by an effective control system on distribution and use of less toxic products and other methods, and careful assessment of its health and environmental impacts.

While GM soya monoculture continues to expand in Argentina, at the same time, organic production is also rising and the country has one of the world's highest percentages of certified organic land (over 2.6 million ha in 2006, in 1,486 farms). Double this acreage is cultivated by non-certified organic farmers who cannot afford, or opt out of, certified supply chains. Organic soya production involves: soil rotivation before sowing to encourage germination of weeds, which are then mechanically controlled in a second pass. Varieties that are resistant to disease and guaranteed clean and healthy are recommended, along with north-south sowing to shade the inter-row space and reduce weed growth. Organic soya needs to be sown early to outcompete weeds and seeds are generally inoculated with nitrogen-fixing bacteria, as in conventional soya, to improve plant nutrition. Seeding density is higher than conventional, in order to suppress germinating weeds. Many organic producers incorporate green manures to boost the soil and use mulches for weed suppression and some also apply biofertilizer preparations using beneficial micro-organisms. For insect control, advice is to avoid plots in which soya has been grown in the previous three seasons and to grow intercrops or combine strips of soya with maize. Field headlands are kept weedy in order to provide habitat for beneficial insects, and organic growers need to carry out selective manual weed control, keeping as 'trap crops' weed species which attract the main pests.

Recent economic analysis by the author reveals that organic production can be more profitable than conventional, GM soya, given a 20% organic price premium. Although production costs are around 20% higher for organic, this is compensated by the premium and higher yields. Organic soya can therefore be a feasible alternative, provided that a total agroecosystem approach is taken, which integrates local energy and nutrient cycling processes and encourages natural control of insects and diseases, with cultural and mechanical weed management.

Conclusions

There is increasing evidence accumulating of the highly damaging environmental and human health impacts of pesticide reliance in intensive soya production in the Southern Cone of Latin America. Concerns have also been raised by the UN Committee on Economic, Social and Cultural Rights, which commented that 'the expansion of soy cultivation has entailed the indiscriminate use of agrochemicals, causing the death and illness of children and adults, the contamination of water, the disappearance of ecosystems and has affected communities' traditional food sources'[16]. Responsibility must also be assigned to the economic policies of Argentina's main export markets for its soya: the EU and China and their livestock and food processing sectors. Ultimately, it is the food chain and consumers that could make a real difference in shifting soya to safer pest management.

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Experts recommend adding two more pesticides to trade 'watch' list

A group of chemical experts, the Chemical Review Committee, has recommended that two additional pesticides – alachlor and aldicarb – be included in the Prior Informed Consent, or PIC procedure, under the Rotterdam Convention.

The PIC procedure of the Rotterdam Convention provides an early warning system that empowers countries to take informed decisions on the import of hazardous chemicals in order to minimize the risks posed to human health and the environment. Government regulators are 'informed' about the risks posed by PIC-listed chemicals before deciding to import them. At present there are 28 pesticides and 11 industrial chemicals subject to this procedure.

Many pesticides which are banned or severely restricted in industrialized countries are still traded and used in developing countries. Too often, such pesticides are sold to farmers who lack the equipment and knowledge to use them safely, resulting in large numbers of injuries and even deaths.

Similarly, industrial chemicals, such as lead additives used to boost octane levels in gasoline, are still used in certain regions, resulting in the build up of lead in the environment.

The recommendation to add alachlor and aldicarb to the PIC procedure is based on a review of regulatory decisions to ban the use of these chemicals taken in several countries due to unacceptable risks to human health or the environment. Decisions guidance documents will now be prepared for alachlor and alidcarb before a decisions to list them under PIC can be taken.

The fourth meeting of the Conference of the Parties to the Rotterdam Convention, will meet in Rome on 27-31 October 2008. This will decide whether to accept prior recommendations of the Chemical Review Committee to include tributyl tin compounds and endosulfan in the PIC procedure and adopt decision guidance documents for these chemicals. It will also further consider the inclusion of chrysotile asbestos.

Chemical experts recommend adding two more pesticides to trade 'watch list', PIC CRC-4 press release, 13 March 2008.