

Risk Reduction Through Better Application Technology

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The importance of application technology is that this, quite simply, determines how products are used in practice and therefore the level of risk with respect to:

- 1) the dose required;
- 2) operator safety;
- 3) non-target impacts – on soil, water, air, and humans; and
- 4) the level and, perhaps as importantly, the variability of pesticide residues.

The application technique is the **only** means of improving targeting of pesticide sprays and minimising human and environmental risks during application (Butler Ellis et al, 2005). Moreover, application equipment and techniques are now recognised as not just affecting risks during the spraying process, but also risks from mixing and filling and sprayer cleaning procedures (which have been shown to have a significant impact on the amount of pesticides found in water) – and even levels of container cleaning (vital for container collection schemes to be successfully implemented).

Micron Sprayers Ltd was founded by my father, Edward Bals, to improve pesticide application in the Third World.

Micron discovered and developed rotary atomiser technology for crop spraying to allow low, or ultra-low, volume applications, particularly critical in aerial application, migrant pest control, and the arid tropics where using large quantities of water is both difficult and costly. This novel technology has primarily been built into simple cost-effective hand-held Controlled Droplet Application (CDA) equipment for Third World smallholder farmers that has proven efficient appropriate technology - and safe to use (Thornhill et al, 1995; Thornhill et al, 1996). A major initial driver was to improve spray targeting to replace inaccurate and inefficient high volume high dosage applications with knapsack sprayers. Knapsack sprayers are also often dangerous to use – frequently leaking pesticide onto the users hands and back. The elimination of carrying pesticide on the operators back, and spraying downwind, enhance operator safety. Micron's original hand-held rotary atomiser sprayer designs (in the late 1960s and early 1970s) also incorporated the potential for very simple chemical transfer systems for use with pre-formulated agrochemicals which would have largely eliminated risks in mixing and filling (which is where the greatest operator risk generally arises due to handling the concentrate without proper equipment) - and also offered colour coded feed nozzles designed to match colour coded agrochemical labels to greatly simplify calibration procedures, thus facilitating training and safe use (Bals 1969). The agrochemical industry failed to support this initiative, so Micron redesigned their sprayers to utilise non-pre packed agrochemical formulations.

Uptake was rapid where this new technology was supported by good research and extension, particularly in peasant cotton production systems in francophone sub-Saharan Africa where over 95% of the market shifted to using this technology in a decade (Cauquil, 1986) with the introduction of this technology helping to triple cotton yields. The World Bank has referred to introduction of this technology as one

of the few success stories in agriculture in this area in the last 40 years. The technology has also proven appropriate for women farmers (Sekamatte and Okoth, 1995). Micron's low volume sprayers have also helped the introduction of herbicides into smallholder production systems, enabling increased yields by ensuring timely weed control (often in conservation tillage programmes) and removing the drudgery of hand weeding (literally back breaking work for many Third World smallholder farmers).

Micron have also developed this technology for migrant pest control. Micron provide hand-held, vehicle mounted and aerial spray equipment for control of migrant pests such as desert locust, African armyworm and sunne pest that plague the Third World. Micron have worked closely with governments and aid agencies in developing these sprayers, with the United Nations Food and Agriculture Organisation (FAO) having evaluated them as the best available for desert locust control (FAO, 2002). Again their key advantages are that they are efficient and safe to use, with widespread training undertaken by Micron in combination with governments and aid agencies.

However, apart from niche markets in the Third World where good extension and training exist, this new technology has not spread widely into other Third World markets, or developed countries, despite evidence that the technology meets customer needs in many instances. It is often argued that this is because the introduction of new technology requires training and support. However, **all** pesticide application equipment requires training and support – and it is the lack of it that has resulted in such appalling standards of application in the Third World. Most Third World smallholder pesticide users are still using application equipment and techniques that are grossly contaminating themselves and their general environment (Matthews and Friedrich, 2004). Sprayers are not well repaired or maintained and nozzles are rarely, if ever, replaced. Most sprayers leak and, with portable equipment, this is generally directly onto the hands or back of the operator who is not wearing PPE, despite product stewardship campaigns advising them to do so, because it is simply unaffordable, unavailable or even inappropriate in most Third World countries. The key is to improve application equipment and practices to ensure safe use - and some very simple measures could be implemented - but this is very rarely done, with the agrochemical industry generally ignoring equipment issues (particularly the introduction of new improved equipment) in favour of attempting primarily to ensure adherence to the product label.

It should be remembered that product label requirements were developed primarily in the immediate post WW2 era when pesticide use had just become widespread in temperate developed countries where farm mechanisation (with low energy costs) masked the true cost of hauling and applying high volumes of water - with obvious, and substantial, output (and thus cash) benefits from applying pesticides. The desire to achieve high pest kill rates meant that high application volumes and dosages were usually recommended on the label, with allowances made for non-optimal timing, due to use of high volumes, operator error and use of poor application equipment.

Labels still generally specify high volume high dosage application techniques and practices (despite the fact that application technology used in registration trials to develop the label bears very little relationship to that actually used by farmers and growers). In the past subsidised agriculture of the developed countries there was a

positive disincentive to go 'off label' - this meant either breaking the law, the general situation in the US, or forgoing the 'insurance protection' that adherence to the label requirements provided, the general situation in most of Europe. This has led to an undervaluation of the importance of application techniques and equipment – to the point where even obvious improvements that rapidly pay for themselves (and also dramatically reduce health and environmental risks) have not been widely adopted e.g. the Constant Flow Valve for knapsack sprayers.

Calls to improve spray efficiency by equipment manufacturers, such as Micron, and various researchers have been almost completely ignored. Lack of interest in application techniques and technology is reflected in the past failure to develop quantitative analytical methods for the study of spray application, with study little more than a subjective art based on (potentially misleading) visual observation (with certain unsupported core beliefs still widely held today).

The primacy placed by the agrochemical industry on adherence to the label has been carried into product stewardship campaigns, which have therefore generally failed to consider improved application techniques and equipment and have focussed on single problem issues with a limited time scale and budget. They have failed to fully involve all stakeholders, change general behaviour or provide consistent industry wide messages (Frei, 2002).

This undervaluation of the importance of application technology and techniques has serious consequences. Users, regulators and others are confused by inconsistent messages (i.e. equipment manufacturers advocating use of new equipment but the agrochemical industry not supporting this - or even opposing it). The (defensive) insistence by the agrochemical industry that the regulatory framework guarantees product safety in use (when it most patently does not – particularly in the Third World) has led to a degree of dissonance within the industry.

There is also a need for development of new application technology and techniques in the developed countries to reduce risks (to comply with ever more stringent human and environmental safety requirements, particularly in Europe).

Micron's rotary atomiser sprayer technology was introduced into UK mechanised agriculture in the early 1980s. Enthusiastic initial users (who were all trained in use of the sprayers – something done by no other equipment manufacturer at the time) improved both spray timing (generally applying spray volumes under 50 l/ha) and spray targeting and were achieving significant dosage reductions from label recommendations. UK government trials also showed the ability of rotary atomisers, due to their narrow droplet spectrum, to reduce spray drift potential compared with traditional hydraulic pressure nozzles. However, the agrochemical industry opposed these developments, and, despite the reduced risk advantages of this new technology, introduction of regulation in the UK in the mid-1980s initially threatened to ban this technology by making adherence to label volumes mandatory. Opposition from users and the equipment industry led to this position eventually being relaxed (Bals, 1993) but not before UK manufacture of vehicle mounted rotary atomiser sprayers had been eliminated. Ironically, the 'Reduced Volume' guidelines now contained in the UK Code of Practice for safe pesticide use allow considerable flexibility to go off label (at the users own risk) and have been in operation for nearly 15 years without any human

or environmental safety problems (although they are still not well understood, or publicised, by the agrochemical industry).

The agrochemical industry has generally failed to support new nozzle developments despite the fact the nozzle determines the droplet size, velocity and trajectory – and in essence is the primary determinant in most spraying operations of where the spray actually goes e.g. nozzle choice affects drift levels by an order of magnitude more than the effects of sprayer type and construction. Optimisation of spray characteristics is essential to ensure efficacy and minimise off target losses – in theory spray characteristics should, and can, be matched to the specific biological target (which varies tremendously – from bare soil to thin stemmed cereals and grasses, and even within crops e.g. cereal ears, stems or leaves).

Droplet size is the most critically important factor for pesticide retention and efficacy, and in determining relative drift risk.

Over the past 25 years nozzle manufacturers have led the way in developing different nozzle designs to mitigate the risk of spray drift. Currently air induction (AI) nozzles are widely promoted for drift reduction but although AI nozzles have been widely taken up in the UK and much of the rest of Europe no consistent advice is available on their use (particularly at lower volumes) – and no system for classifying the ‘spray quality’ (as per the BCPC scheme) has been produced for AI nozzles – or other new nozzles/atomisers (despite calls by the equipment industry and researchers for work on this to be undertaken as a priority).

The lack of attention given by the agrochemical industry to nozzle development and choice is quite astounding when the last decade has shown how nozzle choice dramatically affects the risk of water course contamination from spray drift, a major issue for the industry. Correct nozzle choice can reduce drift potential by over 75% (even over 90%) and allows modification of buffer zone widths in various countries – a direct economic benefit to farmers, and of course the agrochemical industry!

Sprayer choice, calibration and maintenance are also of course critically important. Increasingly larger sprayers, and often faster sprayer speeds, have been chosen throughout much of Europe. This has very often been as an alternative to using reduced volumes as a way of increasing workrate to cope with increasing farm sizes. Obviously calibration of sprayers is critical and here operator training is the key. Training of operators is absolutely essential given widespread evidence that, without it, labels are frequently not understood – if they are read at all! Operator training is also essential for correct maintenance of the sprayer throughout the season – in addition to the annual or biannual sprayer testing now common throughout Europe. Electronic controls can reduce the possibility of fundamental calibration errors, but they also carry risks – particularly in altering pressure, and thus spray quality, to the point where efficacy and drift potential can be affected. Electronic controls will however be increasingly required for the more stringent recording and monitoring of sprayer operations that is inevitable in the future.

Application equipment design is also critical for mixing and filling and cleaning procedures. Work in the UK and Germany in particular shows point source contamination of water from these processes can be an order of magnitude greater

than from spray drift during application. The equipment industry, at least in the UK, had already led the way in fitting induction hoppers to new sprayers and developing Closed Transfer Systems (which can in some instances reduce risks of operator exposure by a thousand fold). With respect to sprayer cleaning the equipment industry has again improved matters by developing recirculating systems on spray booms and 'suck back' systems that enable the liquid in the spray lines to be drawn back into the tank at the end of the spraying operation. Researchers have also now designed dedicated loading stations and biobeds for the management of dilute pesticide waste.

Micron is currently pioneering other novel risk reducing technologies e.g. shrouded sprayers for weed control, weedwipers, novel twin fluid nozzles, and variable rate applicators for use in precision farming systems. However, these novel nozzle and sprayer developments have had limited commercial success and **no** support from the agrochemical industry or regulators. Other innovations such as air assistance and electrostatics to improve spray targeting and retention are also very useful, but are relatively expensive – with no past economic benefit to farmers and growers in using them if they simply stick to label recommendations for dose and volume. Again, there is no consistent agrochemical industry support, or legislative/regulatory information on (apart from in Denmark), dose and volume reduction based on improved targeting. It should be noted that since currently only a small percentage of the pesticide applied actually reaches the biological target in many applications a modest improvement in spray targeting could lead to significant reductions in the dosages required. This lack of support is despite the fact that this would greatly help development of IPM programmes.

This is difficult to understand in an era when pesticide risk reduction is high on the political agenda. However, increased concerns about pesticide use, particularly in North West Europe (mainly with respect to environmental effects), have primarily led to increasing regulation and testing, rather than development, of application equipment. Testing requirements have led to a significant amount of standards development, mostly within ISO (following the Vienna agreement). However, with the prime emphasis on addressing European testing issues and a failure to consider worldwide application practice (or, indeed, existing documents such as the FAO Guidelines and Minimum Standards for Application Equipment) several international standards are in fact only relevant in Europe (Bals, 2004). Other Standards are far too prescriptive, enshrining current practice by simply making standards of current testing methods and performance limits for traditional high volume high dosage nozzles and sprayers e.g. European Standard EN 12761 has simply taken laboratory patterning and droplet size measurement limits derived for traditional hydraulic flat fan pressure nozzles and made them a Standard which threatens to ban, or at least severely restrict, various novel application techniques and nozzle types that have actually demonstrated the ability to better target sprays and reduce environmental impact, despite the fact that no proof of reduction of environmental impact in practice has been shown to result by complying with EN 12761. Micron participates widely in industry bodies and debates, including the development of UK, European, US and International Standards, to try and ensure the ability to innovate is retained but very often it is market forces and/or preservation of the status quo which determines actions or the outcome of debate, rather than scientific argument or proof (with a significant underlying desire by market actors for global harmonisation).

Moreover, Micron, as most equipment companies, is a very small company (less than €10m turnover, less than 50 employees). The resources to carry out wide ranging multi-year multi-site trials to 'prove' new application equipment or techniques in all situations are simply not available, and neither the agrochemical industry nor government have committed to testing new application technology or techniques, despite often compelling demonstrations of health and environmental benefits. In fact government funded research into application technology and techniques in the UK, and most of Europe, has declined precipitously in recent years (and appears to be in inverse proportion to the amount of regulation).

To date, standards and regulation have therefore actually posed threats to, rather than provided opportunities for, new application techniques and equipment that have demonstrated improved spray targeting and reduced environmental impact. Not only has no encouragement been offered to innovate to reduce risks through better application technology but there have actually been disincentives.

This all appears in complete contradiction of the policy aim regarding new technologies espoused at the original OECD/FAO workshop on pesticide risk reduction held in Sweden in 1995, which clearly stated regarding new technologies:

'Governments and other relevant actors should encourage research, development and commercialisation of new products that are low risk and farming practices and technologies which support risk reduction' (OECD, 1995).

Sadly, 10 years later, this has really not taken place. The agrochemical industry generally continues to ignore improved application technology and appeals to work together with all stakeholders in industry wide programmes (Bals, 1999). This must change – with the UK Voluntary Initiative showing what can be achieved when all stakeholders in the crop protection industry work together to improve general practice (although even this has fallen short in researching improved application equipment and techniques in its first phase). Agrochemical industry associations such as CropLife need to lead the development of multi-stakeholder product stewardship campaigns. Support of application equipment development and innovation (with consistent messages to users and regulators) is necessary on an industry wide basis to improve application practices, particularly in the Third World.

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