BOOK REVIEW

MOLECULAR BIOLOGY OF WEED CONTROL

David Cole discusses an important new book by Jonathan Gressel from the Weizmann Institute of Science, Rehovot, Israel, which looks beyond contemporary weed control technology

Introduction

Weeds are the major yield robbers in global crops and are constant threats to world grain security. Yet curiously, they occupy an uncertain place in the hierarchy of things, dismissed or ignored by both science and the policymakers it is supposed to inform. The furore over the introduction of herbicide-tolerant genetically modified crops has catapulted the perceived spectre of 'superweeds' to the forefront of public debate. These fears arise from the results of possible introgression of these new traits from crop to weed. What the public and indeed many scientists fail to appreciate is that weeds competing in agriculture have always been 'superweeds'. They are not in any sense wild, having adapted to agricultural systems or a 'human-disturbed' environment by evolving their own weediness traits or cleverly mimicking traits of competing crops in their quest for co-survival.

Urbanised societies now view the countryside as a green amenity space; farmers must therefore make compromises with town dwellers where the technology and impact of weed control is quite rightly selected to ensure biodiversity and a safe environment. Sustainable production in both grain basket areas and urban hinterlands require imaginative mix n' match solutions for weed control and policymakers need to encourage the foundations for this. As one of the few people of my generation experienced in paid manual weed control, I'm certain that this does not mean abandoning chemical weed control to return to unglorious manual weeding; the labour is no longer there anyway. Neither does it mean wholesale adoption of upgraded mechanised methods which are not necessarily any more sustainable than blanket chemical treatments or hand labour. New thinking is needed. Genomics, for example, is seen as a gateway to a new understanding of biology, yet virtually no scientist has started to apply genomic analysis in order to understand the molecular basis of weedy traits in 'real' problem species (Anderson and Horvath, 2001).

Weed control at a crossroads

The new century sees weed control at a crossroads. Chemical herbicides have been the mainstay technology of the last fifty years and phenomenally successful too, by any yardstick. The clouds on the horizon are not so much the inevitable tightening of environmental regulation and de-rating of certain older chemistry, but more the signal failure of the agrochemical industry to come up with much significantly new in the last decade or so (Figure 1).

One may take the view that an inevitable maturation of technology is taking place. The best chemistry has been found, the hurdles are ever higher and a law of diminishing returns has set in. However, one can also highlight disturbing trends within the agrochemical discovery industry. The frenzy for new products has led R&D to risk all on the parallel pillars of combinatorial chemistry, high throughput screening and genomics. These are carried out as self-justifying enterprises, displacing the teamwork, intuition and artisanship key to an essentially serendipitous process and upon which the success of the industry was built. The huge resource allocation to genomics research in the pesticide industry has been particularly misguided. CEOs and shareholders have been seduced by hyperbole and some of their own scientists' hubris that genomics offers a revolutionary new paradigm for blockbuster product discovery.

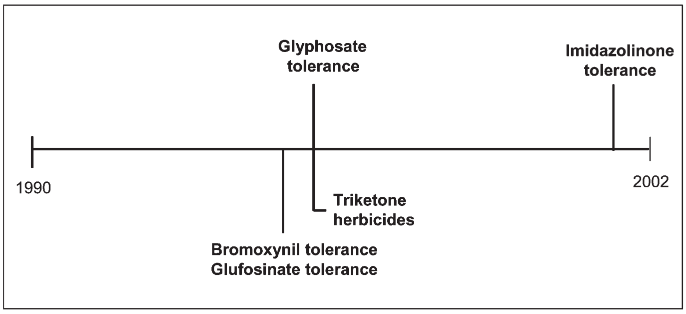

Figure 1. **Landmarks in herbicide technology since 1990. Transgenic and other biotechnology-derived herbicide tolerant crops, rather than new herbicide chemistry, have been the main introductions into agriculture.**

Inventiveness is also contingent on industry structure. Global market pressure and shareholder value are fully understandable drivers which have dramatically consolidated the agrochemical industry as we see it today. Alas, this has taken large chunks out of the industry's innovation base. Across Europe and North America, the smaller research centres which offered their own unique R&D cultures and an enabling lack of bureaucracy have closed. So often, these were centres of origin for some of the more innovative products which are still thriving on the market today. The narrowing of practical and intellectual diversity in invention

'Molecular Biology of Weed Control' (ISBN 0-415-26642-4) by Jonathan Gressel of the Weizmann Institute of Science, Rehovot, Israel, is available from Taylor and Francis, 11 New Fetter Lane, London EC4P 4EE Tel: +44 (0) 171 583 9855; Fax: +44 (0) 171 842 2298; http://www.tandf.co.uk/books/. 520 pp. £75.

DOI: 10.1039/b206512f

has obvious consequences. The trade press's regular panegyrics to corporate consolidation invariably fail to look beyond the PR to analyse future implications.

For whatever reasons, the armoury of herbicides open to farmers will be smaller and less diverse. We must therefore turn to biological inspiration which can support new weed control approaches meeting future changing needs. Few weed scientists are willing or able to put their heads on the block by challenging established nostrums and speculating constructively on the future. Professor Gressel is brave enough to do so and should be heeded as one of the few stellar figures we have in the discipline. This essential text will stand head and shoulders above most of its companions on the shelf. As the author proposes, its strength lies in providing a bird's eye view of how molecular biology can be exploited in weed control, from the perspective of a generalist. By turns inspirational, provocative and pedantic, the maverick author takes us on a wide ranging tour, analysing critically the state of the art, exposing knowledge gaps and proposing radical new approaches to weed control. Pondering the big questions, a lifetime's numerous strands of thought are brought together. Up to date, the book freely provides ideas for any number of research proposals, laying down clear challenges to science.

Highlights of the book

The highlights of the book are the earlier and later chapters. For openers, Gressel unapologetically redefines the weed threat and the significance of plant molecular science in meeting this. This sets the scene for a detailed exposition on molecular tools used in herbicide discovery. Here, the author makes a sceptical but reasoned dissection of the technologies used or being implemented by agrochemical R&D, ranging from high throughput screening through to genomics and *in silico* design. All technologies have their place but do they add up to a fireproof or cost-effective whole? There is little here I would disagree with, but this is the first time that such an authoritative critique from an independent voice has been committed to print and has tremendous value. Gressel identifies surprising gaps in our understanding of the genetic relatedness of crops with some of their companion weed species. In a handy subsequent chapter, current DNA fingerprinting techniques are evaluated which are needed to underpin better management of herbicide resistant weeds and resistance transgenes.

The central part of the book is devoted to core topics in herbicide action; their mode of action, herbicide tolerant crops and herbicide resistant weeds. There are any number of creditable contemporary texts which offer factual accounts and the novice is advised firmly to start with these. Here, the author is setting out to do something different. The spotlight is put on knowledge gaps and recommendations on how these might be addressed rather than merely dwelling on what has been done. The tendency to regularly highlight perceived shortcomings in the reported science can be irksome as much as it is valuable. However there is no doubt that by keeping the long term economic needs in view, current state of the art is thrown into sharper relief than will be found elsewhere. Key themes are well crystallised here – how molecular biological understanding can help predict the long term utility of herbicide technologies, identifying weed threats to the sustainability of global rice and wheat production and needs unmet by big business which can technically at least, be addressed.

Often, known biology has been ignored in the commercial deployment of herbicide-tolerant crops. No punches are pulled in criticising the introduction of rice tolerant to herbicides in the USA, in the absence of understanding introgression risks to optimise herbicide management in a crop infested with genetically identical or similar weeds. The author does not always follow his own logic. I was surprised that having drawn attention to the high risk of herbicide resistance arising in orchards through repeated herbicide applications, advocacy is then made for the adoption of herbicide tolerant trees. Despite lots of ideas for preferable types of herbicide tolerant crops, the additional markets are not always there and enlightened self-interest is not high up on business' agenda. Frankly, we are unlikely to see genetically modified crops coming onto the market tolerant to new herbicides.

Not just about chemical control

Refreshingly, this is not a book just about chemical weed control. The later chapters turn to more novel possibilities of weed control, entailing a degree of crystal ball gazing. Arguments are, for example, put forward for transgenically neutralising the aggressiveness of weeds or for engineering the required hypervirulence into pathogens for effective biological weed control. By the author's own admission, some ideas are flights of fancy but in other cases, a deal of the molecular ground work is there. Creditably, failsafe mechanisms to limit inter-specific transgene transfer are imaginatively discussed in the same level of detail as the warfare technology itself.

Gressel's highly personal, restless and well referenced essay will find a home on the bookshelves of many scientists. Will it be consulted by policymakers? I doubt it and so the calls for greater public and institutional backing for research to help secure long term sustainability of weed control beyond private industry's time horizons are likely going to fall on deaf ears. To rent a quote from within 'the human mind is like a parachute – useful only when open'. In a world where orthodoxy is in the ascendant in science we need those open minds more than ever. Weeds are a lot smarter than we give them credit for and orthodoxy will not give us the tools to stay on top.

Reference

Anderson, J. V.; Horvath, D. P. (2001) Random sequencing of cDNAs and identification of mRNAs. *Weed Science*, **49**, 590–597.

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