The BCPC Weeds Review 2023: Ken Pallett (*Outlooks on Pest Management* Editorial Board Member)

The 60th Annual BCPC Weeds Review took place on Thursday 2nd November 2023 at Sophi Taylor Building, NIAB, Cambridge with a total of 124 delegates at NIAB or online. The Expert Review was split into three sessions. Firstly, a reflection on 60 years – 'looking back and forward' – what can we learn? The second session was a crop/weed focus and the Review was completed by a session covering the advances in technologies as IWM techniques.

James Clarke (ADAS) started session one with a presentation entitled 'Weed management: 60 years of experience'. The presentation started with some general comments on weeds from a RHS member survey stating that 'weeds are not seen as bad by all' and divide option.

In 1950 the Agricultural Research Council established a weed research unit in Oxford. One of its objectives was to develop chemical weed control using inorganic, and the first organic herbicides. In 1953, the constitution of the British Weed Control Council (BWCC) was adopted with objectives including; the promotion and encouragement of science and the practice of weed control; the organisation of conferences on weed control; the dissemination and publication of information on weed control; and the collaboration with other organisations to encourage the science and practice of crop protection. Similar organisations were established to address pests and diseases and in 1967, were amalgamated to form BCPC.

The extent of interest in weeds was clear in 1956 with the first biennial British Weed Control Conference in Harrogate comprising 1745 delegates, 132 papers in 3 volumes. Elsewhere other organisations were established to address weed research globally with the formation of the European Weed Research Council in 1960 (the European Weed Research Society since 1975) and in 1979 the International Weed Science Society was formed. A further significant milestone in weed research was the establishment of Weed Research Organisation (WRO) from 1960. This reached a peak of 79 scientists and a total of 135 staff prior to its closure in 1986 and relocation of about 30 staff to Long Ashton Research Station. In 1990 when Long Ashton was closed, government research efforts on weeds were covered by 4 scientists at Rothamsted, a sad reflection on the status of weed science in the UK today.

The review of the last 60 years covered the growth of publications such as the BCPC Weed Control Handbooks, as well as various weed biology texts from other publishers. These became the foundation texts for the author during his research and teaching in the 1970s and 1980s

The establishment of weed research was triggered from the use of the first herbicides and from then onwards agrochemical companies started their own R&D. The 1980s and 1990s was the peak of new herbicide discovery and commercialisation with the biennial BCPC Weeds conferences playing a role in the launch publications in the new molecules sessions which kicked off the conferences.

Now many of these molecules have been withdrawn from use for regulatory or commercial reasons and the challenge is to maintain the remaining herbicides and to integrate them with other weed management measures. The alternatives to herbicides were briefly reviewed starting with manual weed control, then with the assistance of horsepower, the use mechanical measures, developments in application technology with herbicide application and non-chemical alternatives such as electric, foam and laser technologies.

However, herbicides will still play a major role in the changing balance of weed control but the greatest concern is their environmental impact on water quality and the development of weed resistance. It is also becoming very challenging to develop and authorise new herbicides due to specific issues such as non-target plants regulations. A further challenge will be the integration of herbicides with cultural weed management measures both within field and in crop rotations.

The final part of the presentation covered the initial outcome of a survey on reflections and experiences over the last 60 years. The survey covers the profile of the respondents, their views on the worst weeds, those weeds which most influence decision making, the importance of weed management measures (to date and in 10 years' time, the decade when weed management was easiest and most successful, the challenges in the next 10 years and priorities for R&D investment.

The main results from an initial 36 respondents were presented. Annual and arable weeds still dominate and others (e.g. perennial broad-leaved weeds) are just as important in specific situations. Herbicides will remain important with the major challenges of their availability, weed resistance and regulatory authorisation. There is a demand for improved prediction, decision support (of need & impact) and weed detection. New developments in targeting and application practice and formulation improvements could help. There are needs for investment to gain new knowledge and knowledge exchanges.

Finally, it was concluded that the initial BWCC objectives from 60 years ago are still highly relevant today and weeds still divide opinion. The survey remains open and can be reached via the following link: https://forms.office.com/e/M54Mt6EkPp.

Jim Orson then facilitated a delegate discussion on the dominant weed species for 2002-2023. The weather during autumn 2022 to July 2023 determined the main weed control issues in broad acre crops. The discussion then split into three areas, cereals, sugar beet and peas and beans. **John Cussans** (NIAB) led discussion on cereals and not surprisingly, annual grass weeds such as black-grass, Italian ryegrass and bromes were the major species of concern. There was a general discussion regarding the increase in brome species, particularly in situations of reduced cultivation and where brome seed may be encroaching from field margins. Herbicides appeared to work as well as expected, including the introduction of cimethylin.

Pam Chambers (British Sugar) led discussion on sugar beet. An increased use of min-till and reduced cultivations to establish beet is bringing new weed control challenges, especially where glyphosate is not applied in the early spring. ALS resistance is suspected with poppies, chickweed and mayweeds and this will need monitoring where ALS tolerant beet is being grown. Fat-hen and groundsel have also been issues this year. There is the risk of cover crops and wild bird mixes introducing 'new' weeds to beet such as barnyard grass and chicory. It was discussed that weed species identification is important, especially with the more unusual species to ensure the populations are not building up if less well controlled by current chemistry.

Becky Howard (PGRO) reviewed weed control in peas and beans where pre-emergence herbicides worked well both in the autumn and spring except in early drilled winter beans. The major weed

problems occurred as a result lack of crop competition and a wet July and included fat-hen, black nightshade and black-bindweed. The recent authorisation of aclonifen in peas and field beans will help in pre-emergence control of annual grass weeds.

The session was completed with a suggestion that we should be considering of weeds across the whole crop rotation rather than just thinking of each crop in isolation, including an understanding the weed seedbank and the use of chemical options based on the weed spectrum present.

Ian Graham (Complete Weed Control) began session two with a presentation on IPM in the amenity sector: Challenges posed by a possible withdrawal of glyphosate was the central theme. Complete Weed Control comprises national application specialists serving the amenity sector and is a strong supporter of science leading best practice.

The alternatives to glyphosate are very limited, particularly for weed control in public areas. Those mentioned included: doing nothing; hand weeding; hot water or steam; infrared exposure; flame; hot foam; brushing; or acetic acid. All of which were considered non-viable with challenges driven by political, social, practical, financial, environmental and labour considerations.

The remaining part of the presentation focussed on an independent trial commissioned by Cardiff Council for alternative weed control treatments on pavement areas over a whole growing season. The trial comprised a large scale test under 'real world' conditions designed to provide realistic data to underpin decision-making. The treatments were: acetic acid (contact herbicide); hot foam (contact treatment); glyphosate (systemic herbicide) were used to benchmark alternative treatments; and a control (no weed treatment). Data analysis addressed treatment cost, environmental impact (water use, herbicide use, fuel consumption and modelled CO_2 emissions), customer complaints and efficacy.

Hot foam had higher environmental impacts in all categories calculated except for freshwater eutrophication where glyphosate had the greatest impact. The treatment which had the lowest overall environmental impact was glyphosate. Glyphosate-based control methods used the least materials, had the lowest environmental impacts and also the lowest economic costs. Objectively, glyphosate was the most sustainable treatment. In summing up, it was stated that an annual foliar application of glyphosate was the only serious solution for Japanese knotweed control. It was also stated that there is a need to think carefully about the evaluation of sustainability in amenity weed control and that new/alternative approaches must be rigorously tested before we consider adopting them as best practice.

John Cussans (NIAB) then gave a presentation on the increasing threat of Italian ryegrass. A number of surveys conducted in recent years have shown that Italian ryegrass (*Lolium multiflorum*) is becoming an increasing on farm problem. It is competitive with a high seed production (1500-3000 seeds per plant in October–drilled winter wheat) greater than that of black-grass. It is predominantly autumn germinating in a winter wheat crop but with a relatively long 'tail', with plants emerging through to April. Cultural control such as ploughing, deep non-inversion and direct drilling that work for black-grass also work for Italian ryegrass but not as well. It is a diverse weed problem with phenotype variation hints at the genetic diversity between populations. There are also differences in ploidy levels between populations, although almost all problematic arable weed populations are diploid.

Italian ryegrass as an arable weed has variable vernalisation requirements which determine the fitness of a population in different cropping scenarios. There is also variation in field populations of freshly shed seed, in overall dormancy and in response to light/dark conditions. Sensitivity to herbicides is also variable and as an example when populations collected from two fields on the same farm well

over half are significantly different in herbicide sensitivity which is important to understand when planning resistance testing/monitoring. An example was given for the sensitivity of plants to flufenacet from 10 fields on the same farm which ranged from total sensitivity to complete tolerance. A recent survey has also shown variable sensitivity for ALS inhibitors and pinoxaden however, the nature of the resistance mechanism in ryegrass to flufenacet in particular, means that a mode of action diversity approach brings not just resistance management but also improved efficacy.

The major concern with Italian ryegrass is resistance to glyphosate. A 5-fold difference in glyphosate sensitivity between 50 'difficult' populations has been shown, greater than that for blackgrass, sterile brome and rat's tailed fescue.

It was concluded that Italian ryegrass was becoming more widespread and an increasing challenge on individual farms. It is more challenging to manage than black-grass from a cultural perspective especially in terms of the effectiveness of spring cropping. The number of herbicide resistance traits are becoming more common with reduced sensitivity to pre-emergence herbicides is evolving rapidly. Monitoring of glyphosate sensitivity is an absolute priority; nationally and on individual farms. The inherent genetic diversity of the species is part of the challenge and means understanding the genetic relatedness of individuals and populations needs to be the key focus

The session was completed by a PhD pitch slot and poster session with **Jasper Kanomanyananga (University of Lincoln)** presenting his research project 'Unlocking weed seed losses in regenerative agriculture for resilient weed management'. This project focusses on reducing post-harvest seedbanks of blackgrass and other annual weeds. Initial results indicate that in spring wheat, weed surfing three times (80, 90, and 100 days after sowing) and at the middle (90 DAS) and later stages of the reproductive phase (100 DAS) reduce the total number of heads by about 45 - 55% in both black-grass and Italian ryegrass. No-tillage fields had a significantly higher predation rate than conventionally cultivated fields, indicating the importance of minimum soil disturbance for promoting beneficial predators that can suppress seed populations. The potential implications for these approaches may offer an option for durable weed control and support the principles of regenerative agriculture, offering valuable tools for more resilient and sustainable agroecosystems.

Session three started with a presentation by **Harry Fordham (Syngenta)** on 'Application Technology - The past, the present and the future'. The history of spray application was reviewed with a characterisation of the early nozzle types. The need for drift reduction and buffer zones changed application technology from the point of nozzle design and 90% drift reduction is now possible. New nozzles such as 3D ninety not only achieve the 90% drift reduction requirements but are optimised for efficacy of pre- and post-emergence herbicides and fungicides.

Syngenta have developed 'Spray Assist', an application which covers: 5-day weather with hourly spray timing guidance and alerts if conditions change; planning of sprays and recommendations on nozzles and parameters; registration of equipment and nozzles used to receive optimised recommendations); and access to the Syngenta Digital Farm Set-up. The future for application technology will move from broadcast applications to 4 levels of precision application, banded, patch prescription, variable rate (VR) prescription and plant-by-plant optical spot spray. All these technologies allow targeted applications to individual pests, diseases or weeds in the field.

David Comont (Rothamsted Research) then gave a presentation which gave more detail on imagery of weeds entitled 'Weed detection for targeted weed management and control'. Computer vision could offer the potential to discriminate weed plants from crops in-field. A growing body of work is attempting to develop this technology and apply it to precision weed management. Precision weed

management might deliver both economic and ecological benefits via reduced herbicide use – provided weeds can still be controlled simply and effectively. Weed detection can be achieved using drones or on-farm machinery.

Two case studies were presented, firstly addressing the detection of black-grass at the flowering stage using UAVs (drones) to capture imagery in-field and to train algorithms to recognise weeds. Two imagery types were analysed. Firstly, the visible light spectrum or standard red-green-blue (RGB) and secondly multispectral (collecting data at wavelengths 475, 560, 668, 717 and 840nm). Normalized Difference Vegetation Index (NDVI) was applied which provides a measure of "greenness" and is a standard measure in assessment of crop health and development.

The second case study addressed upgrading farm machinery to detect weeds by incorporating cameras/sensors such as a smart sprayer system, developed by Bosch and BASF and again focussed on black-grass detection. This involved building up a large library of black-grass and wheat imagery from plants at different growth stages grown in trays. Images were captured using the same camera and lighting equipment to be deployed in the field to create an imagery database to aid algorithm development. Weeds can be successfully detected at earlier growth stages, but the bottleneck is annotation of imagery

It was concluded from the two case studies that for UAV mapping, resolution was the most important aspect, followed by speed (slow!), lighting, and timing. Increased infrared data from the multi-spectral sensor did not aid model performance. NDVI was not helpful in detecting flowering blackgrass, but is useful in separating vegetative plants from background: soil, crop residues etc. The smart-sprayer system allowed the collection of large amounts of crop weed imagery. The real bottleneck now is finding ways to accurately and quickly annotate images for model training.

Nick Tillet (Tillet & Hague Technology) completed the session with a presentation on 'Mechanical weed control advances indicating a greater use of mechanical weed control strategies'. These range from a gentle disturbance of the whole cropping area relying on crop robustness for selectivity to aggressive cultivation of uncropped area only. Uniform overall tine and uniform rotary harrowing both rely on desiccation requiring dry conditions as a mode of action to manage weeds. With both there is need to follow ground contour for uniform depth control. With the former, the angle of adjustment controls aggressiveness. There is better tolerance to trash with the uniform rotary harrow. Both require skill and concentration to keep hoe blades aligned.

Reference was made to GPS guidance, the use of optical sensors and use of computer vision based row guidance to support mechanical weed control. However, these tools need to be cost effective for the farmer to use.

Other options for mechanical weed management were presented such as: mechanical feeler row guidance; inter-row soil engaging tools; and in-row cultivation using reciprocating or rotary blades.

Alternatives to mechanical methods were considered. There are a wide variety of thermal weed control techniques which lead to low soil disturbance but are generally slow and have a very high energy demand. Electrocution is potentially good for control of deep rooted weeds but is slow and has safety issues. Laser use is fast acting and concentrates energy but requires very high precision targeting, is slow and has safety issues.

It was concluded that for future mechanical weeding options to be successful, there needs to be an improvement in the ease of guidance setup and performance robustness. The use of new technologies such as using vision system to gather data as well as guide implements need to be integrated. There

should be a doubling up on treatments for more efficient operation e.g. hoeing and targeted fertilizer application. There should be research and education on how to fit mechanical weeding into integrated weed control strategies. Cultivation probably remains the most versatile and cost effective and there should be a full life cycle evaluation of alternative weeding options.