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New strategies to maintain autumn grass-weed control in cereals and oilseed rape.

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1. ABSTRACT

Effective grass weed control is essential if rotations of mainly autumn-sown crops are to be maintained. In future scenarios greater reliance will be placed on fewer herbicides due to increasing herbicide resistance, the absence of any new modes of action and the potential loss of key herbicides arising through the Water Framework Directive and other EU legislation. New weed control strategies need to focus on herbicides that are applied pre- or early post-emergence. The immediate concern that the Industry faces is therefore maintaining effective strategies based on remaining herbicides, but avoiding exacerbating resistance or pollution issues. This research project has ostensibly developed approaches to ‘stacking’ (applying more than one active ingredient or herbicide product at the same time) and ‘sequencing’ (when different active ingredients or mixtures of active ingredients are applied in close succession) techniques to deliver effective grass weed control and make best use of the options available. Research has specifically addressed the control of black-grass (*Alopecurus myosuroides*) and barren (sterile) brome (*Anisantha sterilis*) in cereals, black-grass in oilseed rape and annual meadow-grass (*Poa annua*) in cereals. With regard to the management of black-grass in winter wheat this has been done without the use of iodosulfuron-methyl-sodium + mesosulfuron-methyl (Atlantis, Bayer CropScience) where grass weed resistance is a developing issue. Research has developed approaches suited to a range of scenarios. Considering black-grass in oilseed rape findings highlight the continued importance of propyzamide and carbetamide and outline routes to help maximise their performance. Considering grass weed control in cereal crops, several active ingredients remain key to managing both barren brome and black-grass, notably flufenacet but also prosulfocarb and tri-allate (several other active ingredients have also delivered useful contributions to ‘stack’ and ‘sequence’ approaches). Data suggests that ‘stack’ and ‘sequence’ approaches can improve the robustness of the weed control strategies; with generally at least 3 active ingredients being needed in the more successful approaches. For barren brome control in winter wheat, particularly in high pressure situations, a robust programme involving a residual herbicide and ALS inhibitor (i.e. herbicides targeting the acetolactate synthase (ALS) enzyme) components is likely to be required. Research considering black-grass in cereals has developed a series of stacking and sequencing approaches however, data suggests where populations in untreated plots exceed approximately 100 heads m^{-2} control offered through stacking and sequencing approaches is unlikely to offer >95% reductions in black-grass heads. In all scenarios, where grass weed populations are high non-chemical management practices should also be considered.

2. SUMMARY

Effective control of grass weeds in the autumn is fundamental to the delivery of rotations comprising mainly autumn sown crops. In the future it is likely that in order to deliver effective grass weed control greater reliance will need to be placed on fewer herbicides, due to increasing herbicide resistance, the absence of any new modes of action and the potential loss of key herbicides under the Water Framework Directive and other EU legislation. The immediate concern that the Industry faces is therefore maintaining effective weed control strategies based on remaining herbicides, but avoiding exacerbating resistance or pollution issues. HGCA Research Review 70 indicated that a projected industry loss from black-grass (*Alopecurus myosuroides*) due to potential product withdrawals arising from (or following) 91/414/EEC could be around £185 million p.a. while product losses due to the Water Framework Directive could cost in excess of £500 million p.a.; the review indicated that losses from other grass-weeds would also be appreciable. Research within this project has specifically addressed the development of 'New strategies to maintain autumn grass-weed control in cereals and oilseed rape' in relation to the control of black-grass and barren or sterile brome (*Anisantha sterilis*) in cereals, black-grass in oilseed rape and meadow grass (*Poa annua*) in cereals. Field trials were conducted through NIAB TAG and SAC (now known as SRUC) over 4 seasons in harvest years 2008, 2009, 2010 and 2011 at a range of locations in England and Scotland. Fully replicated field experiments were generally undertaken in 'farm crop' established in accordance with local best practice and were located in situations where a high burden of the desired problem weed was anticipated. Approaches have ostensibly sought to develop 'stacking' (applying more than one active ingredient or herbicide product at the same time) and 'sequencing' (when different active ingredients or mixtures of active ingredients are applied in close succession) techniques. It should be noted that treatments outlined within this report are not necessarily currently approved for use in the crops and scenarios described. This is either due to experimental use of materials to examine their suitability or changes in approval since the research was undertaken (for example chlorotoluron was used in this project as a separate product and it is now only available in co-formulation with diflufenican). A summary of key findings is presented beneath.

2.1 Annual meadow grass (cereals)

Approaches for the control of annual meadow-grass have tended to historically include isoproturon (IPU); in these studies isoproturon delivered, on average, a 95% reduction in the ground cover of annual meadow grass. However, a range of other currently available herbicides also delivered similar, or superior, levels of control across a wide range of application timings (ranging from pre-emergence through to a 2-3 leaf stage of the weed). Many of these approaches will require a modification to timing compared to isoproturon, however they do demonstrate dose flexibility and, in addition to controlling annual meadow grass, many are also capable of delivering useful control of a range of broad-leaved weeds. Pre-emergence programmes including (but not limited to) the active ingredients flufenacet (e.g. in Liberator, Firebird and other herbicides), prosulfocarb (Defy) and pendimethalin (various products) have tended to be among the stronger performing approaches and also demonstrate useful dose flexibility providing a range of cost options to growers. Many of these materials are also suited to peri- or early post emergence use. Post emergence active ingredients such as chlorotoluron (subject to varietal suitability) and flumioxazine (e.g. Guillotine) can still also deliver useful levels of control. For later post emergence control, ALS inhibitor based products (or co-formulations) such as diflufenican + iodosulfuron-methyl-sodium + mesosulfuron-methyl (Othello) can provide effective control and will also provide useful control of other weeds. While research addressing the management of annual meadow grass was only undertaken in winter wheat, where products are approved it could be expected that control in winter barley should be comparable.

2.2 Barren Brome (winter barley)

Across a range of treatments for the control of barren brome in winter barley 'stack' and 'sequence' approaches tended to deliver higher levels of control compared to the use of single actives ingredients or timings; even at low populations. However, findings do suggest that where a brome population of greater than (approximately) 10–15 plants m^{-2} were present in the spring even the more effective programmes struggled to deliver in excess of 80% reduction in brome heads (fertile tillers). This is perhaps not unexpected given that the herbicides available for brome control in winter barley are limited to autumn applied residual herbicides. Strong spring crop competition in barley is also likely to be important. Where brome populations are high non-chemical management practices should also be considered.

The active ingredient flufenacet was common to many of the more effective barren brome control programmes in winter barley and incremental reduction in heads was found in response to increased dose. Tri-allate (Avadex Excel) also gave useful levels of control of barren brome, although typically less than that delivered by flufenacet based approaches. Of the other herbicide options examined, both flurtamone + diflufenican (Graduate) and chlorotoluron (on suitable varieties) tended to be insufficient to deliver effective control alone, however, their contribution within wider programmes and 'stack' and 'sequence' approaches was noteworthy. The range of herbicides examined provides growers with potentially valuable options to deliver suitable 'stacking' and 'sequencing' programmes for the management of barren brome in winter barley.

2.3 Barren brome (winter wheat)

Research within this experimental series suggests that ‘stack’ and ‘sequence’ approaches can deliver higher levels of barren brome control compared to the use of single actives ingredients or timings. Such approaches are key to reducing the number of barren brome plants / heads where brome pressure is high. The active ingredients tri-allate (Avadex Excel), flufenacet (e.g. in Liberator, Firebird and other herbicides), prosulfocarb (Defy) and chlorotoluron (various products) tended to feature among the more effective autumn options. As with barren brome control in winter barley, the active ingredient flufenacet was common to many of the more effective programmes and increasing control was apparent in response to incremental dose. Avadex Excel (tri-allate) also gave useful levels of control of barren brome across a range of weed pressures, particularly when used in ‘stack’ and ‘sequence’ approaches. Chlorotoluron (on suitable varieties) can also provide useful control when used in ‘stack’ and ‘sequence’ approaches.

The use of suitable ALS inhibiting products with a label recommendation for brome (e.g. products containing pyroxsulam or iodosulfuron-methyl-sodium + mesosulfuron-methyl) were particularly effective. In low pressure barren brome scenarios the use of an ALS inhibitor product alone or the use of a suitable autumn residual herbicide programme can substantially reduce brome head numbers and deliver acceptable control. However, in higher pressure situations robust programmes, generally involving residual herbicide and ALS inhibitor components are required. There are a range of ‘stack’ and/or ‘sequence’ options and cost structures available to deliver effective control of barren brome in these scenarios. In very high pressure scenarios it is likely that even intensive herbicide programmes may not reduce populations to a level that would not compromise yield; additional none chemical control routes will be required in these situations.

2.4 Black-grass (oilseed rape)

The choice of residual grass weed herbicides for oilseed rape is becoming increasingly limited and there is concern over water pollution arising from the use of some key active ingredients. However, the crop presents a key opportunity for black-grass management; not least because carbetamide (e.g. Crawler) and propyzamide (e.g. Kerb Flo) are not affected by resistance. Metazachlor (Butisan S and others) have traditionally been key pre- and early post emergence herbicides for use in oilseed rape, however, restrictions on cumulative use are being imposed. Research within this programme has evaluated other options for use in this window, specifically napropamide (Devrinol T) and tri-allate (Avadex Excel). When used alone performance of these products can vary but, when used at commonly applied doses, they delivered similar control of black-grass plants to Butisan S (averaging around 40–45% control). While ‘stacking’ and sequencing’ these materials can improve the percentage control achieved, in general control levels have still typically been inferior to the most effective control programmes based around propyzamide (Kerb Flo and others) and/or carbetamide (Crawler and others); clearly demonstrating their continued importance. Research undertaken with propyzamide and carbetamide indicates that both timing and dose are important in maximising performance. Increasing control was associated with higher doses but research also suggests that with propyzamide a reduced dose at a time conducive to good efficacy can be as effective as a higher dose at a less favourable time. This could have important implications for managing both black-grass populations and the potential movement of herbicides to water. In general carbetamide demonstrates greater timing flexibility while propyzamide shows greater dose flexibility; where these products are to be used in sequence carbetamide should be used first. With regard to maximising overall black-grass control the strongest approaches tended to be the use in ‘stack’ or ‘sequence’ approaches. For example an appropriately timed autumn residual (such as propyzamide and/or carbetamide) with other herbicides (e.g. in a sequence with a metazachlor based product, although other options could be used). Weed pressure will have strong bearing on the cost of achieving effective black-grass control in oilseed rape. However, the opportunity afforded by propyzamide or carbetamide to manage resistant black-grass can contribute the strategy to manage this weed across the rotation (not just in the oilseed rape crop) and should be considered within this.

2.5 Black-grass (winter barley)

Herbicide approaches for the management of black-grass in winter barley are similar to those used in winter wheat (mainly with the exception of post emergence options based on ALS inhibitor materials). This places a strong reliance on autumn applied residual herbicides. With regard to autumn residual herbicides research in this series suggests that treatments involving flufenacet (a constituent of both Crystal and Liberator) tended to give the higher levels of black-grass control and that this control stemmed ostensibly from the flufenacet component of these materials. Prosulfocarb (Defy) used alone generally delivered lower levels of control compared to flufenacet based products, however, where it was used pre-emergence in conjunction with pendimethalin or used alone at an early post emergence stage levels of black-grass control similar to flufenacet based products were achieved; providing an alternative to flufenacet based approaches. Data also indicates tri-allate (Avadex Excel) to be a useful material for black-grass control programmes in winter barley. In general the more robust black-grass management programmes in winter barley involved ‘stack’ and ‘sequence’ approaches; such approaches generally deliver higher levels of control compared to the use of single actives ingredients or timings. While flufenacet featured commonly in approaches delivering higher levels of control, the following active ingredients have also featured; prosulfocarb, tri-allate, chlorotoluron (various products), pinoxaden (e.g. Axial), diflufenican (e.g. Hurricane) and flurtamone (e.g. Graduate). 'Stacking' and 'sequencing' approaches in winter barley can deliver in excess of 90% control of black-grass heads at untreated populations of around 100 heads m^{-2} (this is analogous to findings in winter wheat). There are a range of options and cost structures available to deliver black-grass control and programme selection will be influenced by specific scenarios. Many of the materials highlighted will also provide useful control of other grass (e.g. annual meadow grass) and broad-leaf weeds. Where black-grass pressure is high, consideration should also be given to cultural control options.

2.6 Black-grass (winter wheat)

Black-grass populations in winter wheat are becoming more difficult to control due to increasing herbicide resistance and reducing herbicide availability. Research within this programme has sought to develop further alternative approaches based around 'stacking' and 'sequencing' of available herbicides (or combinations of the two routes) without the use of iodosulfuron-methyl-sodium + mesosulfuron-methyl (Atlantis). The degree of control of heads achieved through these routes is associated with the size of the black-grass infestation and higher levels of control can only be achieved in low to moderate populations. Findings suggest that where populations in untreated plots exceed approximately 100 heads m^{-2} (possibly 10–15 surviving plants m^{-2}) the level of control offered through stacking and sequencing approaches is unlikely to offer >95% reductions in black-grass heads. In high black-grass pressure situations even intensive programmes are unlikely to reduce populations to commercially acceptable levels and additional cultural control routes will be required.

With regard to specific approaches, pre- and early post emergence herbicide options based on flufenacet (e.g. Crystal and Liberator) tended to give the higher levels of black-grass control (with data suggesting that control is ostensibly derived from the flufenacet component). Tri-allate (Avadex Excel) can also deliver similar levels of control. Prosulfocarb (Defy) used alone generally delivered lower levels of control however, where it was used pre-emergence in conjunction with pendimethalin or used alone at an early post emergence stage control improved (to similar to tri-allate and flufenacet based products). However, it is clear that the use of pre-emergence herbicides alone is unlikely to deliver adequate control and combinations through 'stacks' and 'sequences' will be required in most scenarios. Within the experimental series a variety of 'stack' and 'sequence' approaches have been explored and a range of routes demonstrated to deliver acceptable black-grass control; generally at least 3 active ingredients were needed in the more successful approaches. Flufenacet is an important component (incremental doses of this active have been shown to improve the control of black-grass); however, over reliance on any single active ingredient is of concern and approaches have also demonstrated non flufenacet based routes, such as those based around tri-allate (Avadex Excel) and prosulfocarb (Defy). A range of other active ingredients have also featured in specific ‘stack’ and ‘sequence’ approaches, including (but not limited to) chlorotoluron (various products and subject to varietal restrictions), flurtamone (e.g. Graduate) and diflufenican (e.g. Hurricane). These approaches also resulted in a high percentage reduction in black-grass heads even where ALS resistance (resistance to Atlantis) was present. This suggests that effective control is possible where resistance results in little or no contribution from ALS inhibitor products such as Atlantis. Research has shown little difference between ‘stack’ and ‘sequence’ approaches. However, at times, it may be expected that a ‘sequence’ of the same products will be more effective if the components are applied in conditions conducive to herbicide activity. For example in dry conditions treatments based on tri-allate (Avadex Excel) have been shown to more successful in relative terms.

The use of ‘stacking’ and ‘sequencing’ approaches will require an alteration to herbicide strategy for many growers. Specifically the strong reliance on residual herbicides applied pre- or early post emergence will require materials to be applied either before or at early stages of black-grass emergence. ‘Stacking’ and ‘sequencing’ techniques can also provide useful control of other grass (e.g. annual meadow-grass) and broad-leaf weeds. The specific costs of ‘stacking’ and ‘sequencing’ will be influenced by the products used and the deals through which they are purchased. Such approaches in many cases are likely to be more expensive than established strategies for many growers however wider farm adoption has become more common since autumn 2009.