A solution to weed control in grassland containing white clover

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Abstract. Productive grass with white clover can lead to advantages both in forage quantity and quality, economics and in meeting wider expectations detailed in recent EU and UK policy. The ability to achieve this agronomic success is currently difficult due to a lack of options for broad spectrum weed control that also allow establishment or preservation of a white clover population. The aim of this paper is to demonstrate that 3730XL, developed by Corteva Agriscience, is a solution to this critical success factor. Data is presented from 16 efficacy trials (10 from established grassland and 5 from newly sown) where white clover cover of plots treated with 3730XL was recorded relative to an untreated plot. Data is also presented from 106 weed control trials, against a selection of species, demonstrating the efficacy of 3730XL split by grassland scenario. The evidence presented highlights the capability of 3730XL to both control a broad spectrum of weed species and allow the establishment or preservation of white clover. Consequently, growers are able to cultivate the associated benefits that this confers.

Introduction

Governments across the globe are publishing bold commitments aiming to limit the impact of climate change and environmental degradation. The European Union (EU) has the 'Green Deal' (European Commission n.d.) comprising various strategies such as the 'Farm to Fork' strategy that details numerous objectives. Targets include reducing nutrient losses and the use of fertilizers; the Irish government is aiming to reduce chemical fertilizer use, and greenhouse gas (GHG) emissions with a focus on increasing white clover populations in grazing grassland (Buckley *et al*. 2020). Another goal is reducing the dependency on critical feed materials (e.g., soya grown on deforested land) by fostering, amongst other things, EU-grown plant proteins (European Commission 2020). Similarly, the United Kingdom (UK) government has produced a 25-year plan to improve the environment with goals to use fertilizers more efficiently and to support zero-deforestation supply chains (HM Government 2018). Considered along with current fertilizer prices, energy costs and high commodity prices, there is increased focus on maximizing the quantity and quality of home-grown forage.

There is then greater interest in the role of white clover in grassland. White clover, part of the *Fabaceae* family, is a perennial plant that can fix atmospheric nitrogen. This is achieved through a symbiosis with Rhizobia bacteria that live in root nodules on the clover plant and in exchange for sugars provide the clover with nitrogen fixed from the atmosphere (Cooper and Scherer 2012). Depending on management and ground cover, white clover can fix 0-280 kg/N/ha/yr (Cowling 1982). White clover in grassland can also increase the nutritional value of the forage produced with possible associated benefits to liveweight gains and milk production (AHDB n.d.). For these benefits to be realised, the grass and white clover must be growing productively which may require weed control.

Corteva Agriscience have developed a product (referred to in this paper as 3730XL) containing the actives Rinskor^{TM} (Epp *et al*. 2016) and amidosulfuron that can achieve the important function of controlling key broad-leaved weed species whilst preserving the white clover population already present. In this paper, data on white clover content after treatment is presented and efficacy data on some of the key weed species controlled. In an established grassland scenario – currently defined as grassland more than 1 year old - data is presented on *Anthriscus sylvestris*, *Heracleum sphondylium*, *Ranunculus repens*, *Rumex obtusifolius* and *Taraxacum officinale*. In a newly sown scenario – currently defined as grassland less than 1 year old – data is presented on *Ambrosia artemisifolia*, *Capsella bursa-pastoris*, *Chenopodium album*, *Matricaria chamomilla*, *Polygonum convolvulus*, *Polygonum persicaria*, *Rumex obtusifolius* and *Stellaria media*.

Methods

Data included in this paper originates from field trials in commercially managed grassland fields (106 in total) used to support the biological assessment dossier. Trials were carried out in accordance with Good Experimental Practice (GEP) principles by competent organisations adhering to relevant standards. Data from Belgium, France, Germany, Ireland, The Netherlands and the UK are included. All trials were conducted to 4 replicates with a plot size of 10-33m^2 to a randomized complete block design. Treatments were applied using bicycle or knapsack precision plot sprayers equipped with flat fan or air induction low drift nozzles delivering a water volume of 200 L/ha. Only data from the 3730XL treatment is presented here.

White clover level is displayed as % visual control (newly sown), as described below, or % visual control after an Abbott's transformation of % ground cover (established) and is relative to the untreated level. Data is presented at different time points post-application. The untreated level is represented by a line along the 0 value. Numbers above the zero line indicate more clover versus the untreated and vice versa for values below. Data on white clover is taken from assessments made in efficacy trials with a line for trials in established grassland (10 trials) and a line for trials from a newly sown scenario (6 trials).
Weed control is assessed on a percentage scale where 0% = no treatment effect and 100% = complete plant senescence. Weed control data is taken from assessments made end of season in the established scenario (60 trials) equating to around 161 days after application (DAA) and at regrowth after cutting equating to around 67 DAA in the newly sown scenario (46 trials).

Results and Discussion

White clover cover

Data relating to white clover level from 3730XL treated plots, relative to untreated areas, and how it changed over time in efficacy trials from established and newly sown scenarios is presented in Figure 1 **Figure *1***below. As a generalization, for newly sown grassland, data at 0-1 months after application (MAA) indicates visual impact to the white clover population soon after application, 2-4 MAA represents the population just before or soon after the first cut and data at 5-7 MAA indicates regrowth following cutting. No results were recorded at 11-13 MAA. For established grassland, data at 0-1 MAA indicates impact to white clover before cutting, 2-4 MAA indicates growth after cutting, 5-7 MAA indicates colonization by end of season (autumn) and observations at 11-13 MAA represent a year after long-term comparison. The untreated line means are denoted by the letter (a). Results significantly different to the untreated are denoted by the letter (b) at p = 0.05 using Tukey's HSD. No letters are presented for newly sown data as no significant differences were observed.

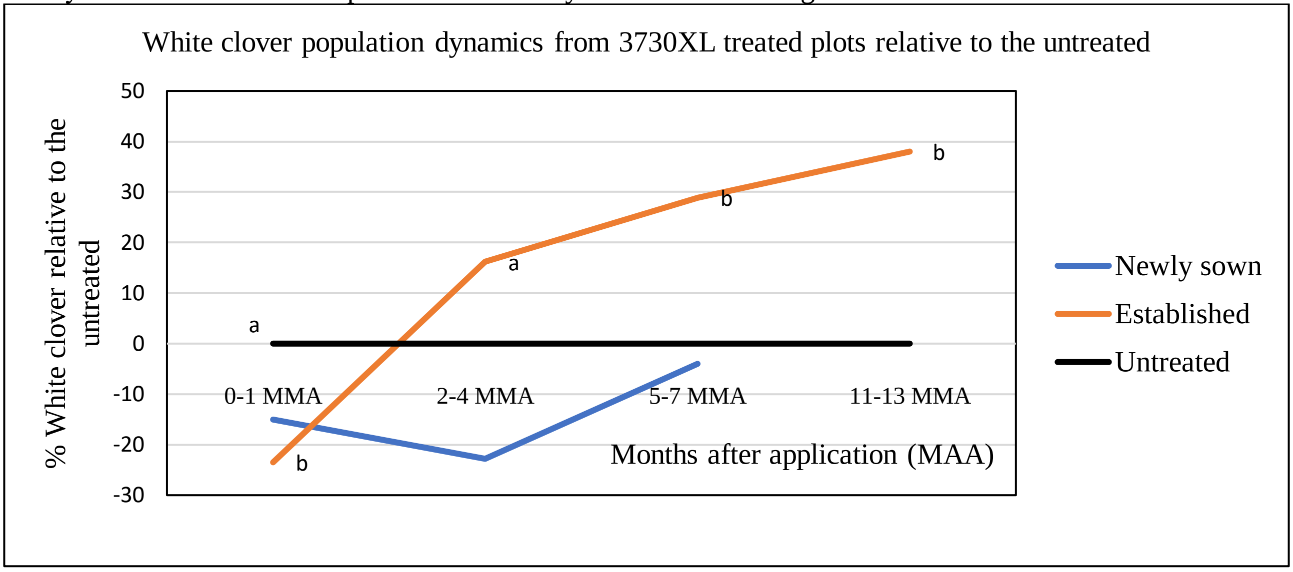

Figure 1: White clover population dynamics from 3730XL treated plots relative to the untreated level, 16 trials

Considering the newly sown data, an explanation for the initial decline - taking into account that the white clover would not be well established - is vulnerability to stress including both cutting and herbicide application which can impact growth rate. Brock and Hay (2001) reference a slow growing seedling phase where clover plants are small and stolon elongation may not have commenced. Once the white clover has overcome these stressors and possibly begun stolon extension and nodal root formation it is able to grow quicker, colonise the space and compete better with the grass. The area covered then approaches the untreated level.
Established grassland results show an initial decrease from 3730XL treated plots prior to the first cut post-application. From this point the white clover level increases becoming higher relative to the untreated. It was observed in the field that this level of increase was a result of 3730XL controlling weeds with the consequent gaps in the grass able to be colonized by the white clover. For pastures around 1-2 years old this is supported by Brock and Hay (2001) who reference a white clover expansion phase with plants rapidly expanding and branching. For older pastures, where the white clover plants may well be in the clonal phase, an explanation could be that although plants may not have a strong tap root, they are numerous enough and have sufficient nodal roots to exploit the newly created space (Brock and Hay 2001). The result is a white clover-rich sward free of weed species. Control of some of these species is presented below.

Efficacy of 3730XL

3730XL has been developed for use in both newly sown and established grassland. Commonly found weed species in newly sown grassland are annual whereas in established pasture are perennial; targeted weed size is also smaller in newly sown grassland. Consequently, a reduced rate is sufficient in newly sown grassland compared to the rate for established grassland. **Error! Reference source not found.** is presented providing information on the density and growth stage of weeds at application, the number of trials, mean control, minimum and maximum levels of control and coefficient of variation values.

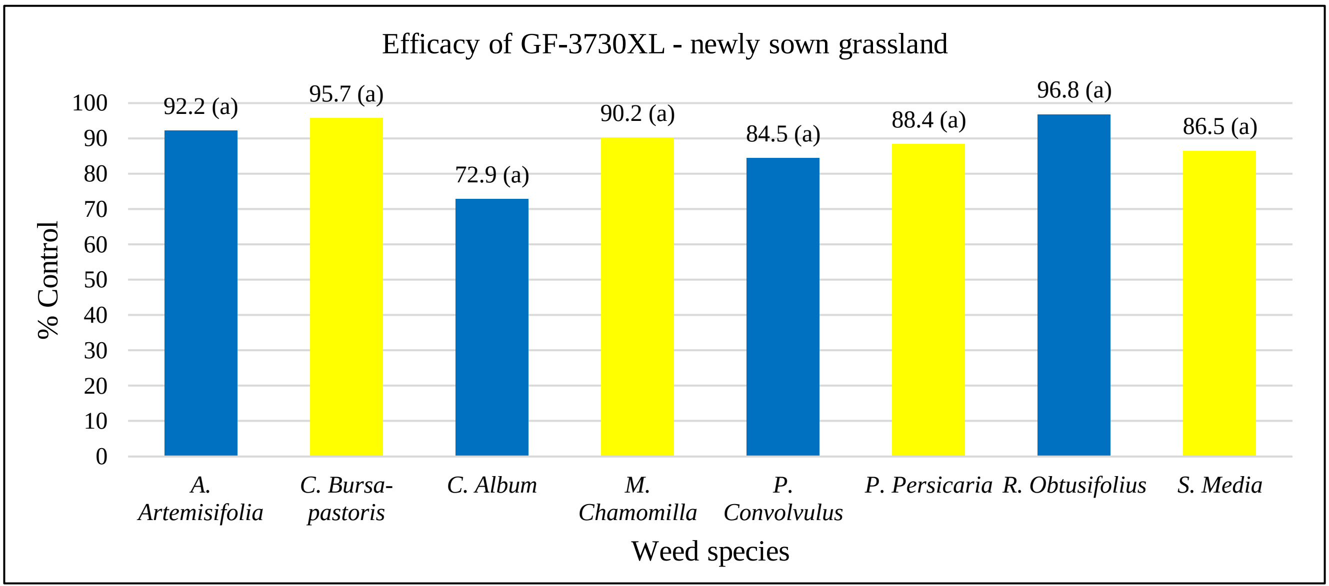

Figure *2* and Figure 3 are presented below, one for each grassland type, demonstrating control against some key weeds from 3730XL. Means followed by same letter do not significantly differ (P=0.05, Tukey's HSD).

Table 1: Data on weed density, growth stage, number of trials (n), mean % control (Ø), minimum and maximum control (min-max) and coefficient of variation (CV) from trials presented in

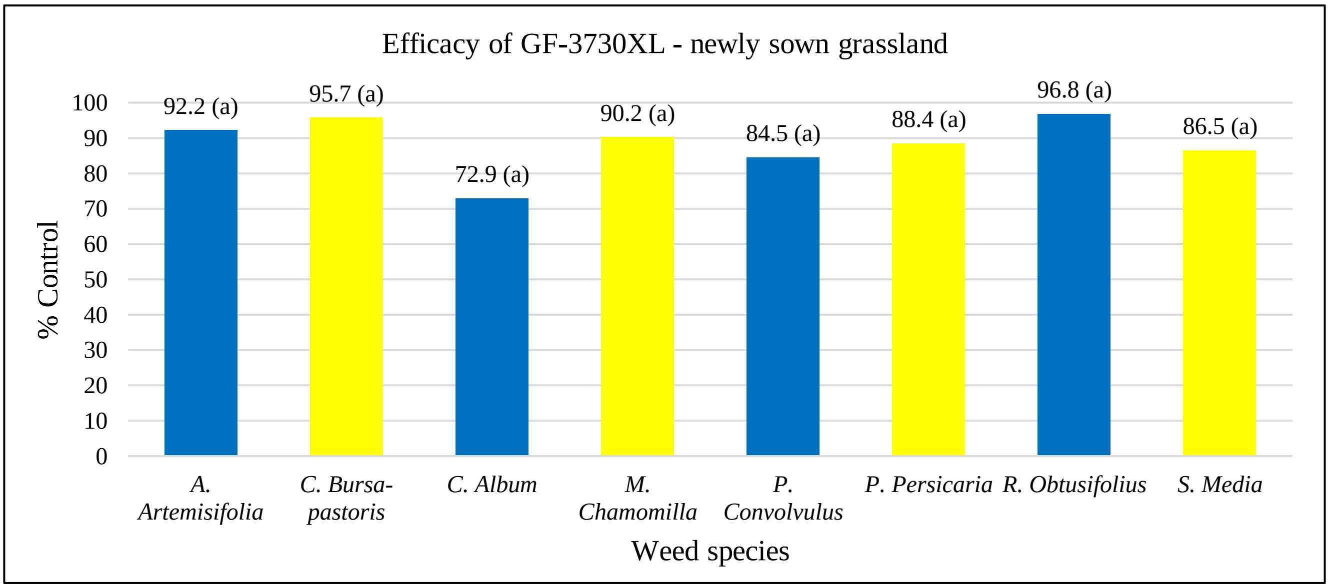

Figure *2* and Figure *3* highlighting efficacy of 3730XL

Grassland type	**Weed**	**Application month**	**Density & growth stage at application**		**% Control 3730XL**			
			(Plts/m2)	**(**BBCH)**	**n**	**Ø**	**min-max**	**CV**
Newly sown	AMBEL	May-June	5-148	10-37	5	92.2	81-99	7.49
	CAPBP	April-Oct	18-45	11-30	3	95.7	65-100	4.71
	CHEAL	May-Oct	4-350	10-61	16	72.9	10-100	32.36
	MATCH	May-June	3.5-356	10-39	9	90.2	55-99	7.97

Grassland type	Weed	Application month	Density & growth stage at application		% Control 3730XL			
			(Plts/m2)	(**BBCH)	n	Ø	min-max	CV
	POLCO	May-June	4-91	11-35	4	84.5	50-100	20.42
	POLPE	May-Oct	4-97	10-61	9	88.4	75-100	10.02
	RUMOB	April-Oct	4-98	10-61	11	96.8	80-100	27.3
	STEME	March-Oct	5-525	11-65	15	86.5	60-100	8.3
Established	ANRSY	April-Sept	4-24 % GC*	13-63	16	98.9	88-100	2.03
	HERSP	April-Sept	4-70 %GC*	14-60	15	96.3	79-100	3.8
	RANRE	April-May	10-38	14-51	9	91.1	33-100	11.73
	RUMOB	April-Oct	9-62 %GC*	12-75	17	92.1	55-100	6.99
	TAROF	April-Oct	6-44 &GC*	13-65	14	89.4	74-100	8.81

* GC = ground cover, **BBCH = Biologische Bundessortenamt Chemical Industry growth stage scale

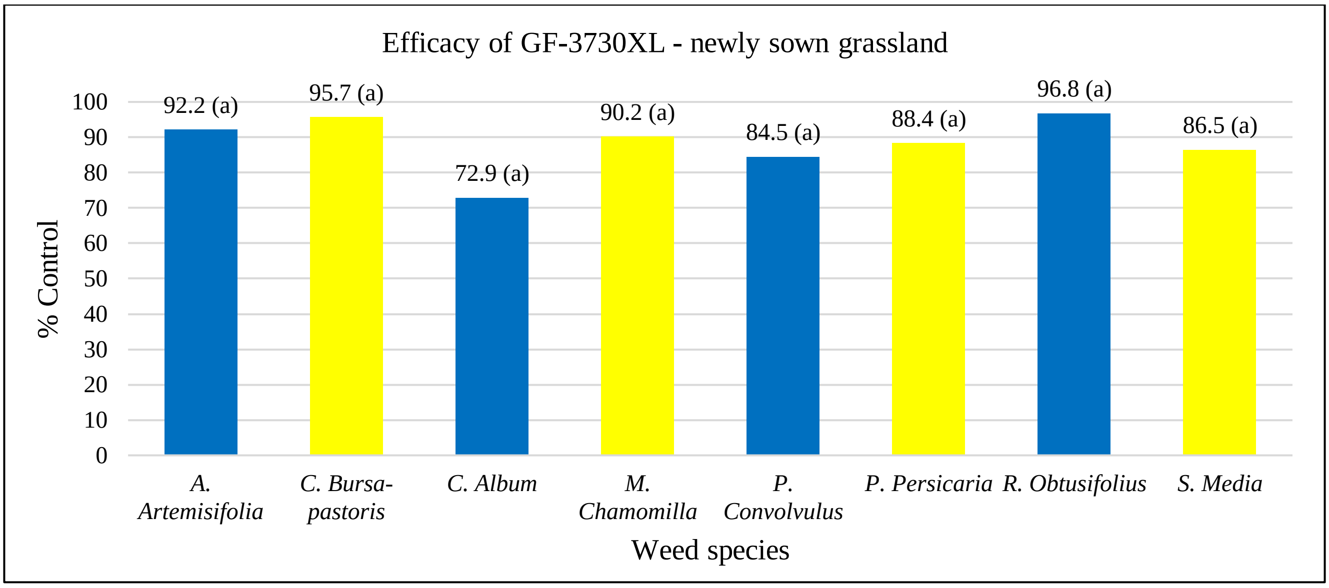

Figure 2: 3730XL control of *Ambrosia artemisifolia*, *Capsella bursa-pastoris*, *Chenopodium album*, *Matricaria chamomilla*, *Polygonum convolvulus*, *Polygonum persicaria*, *Rumex obtusifolius* and *Stellaria media* in newly sown grassland at regrowth after cutting, 46 trials

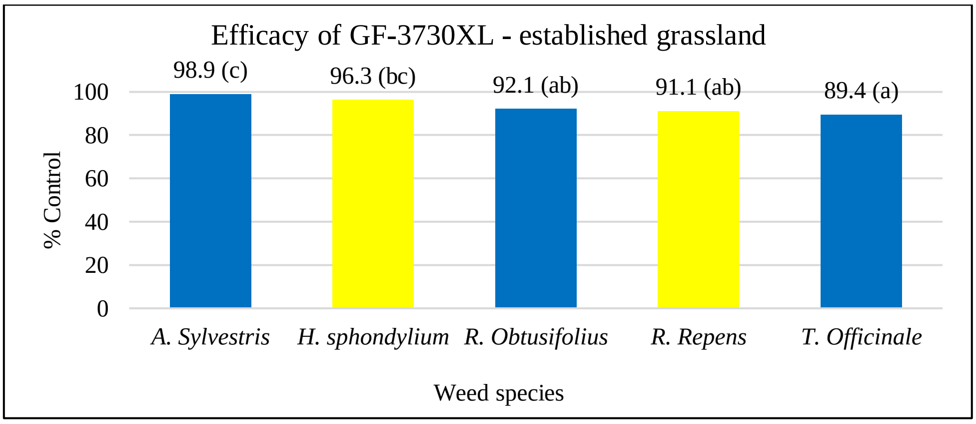

Figure 3: 3730XL control of *Anthriscus sylvestris*, *Heracleumm sphondylium*, *Ranunculus repens*,*Rumex obtusifolius* and *Taraxacum officinale* in established grassland around 161 days after application, 60 trials

Data demonstrates the broad spectrum of 3730XL with control across thirteen species and eight different plant families included as detailed in

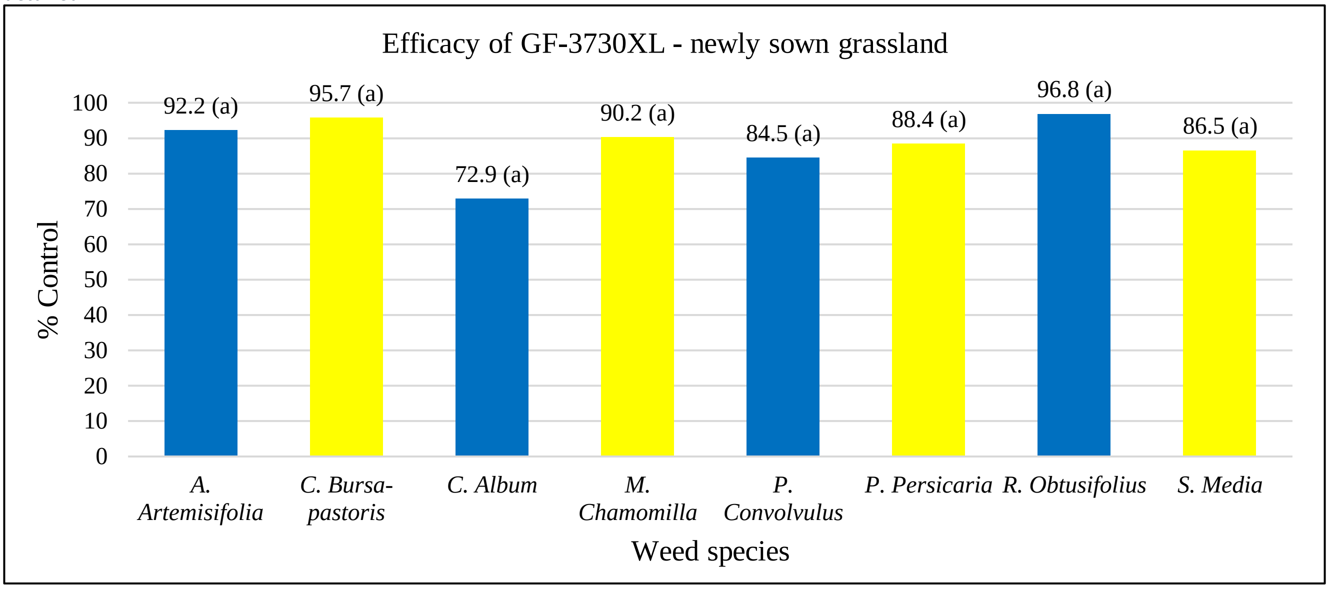

Figure *2* and Figure *3*.
If left unchecked, weeds can colonise gaps in grassland or outcompete newly sown grass competing with the grass for light, nutrients and water leading to reductions in: yield, palatability, grazing area, forage quality and sward life (Buckingham et al. 2013). In some cases, a 10% weed infestation can equate to a 10% yield loss (Voluntary initiative n.d.). Such impacts could lead to repercussions on milk output or liveweight gain and result in an increasing need to re-seed. The importance to successful forage production of weed control is clear. 3730XL offers growers the chance to control a broad spectrum of broad-leaved weeds in newly sown or established grassland whilst preserving or establishing a white clover population.

Conclusions
3730XL represents an effective weed control solution in grassland, including where white clover is present and valued. This provides growers the opportunity to access the associated benefits that white clover-rich grassland can deliver in terms of forage quantity and quality. It also enables growers to satisfy some of the wider expectations placed on them via policy or by society in general.

Acknowledgements

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