Sektion 6: Neue Herbizide
Section 6: New herbicide products

POLAR* (GF-2463) – a new cereal herbicide comprising florasulam and clopyralid for control of dicotyledonous weeds in spring

POLAR (GF-2463) – ein neues Getreideherbizid bestehend aus Florasulam und Clopyralid zur Bekämpfung zweikeimblättriger Unkräuter im Frühjahr*

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Summary

POLAR* (GF-2463=Dow 24630 H) contains the active ingredients florasulam and clopyralid both well known substances found in commercial products such as Primus*[3] (florasulam), Starane XL* (florasulam, fluroxypyr), Ariane C* (florasulam, fluroxypyr, clopyralid) or Lontrel* (clopyralid). POLAR* has a broad dicotyledonous weed spectrum and controls *Galium aparine*, *Matricaria* spp., *Centaurea cyanus*, *Stellaria media*, cruciferous weeds (*Brassica* spp. and others), *Polygonum* spp., *Solanum nigrum* and other weeds when applied post-emergence in spring. Increasingly important weeds in cereal production such as *C. cyanus* as well as *G. aparine* and *Matricaria* spp. at late growth stages can be controlled very efficiently at BBCH 13 to 32 in winter cereals and at BBCH 13 to 30 in spring cereals. POLAR* is formulated as a Suspension Concentrate (SC) with a target dose rate of 200 ml/ha (60 g ai/ha clopyralid + 5 g ai/ha florasulam) in winter and spring cereals. It combines two modes of action: Auxin-like (clopyralid) and acetolactate synthase (ALS) inhibitors (florasulam) and can be safely applied in spring (soft and hard) and winter wheat, spring and winter barley, spring oats, winter rye, winter triticale and spelt.

Keywords: *Centaurea cyanus*, *Galium aparine*, *Matricaria* spp., winter and spring cereals

Zusammenfassung

POLAR* (GF-2463=Dow 24630 H) enthält die Wirkstoffe Florasulam und Clopyralid die beide bestens bekannt sind aus Produkten wie Primus* (Florasulam), Starane XL* (Florasulam, Fluroxypyr), Ariane C* (Florasulam, Fluroxypyr, Clopyralid) oder Lontrel* (Clopyralid). POLAR* hat ein breites Wirkungsspektrum und bekämpft im Nachauflauf im Frühjahr *Galium aparine, Matricaria* spp., *Centaurea cyanus*, *Stellaria media*, kruzifere Unkräuter (Ausfallraps, *Brassica* spp. und andere), *Polygonum* spp., *Solanum nigrum* und andere Unkräuter. Dicotyle Unkräuter mit zunehmender Bedeutung im Getreidebau wie *C. cyanus* aber auch weiter entwickelte Pflanzen von *Matricaria* spp. und *G. aparine* können mit hohem Wirkungsgrad im Stadium BBCH 13 bis 32 im Wintergetreide und BBCH 13 bis 30 im Sommergetreide bekämpft werden. POLAR* ist als SC (Suspension Concentrate) formuliert und wird mit einer Aufwandmenge von 200 ml/ha (60 g ai/ha Clopyralid + 5 g ai/ha Florasulam) in Winter- und Sommergetreide angewendet und kombiniert zwei Wirkungsmechanismen: Auxin-ähnlich (Clopyralid) und Acetolactatesynthase (ALS)-Hemmer (Florasulam). Es besitzt eine ausgezeichnete Selektivität in Sommer- (Hart- und Weich-) und Winterweizen, Sommer- und Wintergerste, Winterroggen, Wintertriticale und Hafer.

Stichwörter: *Centaurea cyanus*, *Galium aparine*, *Matricaria* spp., Winter- und Sommergetreide

1. Introduction

POLAR* is a new cereal herbicide which contains clopyralid (300 g ae/L) and florasulam (25 g ai/L). Florasulam is well known from Starane XL* (fluroxypyr + florasulam, 100 + 2.5 g/l, SE) and Primus* (florasulam, 50 g/l, SC). Florasulam controls *G. aparine*, *Matricaria* spp., *Polygonum convolvulus*, *Papaver rhoeas* and cruciferous weeds including volunteer oilseed rape (SCHLOTTER et al., 1998). Clopyralid has a regulatory approval in oilseed rape, maize, sugar beets and other crops in

[3] *=Trade Mark – Dow AgroSciences LLC

commercial products such as Lontrel 100* (clopyralid, 100 g/l, SL) or Effigo*(clopyralid + picloram, 267 + 67 g/l, SL) and controls *Matricaria* spp., *C. cyanus*, *Cirsium arvense* and legume weeds. While clopyralid exhibits auxin like mode of action, florasulam is an ALS inhibitor demonstrating its strength under very cold conditions on *G. aparine* (BECKER et al., 2000; BECKER et al., 2002). In recent years, ALS-resistant *Matricaria* spp. was observed occasionally and problematic broadleaved weeds such as *C. cyanus* have widely spread. Furthermore, there is an increasing need for controlling larger weeds after mild winters or after failure of autumn herbicide applications. The new herbicide POLAR* combines the well know unique features of florasulam (i.e. *G. aparine* control under cold conditions) with new options for significantly increased level of control of *C. cyanus* and *Matricaria* spp.

2. Materials and methods

Development trials with POLAR* were conducted in 2009 and 2010 in Germany and the UK by Dow AgroSciences internal field development department and trials were carried out by the German Plant Protection Service in accordance with GEP. Generally, trials were carried out with 4 replicates, plot size was 11 to 30 m^2 and weed control of POLAR* and commercial standards were assessed 2, 4 and 8 weeks after application. Phytotoxicity assessments with cereal crops were started one week after application and continued as long as symptoms were visible. The weed control was rated visually as an overall score of the percentage control or phytotoxicity relative to the non-treated check. Crop selectivity and yield was evaluated in efficacy trials with weed infestation as well as in selectivity trials without weed competition. In selectivity trials, safety of the crop was tested with target dose and double dose rate of POLAR*.

Characteristics of POLAR*	
Active ingredients:	Florasulam (25 g ai/L) + clopyralid (300 g ai/L)
Formulation:	Suspension concentrate (SC)
Target dose rate:	Winter cereals 200 ml/ha
	Spring cereals 200 ml/ha
Application timing:	Winter cereals BBCH 13 to 32 in spring
	Spring cereals BBCH 13 to 30 in spring
Mode of action:	Acetolactate synthase inhibitor (ALS, HRAC B) + Auxin-like (HRAC O)
Symbol:	N
Bee toxicity:	No

3. Results

3.1 Weed spectrum

POLAR* was tested in winter cereals at application stage BBCH 13 to 32 and in spring cereals at BBCH 13 to 30. POLAR* performed in winter and spring cereals at very high levels (>90 % efficacy) on *G. aparine*, *Matricaria* spp., *C. cyanus*, *Erophila verna*, *Polygonum* spp., cruciferous weeds including volunteer rape (*Brassica napus*, *Capsella bursa-pastoris*, *Descurainia sophia*) and *S. media. Lamium* spp., *Veronica* spp. and *Viola arvensis* were not sufficiently controlled (Tab. 1).

Tab. 1 Weed spectrum of POLAR* (200 ml/ha) when applied at BBCH 13 to 30 and 31 to 32 in winter cereals and at BBCH 13 to 30 in spring cereals. Figures in brackets indicate number of trials.

Tab. 1 *Wirkungsspektrum von POLAR* (200 ml/ha) bei Anwendung im BBCH-Stadium 13 bis 30 und 31 bis 32 in Wintergetreide und bei BBCH 13 bis 30 in Sommergetreide. Anzahl der Versuche in Klammern.*

Weed species	Weed Code	Winter cereals BBCH 13-30	Winter cereals BBCH 31-32	Spring cereals BBCH 13-30
Brassica napus	BRSSS	97 (2)	97 (2)	94 (6)
Capsella bursa-pastoris	CAPBP	100 (4)	51 (3)	94 (6)
Centaurea cyanus	CENCY	98 (11)	97 (9)	100 (4)
Cirsium arvense	CIRAR	97(2)	70 (1)	89 (2)
Descurainia sophia	DESSO	94 (1)	96 (1)	80 (2)
Erophila verna	ERPVE	99 (1)	99 (1)	
Galium aparine	GALAP	98 (12)	94 (7)	97 (14)
Geranium rotundifolium	GERRT	64 (2)	0 (1)	
Lamium amplexicaule	LAMAM	54 (2)	44 (2)	
Lamium purpureum	LAMPU	25 (5)	17 (3)	52 (5)
Matricaria chamomilla	MATCH	99 (11)	95 (8)	99 (14)
Matricaria inodora	MATIN	98 (3)	97 (2)	100 (5)
Myosotis arvensis	MYOAR	79 (6)	86 (3)	
Papaver rhoeas	PAPRH	82 (7)	84 (6)	84 (1)
Polygonum aviculare	POLAV			88 (9)
Polygonum convolvulus	POLCO	99 (2)	83 (1)	96 (16)
Polygonum lapathifolium	POLLA	99 (1)	85 (1)	
Polygonum persicaria	POLPE			95 (2)
Raphanus raphanistrum	RAPRA			100 (2)
Sinapis arvensis	SINAR			99 (2)
Solanum nigrum	SOLNI			100 (5)
Spergula arvensis	SPRAR	80 (1)		
Stellaria media	STEME	94 (5)	100 (1)	100 (10)
Thlaspi arvense	THLAR	58 (2)	100 (1)	77 (2)
Veronica arvensis	VERAR	38 (1)		
Veronica hederifolia	VERHE	20 (10)	34 (8)	
Veronica triphyllos	VERTR	20 (1)	20 (1)	
Vicia villosa	VICVI	100 (1)		
Viola arvensis	VIOAR	24 (13)	26 (10)	48 (4)

POLAR* also controlled weeds typically occurring in spring crops such as *Solanum nigrum* and *Polygonum aviculare* at high levels. At later application timing and on more mature weeds there was no decrease in efficacy of *G. aparine*, *Matricaria* spp. and *C. cyanus* (see graphs below) while cruciferous weeds and *P. rhoeas* showed significantly lower level of control when treated at later growth stages. When comparing POLAR* at 200 ml/ha to registered rates of Primus* (100-150 ml/ha), the efficacy of POLAR was equivalent on important target weeds independently on the application timing (*G. aparine, S. media* and cruciferous weeds) while *C. cyanus* and *Matricaria* spp. were both significantly better controlled by POLAR* (Tab. 2).

Tab. 2 Weed control of POLAR* (200 ml/ha) compared to Primus (100 to 150 ml) when applied at BBCH 13 to 30 and 31 to 32 in winter cereals. Figures in brackets indicate number of trials.

Tab. 2 *Unkrautbekämpfung von POLAR* (200 ml/ha) im Vergleich zu Primus (100 bis 150 ml) bei Anwendung im Stadium BBCH 13 bis 30 und 31 bis 32 in Wintergetreide. Anzahl der Versuche in Klammern.*

Weed species	Weed Code	POLAR 200 ml/ha		Primus 100 ml/ha	Primus 150 ml/ha
		BBCH 13-30	BBCH 31-32	BBCH 13-30	BBCH 31-32
Brassica napus	BRSSS	97 (2)	97 (2)	99 (2)	92 (2)
Capsella bursa-pastoris	CAPBP	100 (4)	51 (3)	97 (4)	55 (3)
Centaurea cyanus	CENCY	98 (11)	97 (9)	70 (9)	68 (7)
Cirsium arvense	CIRAR	97 (2)	70 (1)	90 (1)	
Galium aparine	GALAP	98 (12)	94 (7)	98 (8)	91 (4)
Matricaria chamomilla	MATCH	99 (11)	95 (8)	92 (9)	86 (5)
Matricaria inodora	MATIN	98 (3)	97 (2)	94 (2)	100 (1)
Myosotis arvensis	MYOAR	79 (6)	86 (3)	73 (6)	81 (3)
Polygonum convolvulus	POLCO	99 (2)	83 (1)	100 (1)	
Stellaria media	STEME	94 (5)	100 (1)	93 (5)	100 (1)

3.2 Efficacy on *Galium aparine*

There was a very flat dose rate response of POLAR* when applied on *G. aparine* at early timings, however later application timings revealed the need for the highest dose rate. *G. aparine* treated at early timings (≤ BBCH 30 of the crop) had an average size of 10 cm (5 to 15 cm) while more advanced and late applied plants (> BBCH 30) averaged 15 cm (10 to 19 cm). The level of control achieved at 200 ml/ha was equivalent to 100 to 150 ml/ha Primus* and slightly superior to the standard when applied at those timings (Fig. 1). The lowest tested rate of POLAR* showed significantly less control when applied on larger weeds (68 %) compared to 94 % when *G. aparine* plants were treated at earlier growth stages.

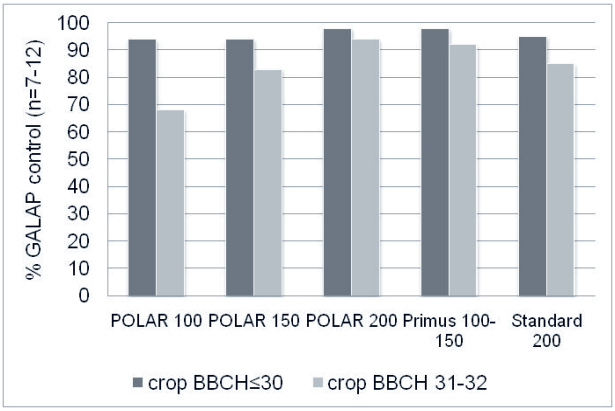

Fig. 1 Efficacy of different rates of POLAR*, Primus* and standard B on *G. aparine* applied at different growth stages. Rate unit of POLAR* and Primus* in ml/ha, standard B in g/ha, n = number of trials.

Abb. 1 *Wirkungsgrade unterschiedlicher Aufwandmengen von POLAR*, Primus* und Standard B auf G. aparine zu unterschiedlichen Wachstumsstadien. Aufwandmenge von POLAR* und Primus* in ml/ha, Standard B in g/ha, n = Anzahl Versuchsergebnisse.*

3.3 Efficacy on *Matricaria* spp.

On *Matricaria* spp., POLAR* was also tested with dose rates of 100, 150 and 200 ml/ha at different application timings and on weeds varying in size. At early application timing, *Matricaria* spp. reached 7 cm on average (3 to 15 cm) and plants at late application timing were 18 cm on average (6 to 32 cm) tall. There was a clear dose response on early and late growth stages of larger *Matricaria* spp. plants whereas the highest tested POLAR* rate provided very high level of control, regardless of the application timing (Fig. 2).

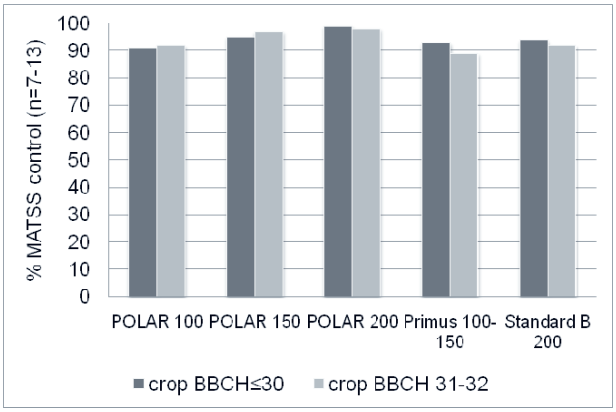

Fig. 2 Efficacy of different rates of POLAR*, Primus* and standard B on *M. chamomilla* and *M. inodora* applied at different growth stages. Rate unit of POLAR* and Primus* in ml/ha, standard B in g/ha, n = number of trials.

Abb. 2 *Wirkungsgrade unterschiedlicher Aufwandmengen von POLAR*, Primus* und Standard B auf M. chamomilla und M. inodora zu unterschiedlichen Wachstumsstadien. Aufwandmenge von POLAR* und Primus* in ml/ha, Standard B in g/ha, n = Anzahl Versuchsergebnisse.*

3.4 Efficacy on *Centaurea cyanus*

POLAR* was tested on *C. cyanus* at use rates of 100, 150 and 200 ml/ha at different application timings in winter cereals (BBCH ≤ 30 and 31 to 32). As a result, the size of the weed varied significantly. At early application timing the average size of the *C. cyanus* plants was 9 cm (4 to 15 cm), when applied late plants had much larger size and measured 21 cm on average (13 to 35 cm). Efficacy of POLAR* at target rate of 200 ml/ha did not differ, regardless of plant growth stage at time of application (Fig. 3). Even the lowest tested dose rate showed better control than Primus* at 100 to 150 ml/ha and a second standard at 200 g/ha (commercial rates).

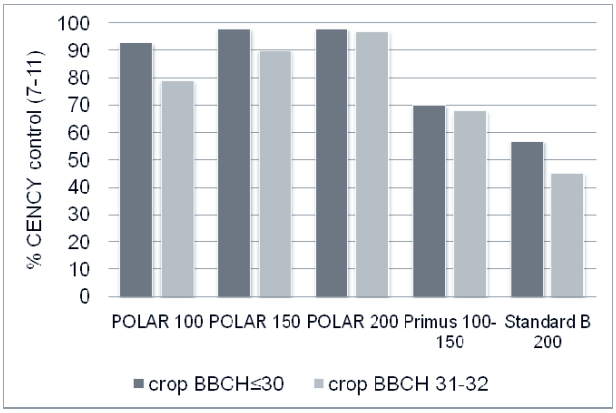

Fig. 3 Efficacy of different rates of POLAR*, Primus* and standard B on *C. cyanus* applied at different growth stage ranges. Rate unit of POLAR* and Primus* in ml/ha, standard B in g/ha, n = number of trials.

Abb. 3 *Wirkungsgrade unterschiedlicher Aufwandmengen von POLAR*, Primus* und Standard B auf C. cyanus zu unterschiedlichen Stadien. Aufwandmenge von POLAR* und Primus* in ml/ha, Standard B in g/ha, n = Anzahl Versuchsergebnisse.*

3.5 Crop selectivity and yield response

The application of POLAR* in winter and spring cereals has demonstrated good crop selectivity when applied from BBCH 13 till 30/32. Visible phytotoxicity symptoms were observed only when application was followed by periods of very cold temperatures, especially at the early application timings (< BBCH 30) and in case of varying temperatures between day and night. If symptoms occurred they were minor and transient and disappeared within 2 to 3 weeks. Selectivity trials were set up with target dose rate (200 ml/ha) and double rate (400 ml/ha). Good crop selectivity was also reflected by yield results (Tab. 3) carried out in weed free situations, where POLAR* at 200 and 400 ml/ha did not reduce crop grain yield in any trial.

Yield was also measured in numerous efficacy trials conducted in 2009 and 2010. There was a yield benefit that resulted from weed control by eliminating competitive weeds (Tab. 4). Positive yield response was well pronounced in winter cereals (11 to 13 %), and slightly less in spring cereals (7 to 13 %).

Tab. 3 Yield response (as percent of untreated check) of POLAR* at 200 and 400 ml/ha when applied to winter and spring cereals at BBCH 13 to 32(30) in weed free situations (number of trials in brackets).

Tab. 3 *Ertragseinfluß (relativ zur unbehandelten Kontrolle) von POLAR* mit 200 und 400 ml/ha in Winter- und Sommergetreide zu BBCH 13 bis 32(30) unter unkrautfreien Bedingungen (Anzahl der Versuche in Klammern).*

Use rate	Winter wheat	Winter barley	Winter rye	Winter triticale	Winter spelt	Spring barley	Spring wheat	Spring oat	Spring durum
200 ml/ha	100 (14)	101 (12)	100 (10)	100 (10)	101 (4)	101 (12)	101 (8)	101 (10)	101 (6)
400 ml/ha	101 (14)	100 (12)	100 (10)	100 (10)	102 (4)	101 (12)	101 (8)	101 (10)	101 (6)

Tab. 4 Yield response (as percent of untreated check) of POLAR* at 200 ml/ha and standard B at 200 g/ha when applied to winter and spring cereals in trials with weed infestation (number of trials in brackets).

Tab. 4 *Ertragseinfluß (relativ zur unbehandelten Kontrolle) von POLAR* mit 200 ml/ha und Standard B mit 200 g/ha in Winter- und Sommergetreide in Versuchen mit Unkrautbesatz (Anzahl der Versuche in Klammern).*

Product	Winter wheat	Winter barley	Winter rye	Winter triticale	Spring barley	Spring wheat	Spring oat
POLAR 200 ml/ha	112 (2)	111 (2)	111 (2)	113 (2)	113 (1)	109 (2)	107 (2)
Standard B 200 g/ha	112 (2)	107 (2)	103 (2)	112 (2)	112 (1)	116 (2)	-

3.6 Impact on following crops

The impact on following crops was assessed with the target and double dose rate, too. Potential succeeding crops tested were catch crops, winter oil seed rape, winter cereals (in the year of application of POLAR*) and spring cereals, spring oil seed rape, potatoes, maize, legume crops and sugar beet. Field trial results did not show any phytotoxicity symptoms in any tested following crop.

4. Discussion

POLAR* is a new herbicide containing the active ingredients florasulam and clopyralid. Clopyralid is now available in combination with florasulam and expanding significantly the weed spectrum and flexibility in timing of application compared to application of florasulam alone. In spring, post-emergence applied POLAR* controls dicotyledonous weeds such as *G. aparine*, *Matricari*a spp., *C. cyanus*, *S. media*, cruciferous weeds (*Brassica* spp. and others), *Polygonum* spp. and others. In recent years, *C. cyanus* has increased in frequency of occurrence in cereal production systems. POLAR* provides excellent control of *C. cyanus*, *G. aparine* and *Matricaria* spp. even when larger weeds are treated. This flexibility is a great benefit to the farmer for three reasons. First, POLAR* can be a rescue treatment when autumn applied herbicide failed. Second, POLAR* gives farmers more flexibility to shift plant protection measures to accommodate personnel workload adjustments. Third, POLAR* provides farmers opportunity to combine weed control with other later applied pesticides, such as fungicides.

POLAR* can be applied very safely to winter and spring cereals and it increases grain yield, depending on weed spectrum and cereals crop, approximately 10 % by controlling weeds.

Since POLAR* contains florasulam, it provides excellent control of *G. aparine* even under cold conditions as shown by BECKER et al. (2000) and BECKER et al. (2002). In addition, recent studies have shown that florasulam (belonging to the triazolo-pyrimidines) generally still controls ALS target-site-resistant *Matricaria recutita* which is no longer controlled by sulfonylurea herbicides (SCHLEICH-SAIDFAR et al., 2011). Further studies will help to understand to what extent the addition of clopyralid to florasulam (i.e. the product POLAR*) will provide even more robust control of ALS target-site-resistant *Matricaria* spp. As a consequence, POLAR* combines the benefits of a broad control spectrum with the flexibility to spray under cooler conditions and when weeds, such as *G. aparine*, *Matricaria* spp. and *C. cyanus,* are at later growth stages.

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