

## Improved weed Control in Clearfield-Plus Sunflowers with superior herbicide solutions

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### ABSTRACT

- The initial **Clearfield**<sup>®</sup> sunflower production system is known as *ImiSun* system. Besides the Clearfield tolerance trait of this system, background genotype and environmental conditions could have a significant impact on the required commercial tolerance – which is defined as tolerance to the 2x rate of a registered imidazolinone herbicide. Yellowing and stunting of *ImiSun* Clearfield sunflowers are occasionally observed as reaction of the imidazolinone treatment. An optimization process of the herbicidal efficacy for improved weed control either by rate or uptake increase of the herbicide would be limited by the tolerance of *ImiSun* sunflowers.
- The development of the new tolerance trait **Clearfield Plus** – which is based on the novel mutation *CLHA-Plus* with a much higher imidazolinone tolerance - allows a significantly enhanced weed control efficacy through the improvement of herbicide formulation and adjuvant without negative effect on crop tolerance. For instance, current herbicide offers for *ImiSun* sunflowers in Europe include Pulsar<sup>®</sup>40 which contains Tween20 as a built-in surfactant because Tween20 as a reliable non-ionic surfactant for a systemic herbicide such as imazamox is best suited for a good balance between weed control and crop tolerance.
- With the enhanced tolerance of *CLHA-Plus*, field experiments were conducted in Europe, US and Argentina between 2007 and 2011 to investigate new adjuvants for Pulsar40 to replace or complement Tween20 for improved weed control. All experiments were conducted as randomized complete-block designs with three or four replications and products were applied postemergence broadcast between 2 to 6 leaf of stage of sunflower. Visual estimates of weed control were determined using a scale of 0 (no control) to 100% (plant death). DASH<sup>®</sup>, a proprietary adjuvant blend of petroleum hydrocarbons, naphthalene, and oleic acid was found to be the most effective combination for improving weed control efficacy; it allowed the reduction of the use rate of imazamox from 50 to 40 g ai/ha while maintaining the same control efficacy on major weed species like *Echinochloa crus-galli*, *Digitaria* spp, *Setaria* spp. and *Chenopodium album*. On average across all weeds and application timings the addition of DASH improved efficacy and consistency of weed control by Pulsar40.
- The higher imidazolinone tolerance of the **Clearfield Plus** trait allows the use of a stronger adjuvant and a better formulation for imidazolinone herbicides and consequently a more flexible and reliable weed control in sunflower by maximizing the herbicidal efficacy per ai unit without any penalty on tolerance.
- The increased herbicide performance on difficult to control weeds and possible relaxed re-cropping restrictions through herbicide rate reduction with the new **Clearfield Plus** system provide sunflower growers a better tool to manage weeds and add to the value of the new Clearfield Plus sunflower production system.

*Keywords:* *Helianthus annuus* - imazamox - postemergence - effective dose – Methylated seed oil – non-ionic surfactant, Tween 20 – adjuvant - MSO - DASH - **Clearfield** – *ImiSun* - *CLHA-Plus*

## Introduction

Weed control is often one of the most limiting factors for global sunflower production. In general, broadleaf weed control options in sunflower have been limited to pre-plant and pre-emergence herbicides. With the introduction of imidazolinone resistant sunflowers as Clearfield<sup>®</sup> production system, farmers had been able to utilize much more effective postemergence herbicides. The imidazolinone family of herbicides control weeds by inhibiting a key enzyme in the branched chain amino acid biosynthetic pathway, acetohydroxyacid synthase (AHAS; EC 4.1.3.18) also known as acetolactate synthase (ALS) (Shaner et al. 1984; Tan et al. 2005). The initial Clearfield sunflower production system is also known as *ImiSun* system. The Clearfield *ImiSun* trait is derived from imidazolinone-tolerant wild sunflowers which were discovered in Kansas, USA in 1996 (Al-Khatib et al, 1998). The herbicide tolerance trait is conferred by a single point mutation (R-gene) in the AHAS enzyme. Besides the R-gene as basis for the tolerance, the background genotype (E-gene) and environmental conditions have significant effects on the commercial tolerance of the phenotype (Pfenning et al, 2008) – which is defined as tolerance to the 2x rate of a registered imidazolinone herbicide. Yellowing and stunting of *ImiSun* Clearfield sunflowers are occasionally observed as reaction of the imidazolinone treatment. An optimization process of the herbicidal efficacy for improved weed control would be limited by the tolerance of *ImiSun* sunflowers. The development of the new tolerance trait Clearfield Plus – which is based on the novel mutation CLHA-Plus (Sala et al, 2011) - confers a much higher imidazolinone tolerance compared to *ImiSun* and allows therewith a significantly enhanced weed control efficacy through the improvement of herbicide formulation without negative effect on crop tolerance.

## Materials and Methods

Field experiments were conducted in Europe (France, Greece, Spain, Hungary, Slovakia and Germany) between 2007 and 2011 to evaluate the effect of new adjuvant systems with Imazamox in comparison to the commercial Pulsar<sup>®</sup>40 formulation. All experiments were conducted as randomized complete-block designs with three or four replications. Herbicides were applied postemergence broadcast between 2 to 6 leaf of stage of sunflower. Visual estimates of weed control were determined using a scale of 0 (no control) to 100% (plant death). Pulsar40 (Imazamox 40 g/l + 400 g/l Tween 20) at 30, 40 and 50 g ai/ha were compared to Pulsar 40 plus DASH<sup>®</sup>, a proprietary adjuvant blend of petroleum hydrocarbons, naphthalene, and oleic acid as well as to BAS 720 AM H (25 g/l Imazamox) an experimental Imazamox formulation with a new adjuvant system. Box and whisker graphs contain the standard deviation, median and 5, 25, 75 and 95 percentile.

## Results

*Pulsar40 versus Pulsar plus DASH.* In an orthogonal rate by rate comparison the addition of DASH improved the activity against CHEAL with 32 g ai/ha from 71% to 83% and at 40 g ai/ha from 78% to 88%. Similar effects were evaluated on AMBEL, DATST, and DIGSA. The response of ECHCG was greatest resulting in 24% higher activity at 32 g ai/ha (Table 1).

*Pulsar40 versus BAS 720 AM H.* In a multi-year summary BAS 720 AM H provided substantially better annual grass weed control (*Echinochloa crus-galli*, *Digitaria sanguinalis*, *Setaria viridis* and *Setaria verticillata*) compared to Pulsar40 (Figure 1). With the reduced dose rate of 32 g ai/ha BAS 720 AM H outperformed Pulsar40 at 40 g ai/ha with 82% versus 75%. Comparing both products at 40 g ai/ha, the weed control consistency with BAS 720 AM H was considerable better compared to Pulsar40 besides the 7% higher mean value. A dose rate increase to 50 g ai/ha resulted in an excellent control level of 95% with very little variation in the results at 6-8 weeks after application

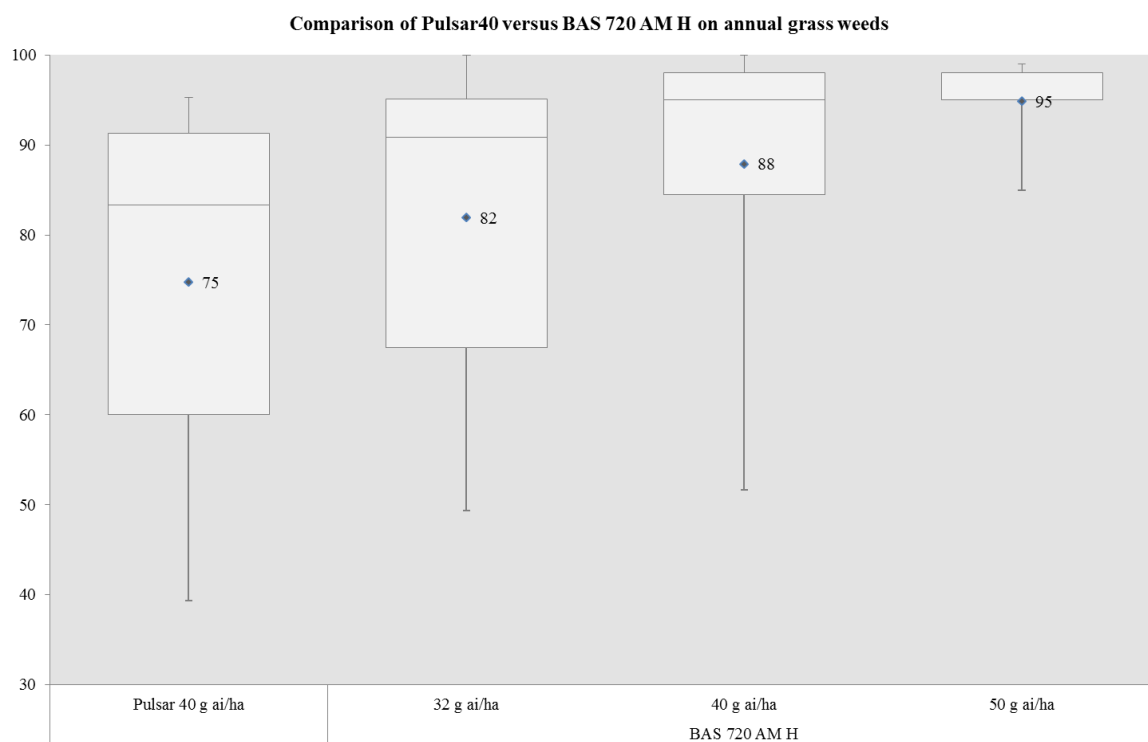
*Crop tolerance impact of BAS 720 AM H.* In 2011 the influence of the improved formulation BAS 720 AM H on crop tolerance was evaluated (Table 2). At both locations, the *ImiSun* hybrid NK NEOMA CL was substantially higher affected compared to the homozygote *CLHAplus* hybrid LN 11179 and the *CLHAplus* / *ImiSun* stack – PARAIISO1001. Application of 40 ai/ha of Pulsar40 showed only minor symptoms with the *ImiSun* hybrid, whereas the use of BAS 720 AM H treatment caused in Spain between 10 and 20% injury. The same dose caused up to 60% injury in Hungary. Injury symptoms were a combination of stunting, chlorosis and with the high injury rating also deformation and necrosis.

**Table 1.** Mean percent control of CHEAL, AMBEL, ECHCG and SETVI in response to different doses and formulations of Imazamox at 38-56 DAT in Europe from 2010 to 2011 - orthogonal comparison per weed

Treatment	Rate	Weed control <sup>a</sup>									
		CHEAL	(n)	AMBEL	(n)	DATST	(n)	ECHCG	(n)	DIGSA	(n)
Pulsar 40	g ai/ha										
	32	71	(32)	60	(3)	88	(4)	57	(6)	61	(4)
	40	78	(32)	70	(3)	92	(4)	69	(6)	66	(4)
Pulsar 40 + DASH	32 + 11	83	(32)	81	(3)	94	(4)	81	(6)	69	(4)
	40 + 11	88	(32)	86	(3)	96	(4)	88	(6)	81	(4)

<sup>a</sup> Abbreviations: CHEAL, *Chenopodium album*; AMBEL, *Ambrosia elatior*; DATST, *Datura stramonium*; ECHCG, *Echinochloa crus-galli*; DIGSA, *Digitaria sanguinalis*;

**Figure 1.** Control of annual grass weeds in CLHApplus sunflowers oilseed rape with BAS 720 AM H in an orthogonal comparison with Pulsar40. Europe 2010-2011



DAT: 38-58; Pooled data summary of *Echinochloa crus-galli* (n=12), *Digitaria sanguinalis* (n= 8), *Setaria viridis* (n=4) and *Setaria verticilata* (n=6).

**Table 2.** Crop tolerance impact of BAS 720 AM H on CL-ImiSun and CLHAplus hybrids in comparison to Pulsar40 at 40 g ai/ha. Spain and Hungary 2011

Trial location and year	Hybrid	Tolerance Type	*DAT	Crop Injury % with 40 g ai/ha	
				Pulsar 40	BAS 720 AM H
Spain 2011	NK NEOMA	CL - Imisun	8	6	20
	LN 11179 CL	<b>CLHA plus</b>	8	0	2
	NK NEOMA	CL - Imisun	14	7	10
	LN 11179 CL	<b>CLHA plus</b>	14	0	0
Hungary 2011	NK NEOMA	CL - Imisun	11	0	60
	PARAISO 1001	<b>CLHA plus</b>	11	0	4
	NK NEOMA	CL - Imisun	32	0	30
	PARAISO 1001	<b>CLHA plus</b>	32	0	0

### Discussion

With the current Clearfield ImiSun system, amplified herbicide performance was penalized with unacceptable crop response. Other broadleaf herbicides for a combination with Imazamox in postemergence sunflower use are currently not available. This situation restricted an improvement of the herbicidal efficacy of the Imazamox based Clearfield system. The development of a higher imidazolinone tolerance with the **Clearfield Plus** trait allows the use of a stronger adjuvant and a better formulation for imidazolinone herbicides and consequently a more flexible and reliable weed control in sunflower by maximizing the herbicidal efficacy per ai unit without any penalty on tolerance.

The increased herbicide performance on difficult- to-control weeds and possible relaxed re-cropping restrictions through potential herbicide rate reduction with the new **Clearfield Plus** system provide sunflower growers a better tool to manage weeds and add to the value of the new Clearfield Plus sunflower production system.

### References

- Al-Khatib, K., J.R. Baumgartner, D.E. Peterson, R.S. Currie, 1998: Imazethapyr resistance in common sunflower (*Helianthus annuus*). *Weed Sci.* 46, 403-407
- Pfenning M, Palfay G, & Guillet T, 2008: The CLEARFIELD® technology – A new broad-spectrum post-emergence weed control system for European sunflower growers. *J.Plant Dis.Protect. Special Issue 2008*: 649-654
- Sala CA, Bulos M, Altieri E, Weston B., 2011: Response to imazapyr and dominance relationships of two imidazolinone-tolerant alleles at the Ahas11 locus of sunflower. *Theor Appl Genet* DOI 10.1007/s00122-011-1713-6
- Shaner D.L, Anderson P.C, Stidham M.A (1984) Imidazolinones: potent inhibitors of acetohydroxyacid synthase. *Plant Physiol* 76:545–546
- Tan S, Evans R.R, Dahmer M.L, Singh B.K, Shaner D.L (2005) Imidazolinone-tolerant crops: history, current status and future. *Pest Manag Sci* 61:246–257