## The strategic use of chlorsulfuron in the seed production of *Medicago littoralis* cv. Angel[A]

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### Abstract

Contamination by background annual medic (*Medicago* spp.), particularly naturalised burr medic (*M. polymorpha* L.) regenerating from soil hardseed reserves, is a significant problem in the production of certified annual medic seed. An annual strand medic (cv. Angel[A], *M. littoralis* Rhode ex Loisel.) has been developed that is tolerant to residues of sulfonylurea herbicides and this provides new weed control options. We applied chlorsulfuron and assessed the performance of Angel[A] in terms of plant establishment, biomass production and seed yield. We also measured the efficacy of weed control of a simulated background medic contaminant (cv. Scimitar[A], *M. polymorpha*) sown together with Angel[A]. Low rates of chlorsulfuron applied pre-emergent were found to be effective in controlling burr medic and were sufficiently tolerated by Angel[A] with respect to seed yield. This finding demonstrates a significant advantage for the certified seed production of Angel[A].

### Key Words

Sulfonylurea herbicides, seed dormancy, seed certification, selective weed control

### Introduction

Naturally self-regenerating or background annual *Medicago* spp. can be a significant contaminant of certified medic seed crops. Most annual medics are relatively hardseeded, a mechanism of seed dormancy (Taylor 2005). This reduces the risk of false breaks to the growing season causing premature germinations of medic seed and has contributed to their success in the variable and low rainfall areas of temperate Australia. However this ability to self-regenerate from soil reserves of hard seed can make medics a problematic weed when trying to grow certified medic seed of different varieties. The seeds industry now has difficulty in finding 'clean' ground that has not already some background of previously grown medic cultivars. The main methods of controlling unwanted medic are to: 1. deplete soil seed reserves through a number of years of continuous cropping; 2. control initial medic germinations after the opening rains (eg cultivation, knockdown herbicides); 3. hand-rogue distinguishable off-types in-crop (only practical for very small areas) or 4. purify a contaminated medic crop grade by grading the seed. The latter utilises differences in size, density and shape between some of the various *Medicago* spp. but it can be expensive, time consuming and impractical with cultivars of the same species.

In addition to a background of pre-existing medic cultivars, naturalised burr medic (*M. polymorpha* L.) is endemic throughout much of Australia, and since it typically has high levels of hard seed, can be a particularly difficult weed to control in medic seed production areas. Its potential weediness is exacerbated by a tendency to exhibit a delayed autumn seed softening pattern (Lloyd et al. 1997). This can result in significant numbers germinating in-crop after cultivation or knockdown herbicides have already been applied to control the early germinations of weeds after the opening seasonal rains.

The South Australian Seed Certification Scheme for medics requires a minimum cultivar or genetic purity of 99.5% for 'Basic' seed and 95% for 'Certified' seed (Smith and Baxter 2002). Physical purity standards require a minimum of 98% pure seed (i.e. species being certified) and a "maximum of 2% 'other seeds' of which no single species (other than burr medic) shall be greater than 0.5%". The presence of background annual medic poses a constant threat of contamination in certified medic seed production.

Angel[A] is a mutagenically (ethyl methane sulphonate) induced variety of strand medic (*M. littoralis* Rhode ex Loisel.) selected for tolerance to soil residues of certain acetolactate synthase (ALS) inhibiting herbicides including the sulfonylurea (SU) herbicides (Heap 2000, Howie 2004, Howie and Bell 2005). Although SU herbicides are widely used in the cereal-livestock zones of temperate Australia, their residues can persist, particularly where the combination of alkaline soils and low rainfall significantly reduce their breakdown by microbial action and chemical hydrolysis. Regenerating annual *Medicago* spp., widely used in these areas in Australian ley farming systems, are generally intolerant of SU herbicide residues, resulting in stunting, reduced dry matter production, lower seed yields, poor persistence and decreased N fixation. In one study Holloway et al. (2006) reported chlorsulfuron reducing medic yield 24 and 35 months after application by 60% and 21% respectively.

In the past it is has been impossible to selectively control contaminant annual medic in-crop with herbicides. However in this study we report on the ability of Angel[A] to tolerate chlorsulfuron applied pre-emergent at rates sufficient to control a deliberately-introduced annual medic contaminant (cv. Scimitar[A], *M. polymorpha*).

**Methods**

Chlorsulfuron (750g/kg) was applied as a pre-emergent herbicide in 117 L water/ha to moist soil in 2007 and 2008 at Mallala, South Australia (Table 1). One to four days later a mixture of Angel strand medic and Scimitar spineless burr medic was sown. Angel was sown at 8 kg/ha with Scimitar sown as an admixture at 2 kg/ha, to mimic the role of naturalised burr medic and other medic cultivars (SU intolerant) as a weedy contaminant of certified medic seed production. Its different leaf markings and pod morphology enabled it to be differentiated from Angel medic at most growth stages.

**Table 1. Site management and details of experiments conducted in 2007 and 2008.**

| Year | Date of herbicide application | Herbicide rates (g. product/ha) | Sowing date | Dry matter assessment | May/Oct rainfall (mm) |
|---|---|---|---|---|---|
| 2007 | 1/6/07 | 0, 2, 4, 6, 8 & 16 | 5/6/07 | 24/9/07 | 144 |
| 2008 | 28/5/08 | 0, 2, 4, 6, 8, 12 & 16 | 29/5/08 | 9/9/08 | 184 |

Treatments were arranged in a randomised block design with three (2007) or four (2008) replicates and plot size was 5 ? 1.2 metres. The soil was a loam with pH $7.0_{(water)}$. The site area was located directly adjacent to a certified medic seed crop and observation of unsown test strips in the paddock revealed no or negligible levels of pre-existing background medic. Grass and broadleaf weeds (other than medic) were controlled as necessary with selective herbicides to minimise the weed control advantage that plots treated with chlorsulfuron may otherwise have had over the unsprayed control treatments.

Measurements included plant establishment (viable plants with > 3 healthy trifoliate leaves), dry matter production and pod and seed yield. Dry matter production was assessed at flowering on a total sward basis, based on visual assessments and rising plate meter scores, calibrated with pasture cuts. Using these methods it was not possible to obtain individual cultivar dry matter production.

**Results**

*2007*

Angel exhibited tolerance with respect to plant establishment, dry matter production and seed yield, to chlorsulfuron applied pre-emergent at all but the highest rate (Table 2). Seed yield was highest at the 4 g/ha rate, presumably in response to reduced competition from the Scimitar simulated medic contaminant (SU intolerant). This is also reflected in the Angel and Scimitar dry matter production (total, unsorted) which did not decline as much as might have been expected despite the rapid disappearance of Scimitar plants.

By contrast the plant establishment and seed yield of Scimitar was quickly reduced with increasing rates of herbicide. Chlorsulfuron applied at the lowest rate (2 g/ha) reduced plant establishment and seed yield by 75% and 90%, respectively.

**Table 2. The effect of chlorsulfuron applied as a pre-emergent herbicide upon the plant establishment, total dry matter and seed yield of Angel and Scimitar annual medic sown in a mixed sward in 2007.**

| Rate | Plant establishment (p/m$^2$) | | Total dry matter | Seed yield (kg/ha) | | | Scimitar |
|---|---|---|---|---|---|---|---|
| (g/ha) | Angel | Scimitar | (kg/ha) | Angel | Scimitar | Total | (% total seed) |
| 0 | 179 | 49 | 1787 | 382 | 126 | 508 | 24.8 |
| 2 | 187 | 12 | 1709 | 455 | 12 | 467 | 2.6 |
| 4 | 155 | 2 | 1550 | 516 | 5 | 521 | 1.0 |
| 6 | 167 | 9 | 1506 | 402 | 15 | 417 | 3.6 |
| 8 | 156 | 1 | 1526 | 402 | 2 | 404 | 0.5 |
| 16 | 102 | 5 | 1272 | 303 | 0 | 303 | 0 |
| LSD (P=0.05) | 44.6 | 6.9 | 240 | 93.7 | 36.8 | | |

*2008*

The results from the 2008 experiment (Table 3) generally confirmed the findings from 2007. Angel plant establishment was unaffected by chlorsulfuron applied pre-emergent at rates up to 8 g/ha and declined at 12 g/ha and above. However, Angel biomass production was more affected by chlorsulfuron with greater reductions in biomass than in the 2007 experiment. Despite this, Angel seed yield was quite stable, increasing to a maximum at 4 g/ha before declining at 12 & 16 g/ha.

The seed yield of Scimitar was reduced from 23% of the unsprayed control to negligible levels with increasing rates of chlorsulfuron.

**Table 3. The effect of chlorsulfuron applied as a pre-emergent herbicide upon the plant establishment, total dry matter, 1000 seed weight and seed yield of a mixed sward of Angel and Scimitar annual medic in 2008.**

| Rate | Plant establishment (p/m²) | | Total dry matter | Angel 1000 SW | Seed yield (kg/ha) | | | Scimitar |
|---|---|---|---|---|---|---|---|---|
| (g/ha) | Angel | Scimitar | (kg/ha) | (g) | Angel | Scimitar | Total | % total |
| 0 | 166 | 22 | 1,447 | 1.90 | 551 | 168 | 718 | 23.3 |
| 2 | 163 | 0 | 1,081 | 1.98 | 676 | 5 | 681 | 0.7 |
| 4 | 166 | 0 | 872 | 2.10 | 705 | 2 | 707 | 0.2 |
| 6 | 136 | 0 | 708 | 2.10 | 670 | 1 | 670 | 0.1 |
| 8 | 156 | 0 | 674 | 2.11 | 659 | 1 | 661 | 0.2 |
| 12 | 106 | 0 | 478 | 2.09 | 607 | 0 | 607 | 0.0 |
| 16 | 81 | 0 | 347 | 2.06 | 557 | 0 | 557 | 0.0 |
| LSD (P=0.05) | 45.6 | ?NA | 351 | 0.087 | 78 | 18.1 | | |

**Discussion**

This study was conducted in two years of very low growing season rainfall (Table 1) which we believe contributed to the apparent ‘stimulatory’ effect of chlorsulfuron enhancing seed yield of Angel when applied at low rates. In 2007, while total seed yields remained relatively stable at low rates, actual Angel seed yield was maximised at the 4 g/ha rate before declining at higher rates. Similarly in 2008, total seed yield remained quite stable across most rates, with Angel seed yield again being maximised at 4 g/ha. All plants were under regular and severe moisture stress in both seasons and the selective removal of Scimitar as an effective competitor provided Angel with an opportunity to compensate with increased seed yield. The greater reduction in Angel biomass in 2008 (cf. 2007) may also have helped to conserve moisture for the critical reproductive stages (flowering and seed fill), thereby maximising seed yield at the expense of biomass. This effect is possibly also reflected in the Angel 1000 seed weights at 0 and 2 g/ha being 10 and 6 % less respectively than those at 4, 6 and 8 g/ha (Table 3).

Excessive biomass production presents management and harvesting difficulties when vacuum harvesting medic seed and thus some reduction in Angel biomass in response to low rates of chlorsulfuron is unlikely to concern growers who are more focussed on clean seed yield. The experimental seed yields obtained in this study compared favourably with average dryland certified medic seed yields of 350 - 400 kg/ha (Smith pers. comm.).

Scimitar plant establishment in 2008 was unexplainably poorer than expected across all treatments with no plants in any herbicide treated plots being assessed as viable. However, the fact that pod and seed was recovered from some of the treated plots suggests that some plants not considered viable at the time of assessment did in fact recover sufficiently to flower and produce seed. Over the two years of study, Scimitar plant establishment in control plots varied between 22 – 49 p/m² which none-the-less still equated to a higher than expected medic weed burden in paddocks selected expressly for certified medic seed production. On this basis we believe the levels of background medic control achieved by chlorsulfuron in this study to be a relevant and significant finding for the medic seeds industry.

Chlorsulfuron is an ALS inhibiting herbicide with both soil and foliar activity. Dry conditions can reduce root uptake thus reducing efficacy. Injury symptoms are typically slow to develop and include stunting or slowing of plant growth and a slow plant death. Some plants may survive application but will have a greatly shortened root system and therefore be less competitive (Chambers and Dean 2004). Increasing soil pH results in extended soil residual activity and although these studies were conducted on soils with neutral pH, an earlier study has demonstrated Angel's ability to tolerate chlorsulfuron residues on soil with pH 8.5 (Howie and Ward 2004). The maximum registration label rate for most applications is 20 g/ha but in this study we obtained agronomically useful results at relatively low rates (eg 4 g/ha). Chlorsulfuron is not currently labelled for use in medic seed crops and a registration would have to be obtained before it could be used in this way. Currently there is only one medic cultivar, Angel, which is tolerant of sulfonylurea herbicides. Application of chlorsulfuron to medic seed crops of other cultivars would greatly reduce stand establishment and seed set.

## Conclusion

The results from both the 2007 and 2008 experiments show that chlorsulfuron could be safely used as a pre-emergent herbicide at rates of up to 4 g/ha of product for the effective control of background burr medic and other intolerant species and cultivars in the production of certified Angel seed. This statement is predicated on the assumption that naturalised burr medic behaves similarly to Scimitar in its response to sulfonylurea herbicide. This has been demonstrated for other intolerant annual medic species and cultivars (eg *M. truncatula* and *M. littoralis*) in glasshouse screening and field trials (Howie and Peck, unpublished data).

Our findings highlight a particular advantage for Angel seedgrowers in their ability to reduce background medic contamination. This novel feature of Angel can help reduce the risk and expense of failing to meet certification standards, thereby reducing the cost of production to seedgrowers and ultimately the cost of seed to farmers. The SARDI Pastures group is currently using Angel as a parent to breed new SU residue tolerant hybrid cultivars which will also share this trait.

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## References

Chambers AJ and Dean N (2004). Field Crop Herbicide Guide - 7$^{th}$ Edition. Kondinin Group.

Heap J (2000). Increasing *Medicago* resistance to soil residues of ALS-inhibiting herbicides. PhD thesis, Adelaide University.

Holloway KL, Kookana RS, Noy DM, Smith JG and Wilhelm N (2006). Crop damage caused by residual acetolactate synthase herbicides in the soils of south-eastern Australia. Australian Journal of Agricultural Research 46, 1323-1331.

Howie J (2004). Strand Medic, *Medicago littoralis* "FEH-1" in Plant Varieties Journal, 17 (1), pp. 453-455.

Howie J and Ward B (2004). SU tolerant medic - Minnipa 2003. In Eyre Peninsula Farming Systems 2003 Summary, pp. 45-47.

Howie JH and Bell CA (2005). Field performance of an annual medic tolerant of sulfonylurea herbicide residues: Proceedings of the XX International Grassland Congress, Dublin, Ireland, 26 June - 2 July 2005, p. 413.

Lloyd DL, Taylor GB, Johnson B and Teasdale KC (1997). Patterns of seed softening and seedling emergence during three years after a single seed crop in southern Queensland. Australian Journal of Experimental Agriculture 37, 767-78.

Smith, P and Baxter L (2002). South Australian Seed Certification Scheme - Procedures and Standards Manual. Primary Industries and Resources SA.

Taylor GB (2005). Hardseededness in Mediterranean annual pasture legumes in Australia: a review. Australian Journal of Agricultural Research 56, 645-661.