Improved management of key northern region weeds: diverse problems, diverse solutions

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Summary The cropping region of northern Australia has a diverse range of cropping systems and weed flora. A fallow phase is commonly required between crops to enable the accumulation of stored soil water in these farming systems dominated by reduced tillage. During the fallow phase, weed control is important and is heavily reliant on herbicides. The most commonly used herbicide has been glyphosate. As a result of over-reliance on glyphosate, there are now seven confirmed glyphosate-resistant weeds and several glyphosate-tolerant species common in the region. As a result, the control of summer fallow weeds is become more complex.

This paper outlines project work investigating improved weed control for summer fallows in the northern cropping region. Areas of research include weed ecology, chemical and non-chemical tactics, glyphosate resistance and resistance surveys. The project also has an economic and extension component.

As a result of our research we have a better understanding of the ecology of major northern weeds and spread of glyphosate resistance in the region. We have identified and defined alternative herbicide and non-chemical approaches for the effective control of summer fallow weeds and have extended our research effectively to industry.

Keywords Northern region, fallow, glyphosate resistance.

BACKGROUND

The cropping region of northern Australia covers central and southern Queensland and northern New South Wales. The region is a transitional rainfall zone with the more northern parts having a summer dominant rainfall and the more southern parts a winter dominant rainfall. The environment in the region is sub-tropical with hot summers causing high levels of evaporation.

The cropping system is diverse with much of the region capable of producing both summer and winter crops. Between crops there is often a short or long fallow used to accumulate stored soil moisture. Reduced tillage systems are common in the region and help to facilitate the storage of soil water.

Effective weed control during the summer fallow is vitally important to aid in maximizing stored soil water. Weed control in fallow is heavily reliant on herbicides. The most commonly relied upon herbicide is glyphosate as it is cheap, effective, convenient and safe to use (Osten *et al*. 2007, Duke and Powles 2008).

As a result of an over-reliance on glyphosate for fallow control of weeds, there are now seven weed species confirmed as being glyphosate resistant, annual ryegrass (*Lolium rigidum* Gaudin), awnless barnyard grass (*Echinochloa colona* (L.) Link) (BYG), flaxleaf fleabane (*Conyza bonariensis* (L.) Cronquist), liverseed grass (*Urochloa panicoides* P.Beauv), windmill grass (*Chloris truncata* R.Br.) (WMG), common sowthistle (*Sonchus oleraceus* L.) (Preston 2014) and sweet summer grass (*Brachiaria eruciformis* (Sm.) Griseb.) (T. Cook pers. comm. 2014). In addition, a reduced tillage system in combination with reliance on glyphosate has resulted in difficult to control, glyphosate-tolerant weeds such as feathertop Rhodes grass (*Chloris virgata* Sw.) (FTR) dominating summer fallows.

Weed control in summer fallows has become more complex as a result of glyphosate-resistant and -tolerant weed species. There is a need to better understand the ecology of these key weed species and to identify and define alternative herbicide and non-herbicide options for their improved control.

Our research is focusing on awnless barnyard grass, flaxleaf fleabane, liverseed grass, windmill grass, common sowthistle and feathertop Rhodes grass.

SUMMARY OUTCOMES

Weed ecology Three long-term field experiments on the seed-bank dynamics of BYG provided important information on the impact of crop rotations and agronomic practices on emergence and long term persistence of seed in the soil. A wheat-summer fallow rotation had up to 50% less emergence of BYG seedlings, compared to other crop rotations. As well, regular tillage decreased BYG emergence. However, zero-tilled fallows with high levels of wheat (*Triticum* *aestivum* L.) stubble increased the window of BYG emergence. Starting with a seed-bank of 20,000 BYG seeds m^{-2}, stopping seed-set on sprayed survivors for three years resulted in 99% loss of viable seeds in the soil.

Two field trials have been conducted to quantify the persistence of seed of FTR and WMG planted at 0, 2 and 10 cm below the soil surface. For both grasses, the persistence of seed decreased rapidly for the first 6 months and by the end of the experiment (18 months) no seed of either grass had persisted. Seeds of FTR persisted for 10–12 months irrespective of the depth of burial, while a very low percentage (≤ 1%) of WMG seed persisted up to 12 months after burial at 2 cm and 10 cm. The results of both trials indicate that the prevention of seed set in both FTR and WMG will result in rapidly depleted seed banks.

Two glasshouse trials were conducted to study the susceptibility of different populations of FTR to glyphosate. Results indicate that:

1. there are significant differences in sensitivity to glyphosate between individual populations and within the region,
2. spraying with glyphosate alone will not control FTR and the level of control depends on the individual population, and
3. glyphosate-based double knocks may be effective on populations with a greater susceptibility to the herbicide.

A pot experiment was conducted to study variations in the morphology and phenology of populations of FTR and WMG from the northern region. The time to onset of the phenological development stages of plants was similar across regions but there was considerable variability in growth habit from spreading to upright.

The experiment also showed that plants in populations of FTR emerged and commenced tillering before WMG plants, panicles emerged from WMG plants before FTR, and although the onset of maturity occurred at the same time for both species, panicles of FTR matured over a longer period.

Another pot experiment was established to obtain additional information on the phenology of FTR and WMG as well as determining the influence of different sowing dates on the various developmental stages using growing degree days (GDD).

Previous research has demonstrated that optimal control of FTR and WMG with knock down herbicides is achieved before or at the early tillering stage (2–3 tillers); for FTR this stage corresponds to a GDD value of approximately 250, while for WMG the corresponding value is 300.

Non-chemical tactics The impact of different forms of tillage on seed burial and subsequent emergence is being investigated in three field and two pot experiments using seed of BYG, FTR, WMG, liverseed grass, sowthistle and fleabane.

In all three field experiments, harrows had the least seed burial (majority in 0–2 cm) and one-way discs had the most seed burial (majority buried below 5 cm). However, the different weed species responded differently to these treatments.

Emergence of fleabane was reduced by the greatest amount (>90% in Trial 1) irrespective of tillage treatment compared to zero tillage, with the one-way disc treatment producing the greatest reduction in emergence. Similarly, the emergence of FTR seedlings was reduced by all types of tillage, the one way disc treatment being the most effective.

In two of the three trials, all types of tillage reduced emergence of WMG, again with the one-way disc having the greatest influence. However, in the third field trial all tillage treatments increased the emergence of WMG seedlings.

For sowthistle, off set discs and one-way discs reduced emergence in all trials, but in two of the three trials, harrow and tined cultivator (Gyral™) treatments increased seedling emergence.

The one way disc treatment consistently reduced emergence of liverseed grass across the trials, the other treatments increasing emergence in two of the trials. The response of BYG to tillage with one way discs was the same as the other weeds, except in Trial 2 when off set discs were more effective; in the third trial the harrow, tined cultivator and off set disc treatments increased emergence.

These field experiments clearly demonstrate that soil disturbance impacts on the emergence of key weed species in the northern region, and that the results, apart from the superiority of the one way disc treatment across seasons and weeds, were not consistent between seasons. The different timing and amounts of rainfall during the trial can partly explain these differences.

Glasshouse pot experiments have shown that emergence of sowthistle, fleabane, and WMG is greatest when seed of these species are sown on the soil surface, and less when sown at 2 cm. Awnless barnyard grass and FTR also emerged better at 0 cm but this result was not consistent between experiments. In general, emergence decreased as the depth of burial increased for all weeds apart from liverseed grass which had the highest emergence from seeds buried at 2 cm.

One field experiment in southern Queensland was used to investigate the impact of burning FTR patches on surface soil seed viability. Prior to burning, a significant flush of seedling emergence (up to 5800 seedlings m^{-2}) occurred in response to rain, indicating the potential for dispersal of FTR seeds and rapid increase in plant numbers. Burning significantly reduced the numbers of viable FTR seeds on the soil surface by an average of 93%, from 7490 to 500 seeds m^{-2} as assessed through seedling emergence.

Glyphosate resistance and weed surveys A survey of summer fallows (2012) showed that many weeds were not being adequately controlled. The survey, which was done across 600 (10 m^{-2}) transects in 30 paddocks, found that 42 weeds or crop volunteers were present, of which 27 weeds were seeding. The most common weeds were sowthistle (found in 77% of paddocks), fleabane (63%), FTR (50%) and BYG (30%). As the survey did not extend to central NSW, WMG was not recorded as a major problem.

A 2011 survey demonstrated that the extent of glyphosate-resistant BYG in the region was substantially greater than previously expected. Over 50% of the 78 samples collected randomly from summer fallows prior to the first application of glyphosate were resistant. As well, approximately 90% of the samples collected from survivors of glyphosate treatment were resistant.

Sowthistle populations from northern New South Wales, consisting of possible glyphosate resistant biotypes, were tested for their susceptibility to glyphosate. Testing confirmed the first two cases of glyphosate-resistance in common sowthistle in the northern region.

The discovery of glyphosate resistant common sowthistle has important implications for northern region farming systems, including (i) the possible spread of another glyphosate-resistant weed, (ii) the possible development of multiple resistance to Group B and M herbicides, and (iii) increased pressure on Group I chemistry.

Recently, one population of sweet summer grass (*Brachiaria eruciformis* (Sm.) Griseb.) from central Queensland was confirmed as resistant to glyphosate. Glyphosate is heavily relied upon for control of this weed which is usually very susceptible to glyphosate. Alternative options, both chemical and non-chemical, will now need to be identified for its control.

New chemical tactics Two glasshouse trials and a field trial were conducted to quantify the efficacy of new herbicides for the control of flaxleaf fleabane and common sowthistle at different stages of development.

In one glasshouse experiment mixes of bicyclo-prone and bromoxynil at two rates were completely effective on controlling small (5 cm diameter) – large (15 cm diameter) sized rosettes of fleabane and small (4-leaf) to large (8-leaf) sized rosettes of sowthistle. Although bicyloprone provided 100% control of small rosettes of both weeds, it was less effective against larger rosettes.

In a second glasshouse trial the efficacy of two new herbicides (one containing aminopyralid and a new pyridine active) was tested alone or in combination with other herbicides (24 herbicide mixtures or individual herbicides were screened) on fleabane plants at the medium rosette and stem elongation stages and on sowthistle plants at the large rosette and stem elongation stages. The most consistent and efficacious treatments (90–100% control) on medium sized flaxleaf fleabane rosettes were those that contained aminopyralid or the new pyridine active. Commercial standard treatments were less effective. All herbicide treatments were less effective on fleabane and sowthistle plants at the stem elongation stage, with the best treatments (containing aminopyralid or the new herbicide active) providing only 70–80% control.

A field trial was designed to assess the efficacy of the new pyridine active, together with commercial herbicide chemistry, on medium-large sized rosettes of flaxleaf fleabane. The results suggest that the mixture of the new pyridine with either florasulam or aminopyralid provides the best control of fleabane compared to many commercial standards. Most of the pyridine tank mixtures reduced fleabane biomass by 90–98% at 56 days after application. By comparison, commercial standard treatments including 2,4-D amine, picloram + 2,4-D, picloram + MCPA, MCPA, clopyralid and MCPA + clopyralid provided only 25–85% control, depending on the product.

Since the start of the project two field trials and six glasshouse trials have examined glyphosate alternative fallow control options. In the field trials alternatives to glyphosate for management of common sowthistle have been investigated, and in the glasshouse trials the impacts of (i) the interval between knocks, (ii) double knocks on glyphosate susceptible and resistant BYG, (iii) Group A chemistries and (iv) residual herbicides on the management of FTR, WMG and BYG were quantified.

Significant findings of these experiments were:

1. a range of double knock treatments which did not include glyphosate provided excellent control of small and large sowthistle plants in field trials, and are essential in light of the discovery of glyphosate resistant sowthistle populations in northern NSW,
2. the optimum intervals between knocks using glyphosate followed by a paraquat herbicide are 1–14 days for BYG, 7 days for FTR and 7–10 days for WMG, while the optimum intervals for

a Group A herbicide followed by paraquat are 1–4 days for all three weeds, and

3. of the eight Group A herbicides tested for their efficacy against FTR, BYG, and WMG only two provided complete control of WMG, but none were completely effective against the other two weeds.

Trials have been conducted over the course of the project to investigate aspects of spray application, in particular droplet size and night applications. Droplet size (fine, medium or large) had no impact on the efficacy of 2,4-D, glyphosate or paraquat on flaxleaf fleabane or sowthistle. Applying mixtures of glyphosate + paraquat and haloxyfop + paraquat at night (after sunset) was more effective in controlling BYG than applying them during the day (sunrise). In another trial, picloram + 2,4-D and 2,4-D with and without paraquat did not provide commercially acceptable results on fleabane, irrespective of the time or mode of application. These preliminary results indicate that an effective and cheaper alternative to the practice of double knocking glyphosate resistant BYG is night application of herbicide mixes.

Extending IWM The project team has actively promoted research findings to stakeholders and industry. To date, six specific fact sheets have been published, as well the team has made substantial contributions to other fact sheets and weed management campaigns, such as Weed Smart. Five editions of our electronic newsletter have been widely distributed. The team has given 39 presentations at national and international conferences and industry forums including GRDC Updates, 20 industry articles, 17 conference papers and three journal papers published, and participated in 36 other media activities.

FUTURE RESEARCH

There are many components of research which will continue, including ecological experiments especially on FTR and WMG, and an additional tillage experiment to explore the impact of additional passes of tillage on seed burial and emergence.

Many of our results from pot trials will be moved into the field. For example, glyphosate alternatives identified for the summer grass species, including knockdown and residual treatments will be evaluated at a research farm where we have established a population of BYG, FTR and WMG. At the same site, the impact of cover crops on summer fallow weed control will also be investigated.

As a result of confirmation of glyphosate resistance in common sowthistle, work will commence to identify and evaluate glyphosate alternatives for this weed. This will include identifying double knock treatments and defining optimal usage such as time between knocks. In addition, a coordinated and comprehensive survey of common sowthistle glyphosate resistance will take place across the northern region.

Extension efforts will continue with planned publications to include common sowthistle and WMG management and optimal use of residual herbicides.

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