Utilising crop competition for weed management in the wheatbelt of Western Australia – a GRDC review

Abul Hashem, Department of Agriculture and Food Western Australia Northam; **Catherine Borger,** Department of Agriculture and Food Western Australia Merredin; **Chris Johansen**, Department of Agriculture and Food Western Australia Northam (short-term specialist)

Key messages

A GRDC funded project reviewed WA research from 1990 to 2015 on the competitive ability of crops to suppress weeds.

Optimal crop competition can be achieved through increased crop density, reduced row spacing, east-west crop orientation and optimal crop health/nutrition.

Further research is required to clarify the benefits of occasional soil inversion (mouldboard ploughing), varying crop rotations, and to determine the environmental/climatic influences on competitive ability of individual crop species or cultivars.

Aims

Approximately 90% of growers in the WA wheatbelt have adopted no tillage seeding systems, which has led to increased reliance on herbicides and a resultant increase in herbicide resistance (Owen et al, 2007; Walsh et al, 2007; D'Emden et al, 2008). As a result, integrated weed management programs need to focus on non-chemical weed control options. Improved crop competition is a cheap and highly effective method to reduce weed growth. A GRDC funded project (Cultural management options for herbicide-resistant weeds, DAQ00197) aimed to review research conducted in last 25 years on crop competition in WA. The review highlighted the methods of improved crop competition that should currently be incorporated into integrated crop management (ICM) packages and those areas that require further research. Key findings of the review are summarised within this Crop Updates paper.

Methods to increase the competitive ability of crops

There are a wide range of methods to increase the competitive ability of crops, which have been extensively researched from 1990 to the present (Table 1).

Table 1: A summary of the methods utilised in Western Australia to increase the competitive ability of crops.

Method to increase competitive ability	Description of method	Number of WA projects investigating each method from 1990 to 2015	Key references to provide examples of WA projects
Crop species	Some crop species are more competitive than others. For example, wheat and barley are usually more competitive than canola, lupin or pea.	6 projects, 19 trial sites	(Peltzer, 1999; Borger et al, 2010)
Crop variety	Some crop varieties are more competitive, although this varies widely due to site and seasonal conditions. Varieties with an early sowing date, early vigour and early canopy closure tend to be more competitive.	11 projects, 25 trial sites	(Brennan et al, 2001; Pathan et al, 2006; Paynter & Hills, 2009)
Crop density	High density of crops results in reduced weed growth. For example, Peltzer (1999) noted a 60-90% reduction in annual ryegrass seeds/m^2 when wheat, oats, barley or triticale were sown at from 50 to 400 kg/ha.	16 projects, 31 trial sites	(Peltzer, 1999; Minkey, 2002; Paynter & Hills, 2009; Newman & Zaicou-Kunesch, 2013)
Row spacing	Narrow row spacing reduces weed growth. Riethmuller (2005) concluded that wheat yield decreased by around 4% for every 5 cm row spacing increase over 18 cm, which correlated with an increase in ryegrass density.	14 projects, 26 trial sites	(Minkey, 2002; Riethmuller, 2005; Newman, 2014)

Wide row crops	Wide rows reduce competitive ability but allow targeted spraying or mechanical weed control within the rows. However, targeted spraying leads to resistance and mechanical control is ineffective.	6 projects	(Peltzer et al, 2009)
Row orientation	East-west crop orientation shades the weeds in the inter-row space, reducing weed seed production.	2 projects, 10 trial sites	(Borger et al, 2010; Borger et al, 2015)
Sowing time	Early sowing ensures that the crop plants are older/more competitive. Delayed sowing allows the bulk of the weeds to emerge and be killed prior to sowing.	6 projects	(Hashem et al, 1998; Paynter & Hills, 2009; Minkey & Ashworth, 2012)
Sowing depth	A sowing depth of greater than 5 mm delays emergence and reduces initial vigour of the crop seedlings.	No projects in WA	(Photiades & Hadjichristodoulou, 1984)
Sowing method	Sowing methods that maximise the distance between individual crop plants increase competitive ability. For example, cross sowing involves placing half the seed in one direction and the remaining seed at right angles.	3 projects	(Fischer & Miles, 1973; Peltzer, 1999)
Crop rotation	The extent of weed control in the prior crop determines the weed seed bank. A break crop, fallow or pasture phase allows optimal weed control to reduce weed density in following crop.	5 projects	(Flower et al, 2012; Seymour et al, 2012)
Nutrition	Optimal timing of fertiliser will maximise crop growth and minimise fertiliser available to weeds. Nitrogen fertiliser can be applied in ways to minimise weed growth.	4 projects	(Palta & Peltzer, 2001; Blackshaw et al, 2004; Hashem et al, 2013)
Crop health	A healthy crop will more effectively compete with weeds. For example, liming acidic soils improves crop growth, leading to suppression of weeds.	2 projects	(Gazey & Andrew, 2010)

Results

The possible components of an integrated weed management (IWM) strategy in Australian cropping systems have been recently compiled by Storrie (2014). Here, we examine the feasibility of including some of the cultural weed control measures listed above in an overall ICM package applicable to the WA wheatbelt. The emphasis is on reducing the use of herbicides so as to minimise development of herbicide resistance, but recognising that judicious herbicide intervention would inevitably be required. However, the deployment of cultural weed control measures in an IWM or ICM strategy needs to be reconciled with the other aspects of integrated management required in a cropping enterprise. These include integrated management of pests, diseases, weeds, nutrients, soil quality, etc., which the farmer must further integrate into the overall economics of the enterprise.

In the current agronomic system, aspects of an ICM package may include occasional tillage (i.e. inversion ploughing), break crops/pasture phase and improved crop competition. The herbicide resistance problem in weeds is largely an outcome of the widespread adoption of conservation agriculture practices, where herbicide use has replaced traditional tillage practices used for weed control. Although minimum tillage practices have been widely demonstrated as having long-term benefits to soil health, there are advantages to occasional cultivation such as distribution of soil organic matter and nitrogen mineralization (Douglas & Peltzer, 2004; Newman, 2011). Therefore, occasional cultivation to bury weed seeds or kill emerging weeds may be feasible and provide other benefits to the agronomic system. However, in the presence of herbicides, no-tillage systems can have fewer weeds (annual ryegrass and wild radish) due to less soil stimulation (Minkey & Bowran, 1999). A pasture phase is also effective for weed control, and leads to increased (and improved distribution of) soil organic carbon (Minkey & Bowran, 1999; Storrie, 2014). However, the possibility of including a pasture phase would depend on the economic outlook for cropping and animal production enterprises. Monjardino et al. (2004) concluded that the option of highest economic value in situations of high herbicide resistance was phase farming, involving occasional pasture phases of 3-years duration. However, there are additional precautions regarding weed management that are needed with animal husbandry, such as transfer of weeds seed between locations (Storrie, 2014).

Optimal competitive ability of crops can be achieved through use of competitive crop species, increased crop density, reduced row spacing, east-west orientation and optimal crop health and nutrition. The competiveness of individual cultivars tends to vary too widely due to location and seasonal conditions to be a reliable indicator of competitive ability (Hashem et al, 2010). However, there are a range of other agronomic considerations that will affect the use of these techniques in individual situations. Sowing time/depth and fertiliser may be used to optimise weed control but are primarily determined by considerations other than weed management (i.e. soil moisture availability over time and seed drill characteristics).

Future research needs

Much has been learned over the previous two decades about how crops can compete with weeds. However, the following research is required for cultural weed management options to be incorporated into IWM programs to suppress herbicide-resistant weeds in the WA wheatbelt.

- Optimum densities, row width and orientation for weed suppression and optimal crop yield have been established for wheat and barley in the WA wheatbelt. However, further research is required for canola and grain legumes.
- Previous studies on the ability of individual cultivars to compete with weeds have produced inconsistent results. Cultivars with high early growth vigour should have a competitive advantage, at least where soil water is adequate at the establishment phase. There is a need for research to assess the scope for exploiting cultivar differences, by comparing cultivars clearly differing in traits such as early growth vigour, tillering/branching pattern, leaf shape, etc. It is necessary to assess whether it would be worthwhile specifically breeding for greater competitive ability with weeds.
- It is necessary to screen newly released varieties for their competitive ability. Inclusion of information on the competitiveness of cultivars along with other agronomic information at the time of variety release would benefit growers.
- Although much research has been done in the WA wheatbelt on rate, placement and timing of fertilisers, it has usually been done in a weed-free situation. There is scope to examine how various manipulations of fertiliser can influence crop competition with weeds, particularly for nitrogen use in cereals and canola.
- Assessment of existing long term trials and grower surveys are required to ascertain the effect of various crop rotations, including pasture phases, on weed control. Of course, there will be various confounding factors such as herbicide history, agronomic practices, weed regime and locational effects, but it may be possible to better assess which crop rotations are more conducive for management of which weeds.
- There is scope for reincorporating some form of tillage into no-tillage systems, to kill living weeds, bury weed seeds, incorporate lime and gypsum into the sub-soil and distribute soil organic carbon deeper into the profile. However, further investigation is required on timing between ploughings and ploughing technique, to maintain optimal soil health obtained from no-tillage systems.
- Mechanical weed control in wide row crops needs further research, as it remains ineffective compared to herbicide use.
- A comprehensive dataset from a systematic distribution of sites across the wheatbelt would be required to assess the effect of climatic factors, or more specifically soil available water, on crop competitiveness with weeds. Similarly, to ascertain effects of soil type, and distinguish them from climatic effects, experiments would need to be done on contrasting soil types at the same location.
- There is further information to be gained on crop rotation effects on weeds. This could be done using a retrospective assessment of weed dynamics in different rotations in farmers' fields and long-term trials.

Conclusion

An IWM package needs to be practical to implement and economically feasible. Further, an IWM package needs to be integrated into an ICM package. This requires comprehensive involvement with grower groups/individual growers, and a continued monitoring of research outcomes to identify the most appropriate combinations of factors to include in an IWM package.

Key words

Crop competition, integrated weed management, integrated crop management.

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