Increasing weed competition with competitive barley cultivars

Linda Walters[1] and Simon Craig[2]

[1] Birchip Cropping Group, 73 Cumming avenue, Birchip, VIC 3483, www.bcg.org.au, linda@bcg.org.au
[2] Farm360 Pty Ltd, 402-404 Campbell Street, Swan Hill, VIC 3585, scraig@pooles.com.au

Abstract
Barley is a vigorous crop when compared to wheat. Cultivars have different growth habits that can influence the way they compete for light and resources. Some varieties have a slow early vigour, erect growth habit or fewer tillers, allowing more light interception into the canopy, whilst other varieties have high early vigour and grow in a prostrate manner. Increasing pressure on grass herbicide chemistry, is causing resistance to become a serious issue. With few in-crop herbicides that can effectively control problematic grasses, greater weight will be placed on choosing a variety that can compete strongly against weeds or possess tolerance to Clearfield technology. Trials were undertaken in 2013 and 2016 to compare 12-18 current and existing barley varieties to determine their competitiveness in the presence and absence of weeds, to assist the development of variety specific management packages. The presence of weeds (broadcast oat) reduced overall grain yield in both years between 0.6-1.4 t/ha. Shorter varieties that lack early vigour, such as Spartacus CL, Hindmarsh, Wimmera and Urambie incurred higher yield losses. Whereas taller varieties Compass, Fathom and Scope CL which are highly vigorous and grow more prostrate, offer greater competition against weeds and suppression of weed seed production.

Keywords
Barley agronomy, barley, weeds, competition, competitiveness, varieties.

Introduction
Weed competition can be affected by crop variety selection, sowing rate, weed species and density and time of emergence of the crop, relative to the weed. The competitiveness of a crop is related to its capacity to access resources such as light, water and nutrients. It can be looked at as the ability of a crop to tolerate weed pressure and maintain yield, or the ability of the crop to suppress weed growth and seed production. Barley varieties have different growth habits and canopy structure that can influence the way they compete for light and resources. Speed of emergence, rate of biomass accumulation (and ground cover), tillering capacity, height and leaf characteristics (Agriculture and Agri-Food Canada 2017) may all influence a variety's ability to suppress or tolerate weeds. For example, some varieties have a slow early vigour, erect growth habit or fewer tillers, allowing greater light interception into the canopy, whilst other varieties have high early vigour, greater tillering and grow in a prostrate manner. There are very few in-crop herbicides that can effectively control problematic grass weeds, meaning greater weight will be placed on using non-chemical methods for an integrated weed management strategy. Trials were conducted in 2013 and 2016 as part of the GRDC-funded Barley agronomy for the Southern region project comparing the competitiveness of new and existing barley varieties in the presence and absence of weeds.

Methods
Trials were established in the Victorian West Wimmera on Wimmera grey, cracking clay soils. Rainfall distribution is mediterranean and the sites received 339 mm of growing season rainfall in both years and 404mm of annual rainfall (November 2012 – October 2013) in 2013 and 455 mm in 2016. The pre-sowing mineral nitrogen (N) status at the trial site in 2013 was 28 kg N/ha to 100cm (nitrate and ammonium nitrogen) and 101 kg N/ha at the 2016 location. Both trials were sown with a knife point seeder and press wheels on 30 cm row spacing. Oat crop was used to 'simulate' a grass weed in both years. In 2013 a higher target plant density of 175 plants/m² was used for oat and in 2016 a lower density of 75 plants/m². The oat were broadcast with the seeder prior to sowing and then incorporated into the soil at sowing. Wintaroo oat was sown in 2013 and Mitika oat in 2016.

In 2013, the trial was sown on the 23rd April, to a latin square design with three replicates and 18 barley varieties, in the presence and absence of 'weeds'. Barley varieties were chosen for their differences in early vigour, known competitiveness and growth habit. These included Fathom, Westminster, Gairdner, Sloop SA,

Commander, Maritime, Bass, La Trobe, Compass, Hindmarsh, GrangeR, Flinders, Navigator, Yarra, Wimmera, Skipper, Scope CL and Buloke.
In 2016 the trial was sown on the 16th May in a split plot design with three replicates and 12 barley varieties, in the presence and absence of weeds. The varieties trialled were Commander, Compass, Fathom, Hindmarsh, La Trobe, Maritime, Oxford, Rosalind, Scope CL, Spartacus CL, Urambie and Westminster.

Data recorded throughout the season (2013 and 2016) included; establishment counts (barley and oat), crop biomass (barley), stem counts (barley and oat – October), NDVI (Zadoks 31 and Z80), seed production (oat), 1000 grain weight (barley and oat), grain yield and quality parameters. The amount of oat in the 'weed' treatments meant grain quality analysis could not be done on these treatments. Sub-samples (100g) were taken from the original plot grain samples. The yield of the oat and barley in treatments was subsequently determined by separating, counting and weighing the grains, yield was then calculated. Herbicides, pest control and fertiliser were applied to best practice management and applicable to the site history. Plots were harvested with a Wintersteiger plot harvester and protein was measured using a Foss Infratec NIR whole grain analyser. Yields were corrected to 11.5% moisture.

Results

The trial in 2013 established well and the method of incorporating the oat into the 'plus' weeds treatments was successful. The Wintaroo oat had excellent early vigour and growth rate was similar to that of the barley plants, with an emergence of 160 plants/m^2 achieved. It is important to note that the previous year's crop was sown to oat (hay), so volunteer oat emerged, meaning the 'minus weed' treatment had a small population of oat present (3.5 plants/m^2). In 2016, the oat (weeds) were notably slow to establish and were fully emerged about two weeks after the barley. Establishment rates in the oat weren't as high as targeted (75 plants/m^2), averaging 37 plants/m^2. Average rainfall during the season and adequate nitrogen ensured the barley and oat were vigorous in both years.

Effect of 'weeds' on crop growth and yield

All barley varieties (in both years) were affected in terms of yield, in the presence of weeds, regardless of the density of weeds present (Table 1 & 2). These trials indicate the benefit of keeping crops weed free with a 1.4t/ha yield loss in 2013 and a 0.6t/ha loss in 2016 when barley is sown into weeds, with no chemical control.

Barley biomass at both flowering (Z65) and maturity (Z99) was reduced when weeds were present. In 2013 weeds also reduced barley stem thickness (diameter) and barley tiller number (Table 1) as plants had limited access to light, moisture and nutrition with weeds present.

Early NDVI (Z21 in 2013 and Z31 in 2016) was higher in the presence of weeds. This demonstrates an increased amount of greenness captured when weeds are present and the barley canopy is more open. In 2013, NDVI undertaken at Z80 however, showed that the NDVI values were higher in the 'weed free' plots. This may have been due to competition within the weedy plots causing earlier senescence, either because of moisture limitation, (unlikely given the decile 8 season) or competition for nitrogen (low N site).

Table 1. 2013 average performance of barley with and without weeds (oat).

Treatment	Barley plants (m²)	Weeds (oat) (m²)	Barley tillers (m²)	Biomass Z65 (t/ha)	NDVI (Z31)	NDVI (Z80)	Grain yield (t/ha)
Minus weeds	120	3.5	196	6.0	0.79	0.44	5.4
Plus weeds	118	160.5	137	4.0	0.83	0.40	4.0
LSD(P=0.05)	NS	7.9	9.7	0.3	0.01	0.01	0.1

Table 2. 2016 average performance of barley with and without weeds (oat).

Treatment	Barley plants (m²)	Weeds (oat) (m²)	NDVI (Z21)	NDVI (Z32)	Biomass (Z99) (t/ha)	Grain yield (t/ha)
Minus weeds	115	0	0.210	0.820	13.1	4.8
Plus weeds	115	37	0.219	0.824	11.7	4.1
LSD(P=0.05)	NS	2.9	0.003	0.007	0.5	0.3

Interaction between barley cultivars and weeds

When investigating the interaction between varieties, it is important to note the growth habit and canopy architecture of different barley varieties. Varieties such as Rosalind, Spartacus CL, La Trobe and Hindmarsh have a lower NDVI in the absence of weeds (at early tillering), due to their erect growth habit and slower early vigour. Their open canopy, enables greater light penetration, potentially favoring weed growth. By contrast, varieties such as Scope CL, Fathom, Commander and Compass have a more prostrate and vigorous early growth habit which correlate to a higher NDVI reading.

Hindmarsh (in both years of trials) was the poorest competitor against weeds and lacks the ability to suppress weed seed production (Figure 1). Wimmera (2013) and Urambie (2016) also showed a poor ability to compete, due to their later maturity, shorter height and slow early vigour. Spartacus CL, a new Clearfield variety, phenotypically similar to Hindmarsh (trialled 2016), was also another variety that had greater yield loss.

La Trobe could also be expected to behave similarly to Hindmarsh given similar growth habit and vigour, however from two years of trials this has not appeared to be the case. In 2013, it suffered a similar yield penalty to Hindmarsh, but seemed to reduce weed seed set, and in 2016 it suffered a smaller yield penalty and again reduced weed seed set. Further investigation into why this is occurring between two lines that phenotypically would nearly appear identical is required.

Figure 1 shows the percentage of yield loss when different varieties are under weed pressure versus the amount of biomass (t/ha) produced by the weeds. The weed biomass (t/ha) is directly related to weed yield (t/ha). Varieties that allowed the weeds to produce greater weed biomass, also had a greater weed yield in the plot. Figure 2 demonstrates varieties that fit into:

A section: Low final yield loss, high weed biomass (seed) production
B section: High final yield loss, high weed biomass (seed) production
C section: Low final yield loss, low weed biomass (seed) production
D section: High final yield loss, but high weed biomass (seed) production

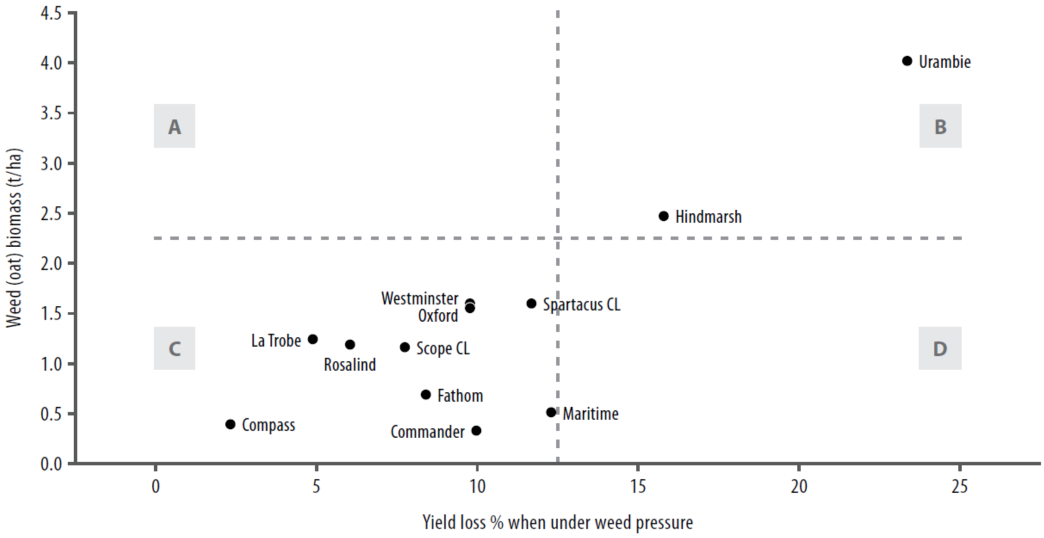

Figure 1. Yield loss (%) in barley varieties when under weed pressure compared to weed (oat) biomass (t/ha) in 2016.

With greater weed numbers in the trial (2016), a greater spread between these categories would be likely. There was a strong correlation between the height of the variety and its subsequent yield loss over the two years; the shorter the variety, the greater the yield loss. Wimmera (S-MS), Flinders (MS), Navigator (S-MS), Hindmarsh (S-MS), Yarra (S-MS), Urambie (MS), Spartacus CL (MS) all lost significant yield when weeds were present. Scope CL, Buloke, Compass, Sloop SA, Fathom are all medium-tall to tall varieties and had the least amount of yield loss when weeds were present. It was not consistent for each variety with Skipper

(M) and Westminster (MT) incurring similar yield losses to the shorter varieties in 2013 and Rosalind (MS) and La Trobe (MS) not incurring high yield loss like its agronomically similar counterpart Hindmarsh. Therefore, not all varieties can be grouped into 'competitiveness' without some form of evaluation, however, height can still provide a useful indication.

The contamination of weeds (oat) in the sample had no effect on grain quality when comparing varieties in the presence and absence of weeds. The presence of weeds though in a grain sample downgrades to feed value, due to contamination of weed seeds.

Previous research conducted by Goss and Wheeler (2015) and Porker and Wheeler (2014) through the GRDC Barley agronomy for the Southern Region SA node, concluded in 2013 and 2014 similar results to Birchip Cropping Group findings. Barley varieties Compass and Fathom have shown a good ability to compete against grass weeds and Commander and Scope CL also offering a higher level of competition. Hindmarsh and Wimmera have competed poorly against weeds (2013 and 2014).

Conclusion

With herbicide costs and resistance on the rise, integrated weed management (IWM) is becoming increasingly important. This investigation into a 'cultural' weed control strategy is just another piece in the puzzle and should be used as part of an integrated approach to weed control.

This research confirms that Hindmarsh is a poor competitor against weeds. Spartacus CL, phenotypically similar to Hindmarsh, also showed a poor ability to compete and both varieties have a poor tolerance to prevent weeds setting seed. Spartacus CL has the benefit of being able to control weeds in crop with Intervix®. However, over-reliance on this technology for more than two consecutive seasons alone is likely to fast-track resistance, especially when using poorly competing varieties in a weedy paddock. In a plant back situation growers may need to consider the long-term impact of growing a poorer competing variety and the likelihood of more weeds emerging in the subsequent season. Other weed management tools would need to be used in this case.

Varieties that have shown good competitiveness against weeds, in line with previous research from the South Australian Research and Development Institute, include Compass, Scope CL and Fathom. Selecting a barley variety, however, is a decision that should be viewed as part of a long-term strategy, with an overarching aim to reduce seed bank levels and to maintain or improve the productivity of the paddock. Growing a variety such as Hindmarsh or Spartacus CL in a problematic paddock, is potentially not the best option due to their lack of competition. However, instead of eliminating a high yielding, but poor competitor out of the rotation, growers should ensure good paddock planning to get optimum performance from those varieties by selecting paddocks that don't host a high weed population.

References

Agriculture and Agri-food Canada (2017).Weed management options which reduce pesticide risk, Competitive crops and cultivars. (http://www.umanitoba.ca/outreach/naturalagriculture/weed/files/singleseason/crops_cultivars_e.htm).

Goss S and Wheeler R (2015). Using crop competition for weed control in barley and wheat, GRDC, 10 September 2015. (https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Using-crop-competition-for-weed-control-in-barley-and-wheat).

Porker K and Wheeler R (2014). Getting the best from barley; agronomy and management, GRDC, 25 February 2014. (https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Getting-the-best-from-barley-agronomy-and-management).