Manipulating crop row orientation and crop density to suppress annual ryegrass

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Key messages

Light is an important resource that crops and weeds compete for, and so increased light interception by the crop can be used as a method of weed suppression.

The average light available to annual ryegrass in the inter-row space of east-west crops compared to north-south crops in 6 trials in 20010 and 2011 was 78% and 91% at crop tillering, 39% and 56% at stem elongation, 28% and 53% at boot/anthesis, and 41% and 59% at grain fill.

Reduced light availability in the inter–row space of the east-west crops resulted in reduced annual ryegrass seed production in five of the six trials (average of 2968 and 5705 annual ryegrass seeds/m^2 in the east-west and north-south crops).

Light availability to the annual ryegrass in the inter-row space was not influenced by crop seeding rate, but the high seeding rate reduced annual ryegrass seed production in three of the six trials (average of 3354 and 5092 annual ryegrass seeds/m^2 in the crops with high and low seeding rate).

Increased competitive ability of crops (through increased light interception or increased crop density) was highly effective in reducing annual ryegrass seed production, and is an environmentally friendly and low cost method of weed control.

Aims

Light is a key determinant of plant growth and seed production. The intense competition between plants for light indicates that minimising light availability to weeds will reduce weed growth while maximising crop yield. Orientating crops to allow them to shade weeds in the inter-row space could substantially reduce weed growth. Other factors that may influence light interception are crop species/cultivar or crop density.

The current study investigated light interception by cereal (wheat and barley) crops in east-west or north-south orientations, at high or low densities, and the resulting impact on annual ryegrass seed production. The study hypothesised that greater shading of annual ryegrass in the inter-row space would be apparent in east-west crops compared to north-south crops, or in crops sown at high rather than low density. The study further hypothesised that where light availability to the inter-row space was reduced, annual ryegrass would have reduced seed production.

Method

Field trials were conducted on Department of Agriculture and Food WA Research Stations at Merredin, Wongan Hills and Katanning, in 2010 and 2011. In 2010 the three trials investigated crop row orientation (east-west or north-south) and seeding rate (wheat cv. Wyalkatchem at 60 or 120 kg/ha). In 2011 the trials investigated orientation, crop type (wheat cv. Wyalkatchem or barley cv. Buloke) and seeding rate (50 or 100 kg/ha). Trials were arranged in a split plot design, with orientation as the main plot factor and seeding rate or all combinations of seeding rate and crop type (for the 2011 trials) randomised within the subplots. Trials were replicated three times in 2010 and four times in 2011 (plot size of 2 m by 20 m).

At all sites non-selective herbicides were used to kill weeds germinating prior to crop sowing. The crops were sown (on 31 May 2010 and 27 May 2011 at Merredin, 11 June 2010 and 16 June 2011 at Wongan Hills, and 24 May 2010 and 24 June 2011 at Katanning), using a no tillage seeding system (knife points and press wheels), with a row spacing of 25 cm, at a depth of 3-4 cm, with 80 to 100 kg/ha of fertiliser (Agras 14, 14, 9.6, 0.04% N:P:S:Zn or CropStar 15, 14, 10% N:P:S). Herbicides or pesticides were applied in crop where necessary to remove broadleaf weeds or crop pests. Crops were harvested on 15 November 2010 and 23 November 2011 at Merredin, 10 November 2010 and 30 November 2011 at Wongan Hills, and 1 December 2010 and 5 December 2011 at Katanning.

Measurements

Light (as photosynthetically active radiation) was measured at tillering, stem elongation, boot to anthesis and grain fill at mid-day at the centre of the inter-row space with a linear Ceptometer (Sunfleck Ceptometer Delta-T Devices LTD, 1 m long). Within each plot light was measured above the crop canopy and above the weed canopy three times, and a single averaged value was recorded. The light available to the annual ryegrass canopy in the inter-row space was expressed as a percent of total light available to the crop canopy.

Crop density was measured at tiller initiation. Annual ryegrass plant samples were taken from 50 cm by 50 cm quadrats prior to harvest, dried at 40^{o}C for three days, weighed, threshed and put through a splitter to get a consistent sample weighing approximately 5 g. Seeds in each sample were manually counted and weight of the sample was used to estimate seed production from the number of seeds in the subsample. Total crop yield per plot was recorded during harvest.

Climate data was obtained from the DAFWA automatic weather station located on each research station. Long term average annual rainfall (and average growing season rainfall from May to October) was 291 mm (191 mm) in Merredin, 306 mm (240 mm) in Wongan Hills, and 347 mm (292 mm) in Katanning. Annual rainfall (and growing season rainfall) for each trial was 168 mm (139 mm) in Merredin 2010, 186 mm (144 mm) in Wongan Hills 2010, 291 mm (191) in Katanning 2010, 400 mm (255 mm) in Merredin 2011, 456 mm (395 mm) in Wongan Hills 2011 and 611 mm (352 mm) in Katanning 2011.

Statistical analysis

The trial data were analysed using ANOVA in a split plot design (using Genstat 15th Edition). The percent light interception was analysed using the same structure, with the split plot design nested within crop growth stage (tillering, stem elongation, boot/anthesis and grain fill). Means were separated using Fisher's protected least significant difference. The normalcy of the data was tested by plotting residuals. To ensure normal distribution of the residuals, a square root transformation was applied to the Wongan Hills 2010, Katanning 2010, Merredin 2011 and Katanning 2011 seed production data. Data are presented as back-transformed means.

Results

Light available to annual ryegrass

At tillering light availability to annual ryegrass in the inter-row space was generally high (average of 84%), although lower at Merredin 2011 due to rapid early crop growth. Light availability was reduced at stem elongation and boot/anthesis (average of 47% and 40%) as the canopy size increased. The light available to annual ryegrass increased (average of 50%) as the crops started to senesce and canopy size reduced during grain fill. The light available to annual ryegrass was reduced in the east-west plots compared to the north-south plots, with an average of 78% and 91% light at tillering, 39% and 56% at stem elongation, 28% and 53% at boot/anthesis and 41% and 59% at grain fill (Table 1).

Crop type influenced light availability at Merredin 2011 and Katanning 2011, but not Wongan Hills 2011. At Merredin 2011 there was reduced light available to the annual ryegrass in the barley crop compared to wheat at both orientations (16% and 25% for east-west crops, 25% and 41% for north-south crops, P <0.001, Lsd: 8). The reduction in light in barley crops compared to wheat was consistent throughout the year (53% and 61% at tillering, 4% and 11% at stem elongation, 6% and 22% at boot/anthesis, 20% and 37% at grain fill, P: 0.009, Lsd: 5). At Katanning 2011, light was again reduced in barley compared to wheat from stem elongation to grain fill (92% and 96% at tillering, 53% and 61% at stem elongation, 34% and 47% at boot/anthesis, 33% and 39% at grain fill, P: 0.021, Lsd: 5). Seeding rate did not affect light availability to annual ryegrass.

Table 1 Light available to the annual ryegrass canopy in the inter-row space of east-west or north-south orientated crops (as a percent of the total radiation available to the crop canopy), at varying stages of crop development. Means of orientation for each growth stage within a trial are separated by least significant difference (Lsd).

Year	Location	Orientation	Crop growth stage				Lsd (P <0.05)
			Tillering	Stem elongation	Boot to anthesis	Grain fill	
2010	Merredin	East-west	92	72	57	75	9
		North-south	100	86	79	95	
	Wongan Hills	East-west	93	52	27	45	14
		North-south	100	67	63	77	
	Katanning	East-west	56	20	19	35	14
		North-south	81	32	40	64	
2011	Merredin	East-west	44	4	7	27	8
		North-south	70	11	21	31	
	Wongan Hills	East-west	90	36	28	32	10
		North-south	96	76	62	43	
	Katanning	East-west	91	49	27	30	7
		North-south	97	64	54	43	

Crop density

Crop density was consistently higher in the high seeding rate plots compared to the low seeding rate plots, and was higher in the wheat plots compared to the barley plots at Wongan Hills 2011 and Katanning 2011 (data not presented). Orientation had no impact on crop density.

Annual ryegrass seed production

Annual ryegrass seed production was significantly reduced in east-west crops compared to north-south crops at all trial sites except Katanning 2010 (average seed production of 2968 and 5705 seeds/m^2 in the east-west and north-south crops), reduced in barley crops compared to wheat crops at Merredin 2011 and Katanning 2011, and significantly reduced by high crop density at Merredin 2010, Merredin 2011 and Katanning 2011 (Table 2).

Table 2 Annual ryegrass seed production (m^2) in east-west or north-south orientated crops of wheat (2010) or wheat and barley (2011), with low or high seeding rates. Means for each factor within each trial are separated by least significant difference (Lsd), where NS indicates that the means were not significantly different.

Treatments	2010 Merredin	2010 Wongan Hills	2010 Katanning	2011 Merredin	2011 Wongan Hills	2011 Katanning
East-west	503	24	529	27	2610	14113
North-south	910	300	465	125	6155	26276
Lsd (P<0.05)	331	36	NS	35	3469	1342
Barley	*	*	*	19	4420	16410
Wheat	*	*	*	146	4345	23378
Lsd (P<0.05)				18	NS	271
Low seeding rate	1032	130	151	119	5029	24087
High seeding rate	381	21	132	30	3736	15826
Lsd (P<0.05)	275	NS	NS	18	NS	271

*Treatment not included in trial.

Crop yield

Yield was greater in east-west crops compared to north-south crops at Merredin 2011 (2957 and 2589 kg/ha, P: 0.019, Lsd: 22) and greater in high rather than low seeding rate plots at Wongan Hills 2011 (2793 and 2491 kg/ha, P: 0.008, Lsd: 218) and Katanning 2011 (2244 and 1840 kg/ha, P <0.001, Lsd: 174). Wheat crops had a greater yield than barley at Merredin 2011 (2992 and 2554 kg/ha, P <0.001, Lsd: 98) and Wongan Hills 2011 (3082 and 2202 kg/ha, P <0.001, Lsd: 218), but reduced yield at Katanning 2011 (1813 and 2271 kg/ha, P <0.001, Lsd: 174).

Conclusion

East-west orientated crops reduced annual ryegrass seed production when ryegrass emerged with the crop. Katanning in 2010 was the only site where crop orientation had no impact on annual ryegrass seed production. The annual ryegrass at this site emerged two weeks after the crop, ensuring that the crop was highly competitive regardless of crop orientation or seeding rate. Annual ryegrass seed production was reduced because the east-west crops had reduced light available to the annual ryegrass compared to north-south crops, which was apparent from an early stage of crop development (tillering or stem elongation). The reduced annual ryegrass seed production in dry years such as Merredin 2010 is of particular importance, as in-crop herbicides can perform poorly in moisture stressed, low yielding crops. East-west crop orientation offers a free method to reduce annual ryegrass seed production, even in low yielding crops. However, if a field is rectangular with the long side in a north-south direction, then using short east-west seeding/harvest runs will result in increased costs due to increased time and fuel consumption.

The barley in Merredin 2011 and Katanning 2011 had reduced light available to the inter-row space, and reduced seed production of annual ryegrass, even though wheat had higher plant density and a greater yield than barley at Merredin 2011 and Wongan Hills 2011. The current research utilised barley cv. Buloke and wheat cv. Wyalkatchem because these cultivars are the industry yield benchmark against which other cultivars are compared in WA (although Wyalkatchem was replaced as the yield benchmark for wheat by cv. Mace in 2013), but both are considered to have poor competitive ability against weeds. Results may vary when using a more competitive crop cultivar.

Increased seeding rate led to greater crop density, but did not affect light availability. Increasing plant density can result in reduced leaf area or reduced tillers per plant, resulting in a canopy that is a similar size regardless of initial seeding rate. However, high seeding

rate still increased the competitive ability of the crop and led to reduced annual ryegrass seed production at half of the sites.

Crop competition remains one of the most economically desirable and environmentally sustainable methods of weed control. Altered crop orientation as a weed control technique may not always be practical to apply, as it is difficult to drive directly into the sunrise/sunset at seeding/spraying/harvest without autosteer technology. However, increasing the competitive ability of crops (through use of competitive cultivars, high seeding rate or east-west orientation) can reduce annual ryegrass seed production, and is a valuable tactic to manipulate the seed bank within an integrated weed management program.

Key words

Wheat, barley, crop orientation, crop competition, annual ryegrass, seed production

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