





## **RUNNING TITLE:**

Canola competitiveness against annual ryegrass

# TITLE:

**Trial 2:** The interaction between the seeding rate and seed size of hybrid and open pollinated canola (*Brassica napus*) varieties on ryegrass (*Lolium rigidum*) growth and competition.

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### INTRODUCTION

Canola is the most widely grown broadleaf crop in Australia since its introduction in 1969 (Angus et al., 2015; Colton & Potter, 1999) due to its profitability and rotational benefits to the successive crops (Seymour, Kirkegaard, Peoples, White, & French, 2012). Canola is an adaptable species in which its yield is highly responsive to agronomic management. Agronomic management can be in the form of optimising herbicide use, N rate, seeding rates, row spacing, seed size and cultivar choice (Seymour et al., 2012).

Past research has demonstrated the link between developing sufficient vegetative biomass before anthesis and canola yield potential (McCormick, Virgona, & Kirkegaard, 2012; Robertson, Holland, & Bambach, 2004), with the biomass produced at anthesis has been shown to be affected by sowing date, cultivar choice (Robertson et al., 2004), N rate (Hocking & Stapper, 2001) and plant population (Brandt et al., 2007). In Australia however, Brill et al (2016) demonstrated that seed characteristics such as seed size were also major determinants of anthesis biomass due to its effect on improving canola establishment and early biomass accumulation in both hybrid and open-pollinated cultivars. It is expected that increased biomass at anthesis will improve the crops competitiveness against weeds and reduce weed seed production. Like Brill et al (2016), Harker et al. (2015) demonstrated that increasing the seed size of both F1 Hybrid and open pollinated varieties improved canola establishment and early biomass accumulation resulting in increased crop biomass and yield. The objective of this study is to determine the optimal combinations of canola cultivar, seeding rate and seed size on annual ryegrass seed production and canola growth and yield.

## **MATERIALS AND METHODS**

### Locations

In 2018, experiments were conducted in Cunderdin (-31.37S, 117. 14E) and Mingenew (-29.19S, 115.44E) in the Western Australian grainbelt. Soil at both sites were a sandy loam over a medium calcareous clay subsoil with a pH of 5.4 and 6.2 respectively with the longterm average growing season (April to October) rainfall at Cunderdin and Mingenew being 333 mm and 293 mm respectively (presented in Figure 1). Each site had been under no-till production for 10 years before initiation of the study.

### Prior to seeding

In March 2018, before weed seed bank germinating rains, the baseline seedbank of both sites were estimated by taking 4 replicated intact soil core samples (8 cm in diameter by 10 cm deep) up the center of each plot location (total of 384 soil samples per site). Soil samples from each plot (n=4) were combined to estimate the annual ryegrass seedbank in each plot. Samples were placed in shallow seedling trays that had been partially filled with weed free potting mix to ensure drainage. The soil samples from the field were then spread in a 2cm thick layer and watered using microjet irrigation. Samples were maintained outside from March to August each year. Germinated seedlings were recorded and removed at regular intervals. The census for annual ryegrass was ceased in August when no new seedlings emerged over a 4 week period. The number of seedlings to germinate in each tray represented the germinable weed seedbank and was converted to seeds per square meter for each plot.

### Trial establishment

In May 2009, all field experiments were direct-seeded into cereal stubble. A factorial combination of canola cultivar, seeding rate and seed size was randomized in complete blocks with four replicates. Canola cultivars, Hyola 559 TT (Hybrid mid maturity triazine tolerant (TT), Pacific seeds Toowomba Australia) and ATR Bonito TT (Open-pollinated mid maturity triazine tolerant, Nuseed, Laverton North Australia) were seeded at only one sowing depth (approx. 2cm) in an effort to minimise the confounding effects of emergence rate differences on biomass and grain yield. Seed from both varieties and seed size fractions had >98% germination and was seeded at a target densities of 20, 35 and 50 viable seeds m<sup>-2</sup> using small (<1.8mm diameter) and large (>2mm diameter) seed as per Table 1.

| Variety treatment  | Target plant density<br>(plants m²) | Canola seed diameter<br>(mm) | Mean canola<br>seed weight<br>(mg/seed) | Canola seeding rate<br>(kg/ha) |
|--------------------|-------------------------------------|------------------------------|---|--------------------------------|
| Open pollinated    | 50                                  | <1.8                         | 2.7                                     | 1.8                            |
| var. ATR Bonito TT | 35                                  | <1.8                         | 2.7                                     | 1.3                            |
|                    | 20                                  | <1.8                         | 2.7                                     | 0.7                            |
|                    | 50                                  | >2mm                         | 4.6                                     | 4.3                            |
|                    | 35                                  | >2mm                         | 4.6                                     | 3.0                            |
|                    | 20                                  | >2mm                         | 4.6                                     | 1.7                            |
| F1 Hybrid          | 50                                  | <1.8                         | 2.4                                     | 1.9                            |
| var. Hyola 559 TT  | 35                                  | <1.8                         | 2.4                                     | 1.3                            |
|                    | 20                                  | <1.8                         | 2.4                                     | 0.8                            |
|                    | 50                                  | >2mm                         | 5.9                                     | 3.3                            |
|                    | 35                                  | >2mm                         | 5.9                                     | 2.3                            |
|                    | 20                                  | >2mm                         | 5.9                                     | 1.3                            |

Table 1: The calculated canola seeding rate used to establish canola seed size treatments for each target establishment rate treatment.

Both cultivars received the same fungicide/insecticide seed treatment comprising of 1L of Cruiser Opti [210 g/L Thiamethoxam 37.5 g/L Lambda-Cyhalothrin, Syngenta Australia] and 400 mL/100 kg Maxim XL [25 g/L Fludioxonil 10 g/L Metalaxyl-M Syngenta Australia] applied per 100 kg of seed . Immediately prior to seeding, all experimental areas were treated with 1.5L ha<sup>-1</sup> Roundup Ultramax (Glyphosate 540 g/L, Sinochem Australia) and 150ml ha<sup>-1</sup> Lontrel (Clopyralid 750g/L, DowAgrosciences Australia) to control all germinated weeds. Each plot was sub plotted with a no additional weed control for competition assessments on weed growth and weed free treatment to assess the effect of factorial combinations on the canola growth and light interception. The weed free treatment was maintained using 1 L/ha Kerb (500 g/L Propyzamide, Dow AgroSciences Australia) incorporated by sowing (IBS), 1.1 kg/ha Atradex (900g/kg Atrazine, Nufarm Australia Limited) IBS followed by 1.1 kg/ha of Atradex and 500 mL/ha Select (240g/L Clethodim, Sumitomo Chemical Australia) applied at the 4-6 leaf stage of the canola. Herbicides were applied using a motorized sprayer calibrated to deliver a carrier volume of 120 L water ha<sup>-1</sup> at 275 kPa pressure. Each subplot size was 4m wide by 10m long. To ensure optimal canola growth, 70 kg/ha Gusto Gold (Summit Fertilisers Australia, N - 10.2%, P- 13.1%, K- 12%, S- 7.6%, Cu- 0.07%, Zn- 0.14% and Mn-0.01%) treated with 300ml ha<sup>-1</sup> Impact (250 g/L Flutriafol, Cheminova Australia) was drilled 3cm below the seed to minimise contact with the germinating canola seed with 100kg/ha of Urea (Summit Fertilisers Australia, N - 46%) broadcast evenly on the soil surface immediately after seeding. At the 4-6 leaf stage of the canola, 100L/ha of urea and ammonium nitrate liquid fertiliser (UAN) (Summit fertilisers Australia) (N- 32%) was evenly sprayed across the site to maintain growth.

At ten weeks after emergence (WAE), canola establishment was assessed by counting two adjacent 50cm rows over 4 replicate locations per plot. Annual ryegrass density was assessed at 10 and 14 WAE by counting the number of plant present in four replicate a 33 x 33cm quadrants (0.11 m<sup>-2</sup>) per plot. To compare the growth of the canola in the weed free split plots, Normalized Difference Vegetation Index (NDVI) was measured at 7, 10, 13 and 16 WAE using a Crop Circle<sup>™</sup> Handheld Optical Sensor Unit (Holland Scientific, Lincoln, NE, USA) oriented 0.8m off the ground, perpendicular to the center row of the plot. NDVI quantifies vegetation by measuring the difference between near-infrared in which vegetation strongly reflects and red light which vegetation absorbs. In each plot three replicate NDVI measurements were made and reported as a plot average.

Measurements of the fractional green canopy cover (FGCC) were done using the Canopeo<sup>™</sup> android application (www.canopeoapp.com) to estimate canopy development and light interception (Patrignani & Ochsner, 2015). Canopeo<sup>™</sup> is an image analysis tool (Mathworks, Inc., Natick, MA) that uses color values in the red–green–blue (RGB) system to measure the green canopy cover percentage. Canopeo<sup>™</sup> images were assessed for all weed free crop treatments at 13 WAE using a 14 megapixel camera that was oriented 0.8m above the top of the crop canopy, perpendicular to the center row of the plot.

Both incoming and outgoing photosynthetically active radiation (PAR) values were measured 14WAS at the top and bottom of the canola canopy throughout the season using line quantum sensor LI-191SA (LICOR Inc., Lincoln, NE, USA). The fraction intercepted (PAR) was calculated as percentage by Monteith (1981)

$$PAR = \frac{(Io-I)}{I}$$
[1]

: where Io is incident PAR at the top of canopy and I is the transmitted PAR at the bottom of the canopy.

Above ground biomass samples of annual ryegrass were removed 27 WAE in three 0.25m2 quadrants per plot. Biomass samples were dried at 60°C and weighed. From these samples, the number of ryegrass panicles were counted. In order to estimate annual ryegrass seed production, a representative sample of 50 panicles were collected from each plot and thrashed to extract seed. The number of seeds extracted was counted using an S-25 optical seed counter (Data Technologies, Kibbutz Tzora, Israel) to calculate the mean number of seeds produced per panicle. Total seed produced was estimated by multiplying the average seed yield per panicle by the number of panicles produced.

At 29WAS, the whole plot (10 m length with 6 by 25-cm rows) was machine harvested to determine grain yield. Grain samples (400 g) were analysed for moisture and oil using an Infratec<sup>™</sup> Sofia Near Infrared Spectroscope (NIR) (FOSS analytics, VIC, Australia). To calculate the mean canola seed weight, approximately 7000 seeds were counted S-25 optical seed counter (Data Technologies, Kibbutz Tzora, Israel) and weighed to calculate the mean canola seed weight.

### Statistical analysis

### **Experimental Design**

Both the Cunderdin and the Mingenew trials were a row-column design with two directional blocking that accommodated a three factorial experiment (2 levels for pollination type, 2 levels for seed size and 3 levels for seeding rate) for both the herbicide applied and herbicide free blocks. In each block, the treatments comprise all factorial combinations of 12 levels. The 12 treatment combinations were replicated 4 times for herbicide applied and herbicide free blocks. , and were allocated in 8 columns (4 herbicide applied and 4 herbicide free) x 12 rows, where each column represented a replicate.

## Statistical Models

The data were analysed using the analysis of variance (ANOVA) technique for the analysis of factorial experiments. The blocking structures reflected the two directional blocking and were accounted in the analysis by Replicate Block (Rep Column) and Replicate Row (Rep Row). The objective of the experiment was to assess the effects of Variety, SeedSize and SeedRate and their interactions on a set of traits, listed below. The treatment structure fitted in the model

was Variety\*SeedSize\*SeedRate. The analysis for herbicide applied and herbicide free treatments was conducted separately.

The above described model was used to analyse the following traits for the trial at Cunderdin:

- (i) for herbicide applied (weed fee): Crop Emergence (10WAS), Weed Density (10WAS), Weed Density (14WAS), Canopeo (14WAS), Radiation interception ( $\mu$  m<sup>-2</sup> s<sup>-1</sup>), Radiation interception (%), Before treatment ARG soil seed bank and Weed free canola Yield (t/ha),
- (ii) for herbicide free (weedy plots): Crop Emergence (10WAS), Weed Density (10WAS), Weed Density (14WAS), Canopeo (14WAS), Biomass ARG (g m<sup>2</sup>), TSP ARG, Before treatment ARG soil seed bank, After treatment ARG soil seed bank and Weed affected canola Yield (t/ha).

Similarly, for the Mingenew trial the following traits were analysed:

- (i) for herbicide applied (weed free): Crop Emergence (10WAS), Weed Density (10WAS), Weed Density (14WAS), Before treatment ARG soil seed bank and Weed free canola yield (t/ha).
- (ii) for herbicide free (weedy plots): Crop Emergence (10WAS), Weed Density (10WAS), Weed Density (14WAS), Biomass ARG (g m<sup>2</sup>), Total Seed Production seeds/m<sup>2</sup>, Before treatment ARG soil seed bank, After treatment ARG soil seed bank and Weed affected canola Yield (t/ha).

The analyses were conducted using R package msanova 1.0 (VSN International Ltd, Hemel Hempstead, UK).



Figure 1: Aerial photo of the A) Cunderdin and B) Mingenew trial site in 2018.

## **Results.**

### Rainfall data

In 2018, the Cunderdin site recorded 230mm of growing season rainfall (April – October) which is less than the 333mm long term average. This rainfall was characterized by a lack of season breaking rains in April and May. The June, July rainfall totals exceeded long term average and the crop was able to mature with good soil moisture. The Mingenew site in 2018 had 276mm of growing season rainfall (April – October) which is similar to the sites long term average of 293mm. The Mingenew site also had a dry season start with minimum rains in April, however good rainfall in June, July allowed the crop to mature with good soil moisture.



Figure 1: The rainfall totals for the 2018 season compared to the historical 20 year mean rainfall for A. Cunderdin and B. Mingenew in the Western Australian grainbelt.

# Trial results Cunderdin 2018

| Herbicide                       | Pollination<br>Type      | Seed<br>Size<br>(cm) | Seeding<br>Rate | Crop emergence<br>6WAS (plants<br>m <sup>2</sup> ) | Canopy cover<br>13WAS (%) | Radiation<br>interception<br>14WAS (μ m <sup>-2</sup> s <sup>-</sup><br><sup>1</sup> ) | Radiation<br>percentage (%) | Canola yield<br>without ARG<br>29WAS (t/ha) | Canola Seed<br>Weight<br>(mg/seed) | Canola Moisture<br>(%) | Canola Oil (%) |
|---------------------------------|--------------------------|----------------------|-----------------|--|---------------------------|--|-----------------------------|---|------------------------------------|------------------------|----------------|
| Herbicide                       | Hyola 559                | Small                | 0.4RR           | 10.8   | 52.7                      | 552.0  | 77.98                       | 1.54  | 3.72                               | 5.83                   | 42.30          |
| applied                         |                          |                      | 0.7RR           | 18.3   | 60.7                      | 591.7  | 84.85                       | 1.82  | 3.63                               | 5.77                   | 42.60          |
|                                 |                          |                      | RR              | 21.0   | 80.3                      | 599.3  | 86.42                       | 1.97  | 3.70                               | 5.77                   | 42.97          |
|                                 |                          | Large                | 0.4RR           | 24.2   | 76.0                      | 562.3  | 82.55                       | 2.08  | 3.62                               | 5.70                   | 43.93          |
|                                 |                          |                      | 0.7RR           | 27.8   | 91.0                      | 582.0  | 83.68                       | 2.09  | 3.82                               | 5.70                   | 43.77          |
|                                 |                          |                      | RR              | 28.8   | 94.3                      | 568.0  | 82.89                       | 2.24  | 3.77                               | 5.73                   | 43.80          |
|                                 | Bonito                   | Small                | 0.4RR           | 21.0   | 45.3                      | 571.0  | 86.13                       | 1.73  | 3.57                               | 6.13                   | 42.50          |
|                                 |                          |                      | 0.7RR           | 26.2   | 71.0                      | 611.3  | 88.81                       | 1.74  | 3.44                               | 6.07                   | 42.37          |
|                                 |                          |                      | RR              | 31.0   | 88.7                      | 565.3  | 81.45                       | 1.83  | 3.51                               | 6.23                   | 42.07          |
|                                 |                          | Large                | 0.4RR           | 22.6   | 70.7                      | 593.0  | 86.36                       | 1.68  | 3.46                               | 6.03                   | 42.20          |
|                                 |                          |                      | 0.7RR           | 27.8   | 81.3                      | 605.0  | 85.70                       | 1.91  | 3.44                               | 5.90                   | 42.67          |
|                                 |                          |                      | RR              | 36.7   | 85.3                      | 551.3  | 84.02                       | 1.86  | 3.57                               | 6.13                   | 42.67          |
|                                 |                          | Sourc                | e of variation  | p-values (5% LSD)                                  |                           |  |                             |   |                                    |                        |                |
|                                 |                          | Ро                   | llination Type  | <0.001 (2.50)                                      | NS                        | NS   | 0.012 (1.766)               | 0.001 (0.093)                               | <0.001 (0.063)                     | <0.001 (0.014)         | <0.001 (0.102) |
|                                 |                          |                      | Seed Size       | <0.001 (2.50)                                      | <0.001 (7.64)             | NS   | NS                          | <0.001 (0.093)                              | NS                                 | NS                     | <0.001 (0.102) |
|                                 |                          |                      | Seeding Rate    | <0.001 (3.06)                                      | <0.001 (9.35)             | 0.030 (22.58)  | 0.057 (2.162)               | 0.004 (0.114)                               | NS                                 | NS                     | NS             |
| Pollination Type x Seed Size    |                          | 0.005 (3.54)         | NS              | NS   | NS                        | 0.003 (0.132)  | NS                          | NS  | 0.002 (0.145)                      |                        |                |
| Pollination Type x Seeding Rate |                          | NS                   | NS              | 0.056 (31.93)                                      | 0.004 (3.058)             | NS   | NS                          | NS  | NS                                 |                        |                |
|                                 | Seed Size x Seeding Rate |                      | NS              | NS   | NS                        | NS   | NS                          | 0.030 (0.109)                               | NS                                 | NS                     |                |
| Р                               | ollination Type x        | Seed Size x          | Seeding Rate    | NS   | NS                        | NS   | 0.050 (4.325)               | NS  | NS                                 | NS                     | NS             |

Table 2: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on crop competitiveness in the absence of ARG at Cunderdin in 2018.

| Herbicide                       | Pollination<br>Type | Seed Size (cm)        | Seeding Rate        | NDVI 7WAS         | NDVI 10WAS     | NDVI 13WAS    | NDVI 14WAS     |
|---------------------------------|---------------------|-----------------------|---------------------|-------------------|----------------|---------------|----------------|
| Herbicide                       | Hyola 559           | Small                 | 0.4RR               | 0.140             | 0.220          | 0.710         | 0.670          |
| applied                         |                     |                       | 0.7RR               | 0.143             | 0.250          | 0.657         | 0.710          |
|                                 |                     |                       | RR                  | 0.147             | 0.267          | 0.783         | 0.730          |
|                                 |                     | Large                 | 0.4RR               | 0.157             | 0.297          | 0.770         | 0.750          |
|                                 |                     |                       | 0.7RR               | 0.163             | 0.393          | 0.840         | 0.777          |
|                                 |                     |                       | RR                  | 0.177             | 0.440          | 0.847         | 0.783          |
|                                 | Bonito              | Small                 | 0.4RR               | 0.147             | 0.263          | 0.517         | 0.667          |
|                                 |                     |                       | 0.7RR               | 0.150             | 0.297          | 0.783         | 0.717          |
|                                 |                     |                       | RR                  | 0.160             | 0.380          | 0.777         | 0.730          |
|                                 |                     | Large                 | 0.4RR               | 0.157             | 0.280          | 0.723         | 0.733          |
|                                 |                     |                       | 0.7RR               | 0.163             | 0.340          | 0.790         | 0.730          |
|                                 |                     |                       | RR                  | 0.183             | 0.450          | 0.823         | 0.770          |
|                                 |                     |                       | Source of variation | p-values (5% LSD) |                |               |                |
|                                 |                     |                       | Pollination Type    | NS                | 0.010 (0.006)  | NS            | NS             |
|                                 |                     |                       | Seed Size           | <0.001 (0.007)    | <0.001 (0.006) | 0.003 (0.020) | <0.001 (0.005) |
|                                 | Seeding R           |                       | Seeding Rate        | 0.001 (0.008)     | <0.001 (0.007) | 0.005 (0.025) | <0.001 (0.006) |
| Pollination Type x Seed Size    |                     | NS                    | <0.001 (0.009)      | NS                | NS             |               |                |
| Pollination Type x Seeding Rate |                     |                       |                     | NS                | 0.014 (0.010)  | NS            | NS             |
| Seed Size x Seeding Rate        |                     |                       | Size x Seeding Rate | NS                | 0.006 (0.010)  | NS            | NS             |
|                                 | Poll                | ination Type x Seed S | Size x Seeding Rate | NS                | NS             | NS            | NS             |

Table 3: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on crop competitiveness in the absence of ARG at Cunderdin in 2018.

| Herbicide                       | Pollination<br>Type | Seed Size<br>(cm)  | Seeding Rate          | Crop emergence 6WAS<br>(plants m <sup>2</sup> ) | ARG density 10WAS<br>(plants m <sup>2</sup> ) | ARG density<br>14WAS<br>(plants m <sup>2</sup> ) | Biomass ARG 19WAS (g<br>m²) | Total seed production<br>ARG (seeds/m <sup>2</sup> ) |
|---------------------------------|---------------------|--------------------|-----------------------|---|---|--|-----------------------------|--|
| No herbicide                    | Hyola 559           | Small              | 0.4RR                 | 11.5  | 145.4   | 87.2   | 656.9                       | 196561   |
| applied                         |                     |                    | 0.7RR                 | 15.1  | 149.3   | 112.5  | 540.2                       | 129275   |
|                                 |                     |                    | RR                    | 23.6  | 137.8   | 88.7   | 407.1                       | 113965   |
|                                 |                     | Large              | 0.4RR                 | 22.6  | 130.1   | 78.8   | 400.3                       | 103495   |
|                                 |                     |                    | 0.7RR                 | 23.6  | 151.4   | 88.7   | 421.7                       | 144287   |
|                                 |                     |                    | RR                    | 37.3  | 135.9   | 69.6   | 228.2                       | 61118  |
|                                 | Bonito              | Small              | 0.4RR                 | 20.0  | 139.9   | 88.7   | 555.3                       | 197258   |
|                                 |                     |                    | 0.7RR                 | 19.0  | 151.5   | 87.2   | 364.3                       | 96118  |
|                                 |                     |                    | RR                    | 26.5  | 113.1   | 98.7   | 311.5                       | 69192  |
|                                 |                     | Large              | 0.4RR                 | 26.5  | 136.3   | 95.6   | 392.4                       | 114870   |
|                                 |                     |                    | 0.7RR                 | 28.8  | 133.3   | 88.7   | 304.7                       | 106043   |
|                                 |                     |                    | RR                    | 35.4  | 123.2   | 72.7   | 195.2                       | 46430  |
|                                 |                     |                    | Source of variation   | p-values (5% LSD)                               |   |  |                             |  |
|                                 |                     |                    | Pollination Type      | 0.001 (2.201)                                   | NS  | NS   | <0.001 (36.79)              | 0.002 (12229.9)                                      |
|                                 |                     |                    | Seed Size             | <0.001 (2.201)                                  | NS  | 0.005 (7.93)                                     | <0.001 (36.79)              | <0.001 (12229.9)                                     |
|                                 |                     |                    | Seeding Rate          | <0.001 (3.112)                                  | NS  | 0.057 (9.71)                                     | <0.001 (45.06)              | <0.001 (14978.5)                                     |
| Pollination Type x Seed Size    |                     |                    | NS                    | NS  | NS  | 0.056 (52.04)                                    | NS                          |  |
| Pollination Type x Seeding Rate |                     |                    | NS                    | NS  | 0.057 (13.73)                                 | NS   | 0.014 (21182.8)             |  |
| Seed Size x Seeding Rate        |                     |                    | NS                    | NS  | NS  | 0.033 (53.73)                                    | <0.001 (21182.8)            |  |
|                                 | Pollii              | nation Type x Seed | d Size x Seeding Rate | NS  | NS  | NS   | NS                          | NS   |

Table 4: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on weed biomass and seed production affected by ARG at Cunderdin in 2018.

| Herbicide                       | Pollination<br>Type | Seed Size<br>(cm) | Seeding<br>Rate | Before<br>treatment ARG<br>soil seed bank<br>(seeds /m²) | Estimated after<br>treatment ARG soil seed<br>bank<br>(seeds /m <sup>2</sup> ) | Calculated<br>increase in<br>ARG seed<br>bank (%) | Canola yield with<br>ARG 29WAS<br>(t/ha) | Canola Seed<br>Weight<br>(mg/seed) | Canola Moisture<br>(%) | Canola Oil (%) |
|---------------------------------|---------------------|-------------------|-----------------|--|--|---|--|------------------------------------|------------------------|----------------|
| No herbicide                    | Hyola 559           | Small             | 0.4RR           | 5701   | 202264   | 3547  | 0.53                                     | 3.844                              | 6.100                  | 42.87          |
| applied                         |                     |                   | 0.7RR           | 3070   | 132345   | 4310  | 0.74                                     | 3.847                              | 5.900                  | 43.67          |
|                                 |                     |                   | RR              | 2704   | 116669   | 4314  | 0.77                                     | 3.859                              | 6.200                  | 42.57          |
|                                 |                     | Large             | 0.4RR           | 3435   | 106930   | 3112  | 1.18                                     | 3.898                              | 5.767                  | 43.73          |
|                                 |                     |                   | 0.7RR           | 3508   | 147796   | 4213  | 1.09                                     | 3.850                              | 6.000                  | 42.77          |
|                                 |                     |                   | RR              | 2339   | 63456  | 2712  | 1.43                                     | 3.868                              | 5.933                  | 43.53          |
|                                 | Bonito              | Small             | 0.4RR           | 5117   | 202376   | 3954  | 0.57                                     | 3.622                              | 6.200                  | 42.60          |
|                                 |                     |                   | 0.7RR           | 1973   | 98091  | 4971  | 0.89                                     | 3.497                              | 5.967                  | 43.57          |
|                                 |                     |                   | RR              | 3947   | 122885   | 3113  | 0.97                                     | 3.558                              | 6.167                  | 42.97          |
|                                 |                     | Large             | 0.4RR           | 2778   | 117648   | 4234  | 0.98                                     | 3.559                              | 6.167                  | 43.23          |
|                                 |                     |                   | 0.7RR           | 3655   | 109698   | 3001  | 1.05                                     | 3.583                              | 6.200                  | 43.40          |
|                                 |                     |                   | RR              | 1754   | 48182  | 2746  | 1.30                                     | 3.450                              | 6.067                  | 43.43          |
|                                 |                     | Sour              | ce of variation | p-values (5% LSD)  |  |   |  |                                    |                        |                |
|                                 |                     | Po                | ollination Type | NS   | NS   | -   | NS                                       | <0.001 (0.064)                     | 0.008 (0.103)          | NS             |
|                                 |                     |                   | Seed Size       | NS   | <0.001 (21739.4)   | -   | <0.001 (0.101)                           | NS                                 | NS                     | NS             |
|                                 |                     |                   | Seeding Rate    | NS   | <0.001 (26625.2)   | -   | <0.001 (0.124)                           | NS                                 | NS                     | NS             |
| Pollination Type x Seed Size    |                     | NS                | NS              | -  | 0.015 (0.144)  | NS  | 0.056 (0.145)                            | NS                                 |                        |                |
| Pollination Type x Seeding Rate |                     | NS                | NS              | -  | NS   | NS  | NS                                       | NS                                 |                        |                |
|                                 |                     | Seed Size 2       | x Seeding Rate  | NS   | <0.001 (37653.7)   | -   | NS                                       | NS                                 | 0.012 (0.178)          | 0.050 (0.816)  |
| I                               | Pollination Type    | x Seed Size       | x Seeding Rate  | NS   | NS   | -   | NS                                       | NS                                 | NS                     | NS             |

Table 5: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on ARG seed bank and Canola yield affected by ARG at Cunderdin in 2018.

| Herbicide    | Pollination<br>Type      | Seed Size<br>(cm) | Seeding Rate        | NDVI 7WAS         | NDVI 10WAS    | NDVI 13WAS    | NDVI 14WAS    |
|--------------|--------------------------|-------------------|---------------------|-------------------|---------------|---------------|---------------|
| No herbicide | Hyola 559                | Small             | 0.4RR               | 0.173             | 0.437         | 0.753         | 0.793         |
| applied      |                          |                   | 0.7RR               | 0.167             | 0.420         | 0.833         | 0.793         |
|              |                          |                   | RR                  | 0.177             | 0.453         | 0.800         | 0.800         |
|              |                          | Large             | 0.4RR               | 0.177             | 0.450         | 0.850         | 0.787         |
|              |                          |                   | 0.7RR               | 0.200             | 0.563         | 0.843         | 0.787         |
|              |                          |                   | RR                  | 0.203             | 0.553         | 0.850         | 0.773         |
|              | Bonito                   | Small             | 0.4RR               | 0.170             | 0.403         | 0.770         | 0.783         |
|              |                          |                   | 0.7RR               | 0.187             | 0.433         | 0.690         | 0.773         |
|              |                          |                   | RR                  | 0.197             | 0.517         | 0.827         | 0.780         |
|              |                          | Large             | 0.4RR               | 0.180             | 0.457         | 0.820         | 0.783         |
|              |                          |                   | 0.7RR               | 0.187             | 0.480         | 0.840         | 0.763         |
|              |                          |                   | RR                  | 0.203             | 0.493         | 0.827         | 0.767         |
|              |                          |                   | Source of variation | p-values (5% LSD) |               |               |               |
|              |                          |                   | Pollination Type    | NS                | NS            | NS            | 0.031 (0.012) |
|              |                          |                   | Seed Size           | <0.001 (0.005)    | 0.001 (0.028) | 0.033 (0.054) | NS            |
|              |                          |                   | Seeding Rate        | <0.001 (0.006)    | 0.002 (0.035) | NS            | NS            |
|              |                          | Pollinatio        | on Type x Seed Size | 0.003 (0.007)     | 0.039 (0.040) | NS            | NS            |
|              |                          | Pollination T     | ype x Seeding Rate  | NS                | NS            | NS            | NS            |
|              | Seed Size x Seeding Rate |                   | Size x Seeding Rate | NS                | NS            | NS            | NS            |
|              | Pollinatio               | on Type x Seed S  | ize x Seeding Rate  | 0.006 (0.012)     | 0.050 (0.069) | NS            | NS            |

Table 6: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on ARG seed bank and Canola yield affected by ARG at Cunderdin in 2018.

# Trial results Mingenew 2018

| Herbicide | Pollination<br>Type      | Seed Size<br>(cm) | Seeding<br>Rate | Crop emergence<br>6WAS (plants m <sup>2</sup> ) | Canopy cover<br>13WAS (%) | Canola yield<br>without ARG<br>29WAS (t/ha) | Canola Seed Weight<br>(mg/seed) | Canola Moisture (%) | Canola Oil (%) |
|-----------|--------------------------|-------------------|-----------------|---|---------------------------|---|---------------------------------|---------------------|----------------|
| Herbicide | Hyola 559                | Small             | 0.4RR           | 7.21  | 53.8                      | 2.01  | 3.259                           | 7.700               | 40.100         |
| applied   |                          |                   | 0.7RR           | 9.83  | 74.9                      | 2.21  | 3.276                           | 7.567               | 41.067         |
|           |                          |                   | RR              | 15.39   | 80.8                      | 2.49  | 3.300                           | 7.533               | 41.900         |
|           |                          | Large             | 0.4RR           | 14.08   | 88.4                      | 2.59  | 3.475                           | 7.667               | 42.500         |
|           |                          |                   | 0.7RR           | 25.22   | 94.0                      | 2.75  | 3.496                           | 7.367               | 42.600         |
|           |                          |                   | RR              | 38.32   | 96.5                      | 2.63  | 3.404                           | 7.333               | 43.133         |
|           | Bonito                   | Small             | 0.4RR           | 13.43   | 81.0                      | 2.00  | 3.315                           | 7.633               | 41.433         |
|           |                          |                   | 0.7RR           | 23.91   | 91.8                      | 2.23  | 3.307                           | 7.633               | 41.500         |
|           |                          |                   | RR              | 29.48   | 90.8                      | 2.27  | 3.291                           | 7.600               | 41.867         |
|           |                          | Large             | 0.4RR           | 21.62   | 87.6                      | 2.24  | 3.338                           | 7.533               | 42.000         |
|           |                          |                   | 0.7RR           | 30.79   | 85.2                      | 2.54  | 3.260                           | 7.633               | 42.200         |
|           |                          |                   | RR              | 42.90   | 94.9                      | 2.34  | 3.296                           | 7.567               | 41.733         |
|           |                          | Sourc             | ce of variation | p-values (5% LSD)                               |                           |   |                                 |                     |                |
|           |                          | Рс                | ollination Type | <0.001 (3.764)                                  | 0.015 (5.57)              | 0.005 (0.116)                               | 0.053 (0.068)                   | NS                  | NS             |
|           |                          |                   | Seed Size       | <0.001 (3.764)                                  | <0.001 (5.57)             | <0.001 (0.116)                              | 0.015 (0.068)                   | NS                  | <0.001 (0.341) |
|           |                          |                   | Seeding Rate    | <0.001 (4.609)                                  | 0.002 (6.83)              | 0.005 (0.142)                               | NS                              | NS                  | 0.015 (0.418)  |
|           |                          | Pollination Ty    | pe x Seed Size  | NS  | 0.001 (7.88)              | NS  | 0.010 (0.096)                   | NS                  | <0.001 (0.483) |
|           | Pol                      | lination Type »   | Seeding Rate    | NS  | NS                        | NS  | NS                              | NS                  | 0.032 (0.591)  |
|           | Seed Size x Seeding Rate |                   | Seeding Rate    | NS  | NS                        | 0.049 (0.201)                               | NS                              | NS                  | NS             |
|           | Pollination Typ          | e x Seed Size x   | Seeding Rate    | NS  | NS                        | NS  | NS                              | NS                  | NS             |

Table 7: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on crop competitiveness in the absence of ARG at Mingenew in 2018

| Herbicide | Pollination<br>Type      | Seed Size<br>(cm)  | Seeding Rate       | NDVI 7WAS         | NDVI 10WAS     | NDVI 13WAS     | NDVI 14WAS    |
|-----------|--------------------------|--------------------|--------------------|-------------------|----------------|----------------|---------------|
| Herbicide | Hyola 559                | Small              | 0.4RR              | 0.157             | 0.237          | 0.560          | 0.593         |
| applied   |                          |                    | 0.7RR              | 0.153             | 0.227          | 0.647          | 0.763         |
|           |                          |                    | RR                 | 0.167             | 0.317          | 0.713          | 0.743         |
|           |                          | Large              | 0.4RR              | 0.170             | 0.343          | 0.713          | 0.733         |
|           |                          |                    | 0.7RR              | 0.200             | 0.433          | 0.757          | 0.797         |
|           |                          |                    | RR                 | 0.223             | 0.470          | 0.767          | 0.830         |
|           | Bonito                   | Small              | 0.4RR              | 0.163             | 0.267          | 0.593          | 0.723         |
|           |                          |                    | 0.7RR              | 0.170             | 0.290          | 0.667          | 0.723         |
|           |                          |                    | RR                 | 0.187             | 0.343          | 0.690          | 0.747         |
|           |                          | Large              | 0.4RR              | 0.167             | 0.333          | 0.697          | 0.783         |
|           |                          |                    | 0.7RR              | 0.170             | 0.353          | 0.687          | 0.770         |
|           |                          |                    | RR                 | 0.203             | 0.420          | 0.727          | 0.783         |
|           |                          | S                  | ource of variation | p-values (5% LSD) |                |                |               |
|           |                          |                    | Pollination Type   | NS                | NS             | NS             | NS            |
|           |                          |                    | Seed Size          | <0.001 (0.009)    | <0.001 (0.027) | <0.001 (0.019) | 0.001 (0.012) |
|           |                          |                    | Seeding Rate       | <0.001 (0.009)    | <0.001 (0.033) | <0.001 (0.019) | 0.009 (0.015) |
|           |                          | Pollination        | n Type x Seed Size | 0.002 (0.013)     | 0.003 (0.038)  | 0.011 (0.027)  | NS            |
|           |                          | Pollination Ty     | pe x Seeding Rate  | NS                | NS             | NS             | 0.013 (0.021) |
|           | Seed Size x Seeding Rate |                    | ze x Seeding Rate  | 0.054 ((0.016)    | NS             | 0.004 (0.0335) | NS            |
|           | Pollinatic               | on Type x Seed Siz | e x Seeding Rate   | NS                | NS             | NS             | NS            |

Table 8: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on crop competitiveness in the absence of ARG at Mingenew in 2018

| Herbicide                       | Pollination<br>Type | Seed Size<br>(cm) | Seeding Rate       | Crop emergence<br>6WAS (plants m <sup>2</sup> ) | Canopy cover<br>13WAS (%) | ARG density 10WAS<br>(plants m <sup>2</sup> ) | ARG density 14WAS<br>(plants m <sup>2</sup> ) | Biomass ARG<br>19WAS (g m²) | Total seed<br>production ARG<br>(seeds/m²) |
|---------------------------------|---------------------|-------------------|--------------------|---|---------------------------|---|---|-----------------------------|--|
| No herbicide                    | Hyola 559           | Small             | 0.4RR              | 4.91  | 93.62                     | 301   | 232   | 234                         | 48113                                      |
| applied                         |                     |                   | 0.7RR              | 8.84  | 92.11                     | 372   | 213   | 262                         | 53216                                      |
|                                 |                     |                   | RR                 | 14.74   | 92.72                     | 300   | 247   | 247                         | 70684                                      |
|                                 |                     | Large             | 0.4RR              | 14.08   | 97.27                     | 363   | 237   | 372                         | 102210                                     |
|                                 |                     |                   | 0.7RR              | 21.29   | 95.66                     | 274   | 246   | 439                         | 100762                                     |
|                                 |                     |                   | RR                 | 34.06   | 97.32                     | 301   | 207   | 403                         | 99842                                      |
|                                 | Bonito              | Small             | 0.4RR              | 11.13   | 89.87                     | 358   | 231   | 230                         | 52320                                      |
|                                 |                     |                   | 0.7RR              | 20.30   | 94.08                     | 366   | 234   | 218                         | 62582                                      |
|                                 |                     |                   | RR                 | 20.63   | 96.39                     | 359   | 229   | 293                         | 66179                                      |
|                                 |                     | Large             | 0.4RR              | 19.32   | 94.27                     | 447   | 270   | 291                         | 65161                                      |
|                                 |                     |                   | 0.7RR              | 26.53   | 95.47                     | 367   | 215   | 330                         | 98519                                      |
|                                 |                     |                   | RR                 | 37.66   | 93.90                     | 291   | 193   | 206                         | 49774                                      |
|                                 |                     | S                 | ource of variation | p-values (5% LSD)                               |                           |   |   |                             |  |
|                                 |                     |                   | Pollination Type   | <0.001 (3.34)                                   | NS                        | NS  | NS  | 0.003 (41.5)                | 0.009 (9893.1)                             |
|                                 |                     |                   | Seed Size          | <0.001 (3.34)                                   | 0.001 (1.322)             | NS  | NS  | <0.001 (41.5)               | <0.001 (9893.1)                            |
|                                 | Seeding Rate        |                   | Seeding Rate       | <0.001 (4.09)                                   | NS                        | NS  | NS  | NS                          | NS   |
| Pollination Type x Seed Size    |                     | NS                | 0.037 (1.870)      | NS  | NS                        | 0.003 (58.7)                                  | 0.001 (13991)                                 |                             |  |
| Pollination Type x Seeding Rate |                     | NS                | 0.028 (2.290)      | NS  | NS                        | NS  | 0.042 (17135.4)                               |                             |  |
| Seed Size x Seeding Rate        |                     |                   | 0.047 (5.79)       | NS  | NS                        | NS  | NS  | 0.013 (17135.4)             |  |
|                                 | Pollination         | Type x Seed S     | ize x Seeding Rate | NS  | 0.060 (3.239)             | NS  | NS  | NS                          | NS   |

Table 9: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on weed biomass and seed production affected by ARG at Mingenew in 2018

| Herbicide                       | Pollination<br>Type | Seed Size<br>(cm) | Seeding<br>Rate | Before treatment<br>ARG soil seed<br>bank (seeds/m <sup>2</sup> ) | Estimated after<br>treatment ARG soil<br>seed bank<br>(seeds/m <sup>2</sup> ) | Calculated<br>increase in<br>ARG seed<br>bank (%) | Canola yield with<br>ARG 29WAS<br>(t/ha) | Canola Seed<br>Weight<br>(mg/seed) | Canola Moisture<br>(%) | Canola Oil (%) |
|---------------------------------|---------------------|-------------------|-----------------|---|---|---|--|------------------------------------|------------------------|----------------|
| No herbicide                    | Hyola 559           | Small             | 0.4RR           | 3362  | 51472   | 1530  | 0.67                                     | 3.254                              | 7.565                  | 42.94          |
| applied                         |                     |                   | 0.7RR           | 2266  | 55479   | 2448  | 0.72                                     | 3.668                              | 7.367                  | 43.20          |
|                                 |                     |                   | RR              | 2193  | 72877   | 3323  | 1.00                                     | 3.575                              | 7.500                  | 42.83          |
|                                 |                     | Large             | 0.4RR           | 877   | 103091  | 11754   | 1.34                                     | 3.709                              | 7.300                  | 44.33          |
|                                 |                     |                   | 0.7RR           | 2412  | 103178  | 4277  | 1.54                                     | 3.573                              | 7.233                  | 43.97          |
|                                 |                     |                   | RR              | 1535  | 101381  | 6604  | 1.92                                     | 3.704                              | 7.333                  | 44.10          |
|                                 | Bonito              | Small             | 0.4RR           | 365   | 52683   | 14433   | 0.77                                     | 3.317                              | 7.567                  | 42.97          |
|                                 |                     |                   | 0.7RR           | 877   | 63458   | 7235  | 0.96                                     | 3.478                              | 7.400                  | 42.77          |
|                                 |                     |                   | RR              | 1316  | 67493   | 5128  | 1.07                                     | 3.352                              | 7.600                  | 42.60          |
|                                 |                     | Large             | 0.4RR           | 365   | 65526   | 17952   | 0.88                                     | 3.371                              | 7.433                  | 43.73          |
|                                 |                     |                   | 0.7RR           | 439   | 98961   | 22542   | 1.27                                     | 3.242                              | 7.533                  | 43.10          |
|                                 |                     |                   | RR              | 877   | 50648   | 5775  | 1.45                                     | 3.423                              | 7.433                  | 43.20          |
|                                 |                     | Sourc             | e of variation  | p-values (5% LSD)   |   |   |  |                                    |                        |                |
|                                 |                     | Рс                | ollination Type | 0.048 (1389)  | 0.013 (11587.3)   | -   | 0.053 (0.135)                            | 0.013 (0.121)                      | NS                     | 0.029 (0.444)  |
|                                 |                     |                   | Seed Size       | NS  | <0.001 (11587.3)  | -   | <0.001 (0.135)                           | NS                                 | NS                     | 0.001 (0.444)  |
|                                 |                     |                   | Seeding Rate    | NS  | NS  | -   | <0.001 (0.165)                           | NS                                 | NS                     | NS             |
|                                 |                     | Pollination Ty    | pe x Seed Size  | NS  | 0.007 (16386.9)   | -   | 0.001 (0.191)                            | NS                                 | NS                     | NS             |
| Pollination Type x Seeding Rate |                     | NS                | NS              | -   | NS  | NS  | NS                                       | NS                                 |                        |                |
| Seed Size x Seeding Rate        |                     | NS                | 0.039 (20069.8) | -   | NS  | 0.025 (0.210)                                     | NS                                       | NS                                 |                        |                |
|                                 | Pollination Type    | x Seed Size x     | Seeding Rate    | NS  | NS  | -   | NS                                       | NS                                 | NS                     | NS             |

Table 10: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on ARG seed bank and Canola yield affected by ARG at Mingenew in 2018.

| Herbicide                       | Pollination  | Seed Size           | Seeding Rate            | NDVI 7WAS         | NDVI 10WAS     | NDVI 13WAS    | NDVI 14WAS    |
|---------------------------------|--------------|---------------------|-------------------------|-------------------|----------------|---------------|---------------|
|                                 | Туре         | (cm)                |                         |                   |                |               |               |
|                                 |              |                     |                         |                   |                |               |               |
| No herbicide applied            | Hyola 559    | Small               | 0.4RR                   | 0.200             | 0.393          | 0.737         | 0.823         |
|                                 |              |                     | 0.7RR                   | 0.213             | 0.423          | 0.740         | 0.793         |
|                                 |              |                     | RR                      | 0.227             | 0.417          | 0.777         | 0.787         |
|                                 |              | Large               | 0.4RR                   | 0.240             | 0.493          | 0.793         | 0.837         |
|                                 |              |                     | 0.7RR                   | 0.247             | 0.500          | 0.783         | 0.803         |
|                                 |              |                     | RR                      | 0.270             | 0.550          | 0.783         | 0.823         |
|                                 | Bonito       | Small               | 0.4RR                   | 0.210             | 0.400          | 0.733         | 0.780         |
|                                 |              |                     | 0.7RR                   | 0.227             | 0.427          | 0.757         | 0.813         |
|                                 |              |                     | RR                      | 0.233             | 0.467          | 0.767         | 0.847         |
|                                 |              | Large               | 0.4RR                   | 0.223             | 0.447          | 0.787         | 0.810         |
|                                 |              |                     | 0.7RR                   | 0.233             | 0.470          | 0.767         | 0.813         |
|                                 |              |                     | RR                      | 0.253             | 0.493          | 0.753         | 0.803         |
|                                 |              |                     | Source of variation     | p-values (5% LSD) |                |               |               |
|                                 |              |                     | Pollination Type        | NS                | NS             | NS            | NS            |
|                                 |              |                     | Seed Size               | <0.001 (0.004)    | <0.001 (0.027) | 0.032 (0.024) | NS            |
|                                 | Seeding Rate |                     | Seeding Rate            | 0.003 (0.004)     | 0.021 (0.027)  | NS            | NS            |
| Pollination Type x Seed Size    |              |                     |                         | 0.033 (0.006)     | 0.022 (0.038)  | NS            | NS            |
| Pollination Type x Seeding Rate |              |                     |                         | NS                | NS             | NS            | 0.024 (0.010) |
|                                 |              | Si                  | eed Size x Seeding Rate | NS                | NS             | NS            | NS            |
|                                 | Ро           | llination Type x Se | ed Size x Seeding Rate  | NS                | NS             | NS            | NS            |

Table 11: Mean, P-values and LSD for Pollination Type, Seed Size (cm) and Seeding Rate on ARG seed bank and Canola yield affected by ARG at Mingenew in 2018.

### Discussion

In this study the main effect of canola cultivar (F1 Hybrid vs Open pollinated), canola seeding rate and canola seed size was assessed in a field trial in Cunderdin and Mingenew in Western Australia in 2018. The results from the analyses of the traits at the Cunderdin trial are presented in Tables 2-4 with the results from the Mingenew trial are presented in Tables 5-7.

#### Main effects at Cunderdin

At Cunderdin, the main effects of pollination type, seed size and seeding rate were significant when herbicides were applied (weed free) for crop emergence, % canopy cover (not pollination type), radiation interception (not pollination type, seed size), canola yield (weed free), NDVI (7DAS) (not pollination type), NDVI (10DAS), NDVI (13DAS) (not pollination type), and NDVI (14DAS) (not pollination type). When herbicides were not applied (weedy situation), crop emergence, weed density (14WAS) (not pollination type), ryegrass biomass, ryegrass total seed production and canola yield (with weeds), NDVI (7DAS) (not pollination type), NDVI (10DAS) (not pollination type), NDVI (13DAS) (not pollination type, seed rate), and NDVI (14DAS) (not seed size, seed rate) had main effects identified. In a weed free situation crop emergence was improved in OP treatments and when seeding rate was increased. Percent canopy cover was increased when seed size and seeding rates were increased, with a non-significant trend of increased responsiveness in hybrid plots. Radiation interception was increased with seeding rate and weed free canola yield increased by all main factors with the greatest response to seeding rate or seed size occurring in the open pollinated treatments. When post emergent ryegrass control was not applied (weedy situation), crop emergence was affected by all main factors. Initial weed density counts (10WAS) was not significantly affected by main factors however a later weed count (14WAS) was affected by increased seeding rate and seed size, resulting in ryegrass biomass being affected by all main factors. As ryegrass biomass is a determinant of ryegrass seed production, all main factors affected ryegrass seed production. With significant weed densities, canola yield was increased in higher seeding rate treatment and where large seed was used.

### Main effects at Mingenew

Alternatively at Mingenew site in the weed free situation (herbicide applied) the main effects were significant for crop emergence, % canopy cover and canola yield (weed free). For NDVI

measurements and in the weed-free situations, the main effects of seed size and seed rate were significant, but not the pollination type. When herbicides were not applied at the Mingenew site, crop emergence, ryegrass biomass, ryegrass seed production and canola yield (with weeds) were affected by the main effects of cultivar, seeding rate and seed size. Similarly, NDVI (7WAS) and NDVI (10WAS) were affected by the main effect of seed size. In a weed free situation crop emergence was increased in OP treatments when seeding rates and seed size was increased, with weed free canola yield increased by all main factors with the greatest response to seeding rate or seed size occurring in the hybrid treatments. When post emergent ryegrass control was not applied (weedy situation), crop emergence was also affected by all main factors. Whilst initial weed density counts were not significantly affected by main factors, seed size affected ryegrass biomass and seed production, especially in the OP canola variety. Canola yield was increased in all main factor treatments with the largest yields found in the Hybrid treatments where high seeding rate and applied seed diameter's were used.

### Main effect interactions at Cunderdin

Within factorial experiments, the interaction between main effects are important. Analyses revealed significant interactions between pollination type and seed size for canola emergence and yield when herbicides were applied. Interactions between pollination type and seed size were also identified for annual ryegrass biomass and canola yield when herbicide is not applied for Cunderdin. The interaction between pollination type and seeding rate was significant for canola radiation interception when the herbicide is applied and for weed density (10WAS) and total annual ryegrass seed production when herbicides were not applied. For NDVI measurements and in the situation of weed-free plots, interactions between pollination type × seed size, pollination type × seed rate, and seed size × seed rate were identified at second time of measurement (NDVI 10WAS). The interaction between canola seed size and canola seeding rate was significant for ryegrass and ryegrass total seed production within the nil herbicide applied plots. There was no interaction between all three main factors at the Cunderdin site, except for NDVI (7WAS) and NDVI (10WAS).

### Main effect interactions at Mingenew

In the weed-free situation, the interaction between pollination type and seed size was identified for % canopy cover, canola 1000 seed weight, % oil content, NDVI (7WAS), NDVI (10WAS), and NDVI (13WAS). The interaction between pollination type and seed rate was identified for NDVI (14WAS). The interaction between seed size and seed rate was identified for NDVI (7WAS). The interaction between pollination type and seed rate was identified for NDVI (7WAS). The interaction between pollination type and seed size was identified for ryegrass biomass, ryegrass seed production, canola yield, NDVI (7WAS), and NDVI (10WAS) when herbicides were not applied at Mingenew. The interaction between pollination type and seed ing rate was only significant for annual ryegrass seed production and NDVI (14WAS) at the Mingenew site when herbicides were not applied. The interaction of seed size and seeding rate is significant for crop emergence, ryegrass seed production and canola yield in Mingenew when herbicides were not applied. The interaction of the three main factors is not significant for any traits at Mingenew irrelevant of the presence or absence of herbicide application.

## **Summary and Implications**

The results of this study suggests:

- Crop emergence was affected by pollination type (greater in open pollinated var. Bonito), increased seeding rates and increased seed size at both the Cunderdin and Mingenew sites, with seed size and seeding rate interactions at Mingenew.
- 2. Weed densities were reduced by seed size and seeding rates at Cunderdin. No significant decreases were identifies at Mingenew due to the high weed densities.
- Ryegrass biomass was reduced by Pollination type (reduced in the open pollinated var. Bonito), increased seed size at both the Cunderdin and Mingenew sites. Seeding rate was found to reduce ryegrass biomass at the Cunderdin site.
- 4. Canola yield was increased by increasing seeding rate and seed size in both weedy and weed free situations at the Cunderdin and Mingenew sites.

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