Effect of cultivar, seed rate and herbicides on annual ryegrass management in canola (Roseworthy, SA)

Key messages

- This field trial at Roseworthy was undertaken to investigate factorial combinations of canola seed rate and herbicides on the management of annual ryegrass (ARG).
- Canola seed rate had a significant effect on crop density (P<0.001). Crop density achieved was 30 plants/m^2 for the low seed rate and 50 plants/m^2 for the high seed rate.
- ARG plant density in various canola cultivars x weed management strategies was <100 plants/m^2 (Table 6). Among herbicide tolerant crops, Truflex® (TF) glyphosate tolerant system and LT (LibertyLink® + Triazine tolerance) canola had a significantly lower ARG plant density (P=0.019) than the TT (triazine tolerant) canola. Within a canola cultivar, differences in ARG plant density were only observed in TT canola where application of clethodim alone or clethodim + butroxydim significantly improved ARG control as compared to pre-emergent herbicides alone (HT 1 and 2).
- There were significant differences between canola cultivars in ARG spike density. Application of propyzamide before sowing followed by two applications of glyphosate in TF canola reduced ARG spike density to less than 1 spike/m^2. In contrast, spike density of ARG in TT canola was significantly greater (42-191 spikes/m^2). As ARG population present in the trial paddock was glyphosate susceptible, use of this herbicide on TF canola proved extremely effective for ARG control.
- When averaged across the four weed management strategies, TF (Nuseed Raptor) canola (4.338 t/ha) produced significantly higher yields than TT (HyTTec® Trophy) (3.669 t/ha) and LT (Invigor® LT4530P) (3.523 t/ha) (P<0.001; LSD = 0.189).
- In this trial, glyphosate application in the TF canola not only provided excellent ARG control, but it also had excellent agronomic features, which resulted in grain yields well above 4 t/ha. Even though the differences between the herbicide treatments in TF canola were small, application of propyzamide pre-sowing gave a significant increase in yield relative to sole reliance on post-emergent glyphosate (HS 2 vs 4). Use of pre-emergent herbicide is likely to have reduced competition from ARG during the early vegetative stages prior to the use of glyphosate. Use of multiple modes of action is also beneficial for delaying the evolution of herbicide resistance in ARG populations.

Introduction

Canola (*Brassica napus* L.) is an important oilseed crop worldwide, which has also gained popularity in Australian cropping systems. In addition to being an important cash crop, canola has also been shown to be an important break crop for the suppression cereal root diseases.

There are now many commercial cultivars available to Australian growers, including herbicide-tolerant types (glyphosate, triazines, imidazolinones, glufosinate) alone, or stacked, in both open-pollinated and F1-hybrid genotypes. Despite a broad range of herbicides available for weed control, weeds are a considerable cost to farmers through reduced crop grain yield and quality, and control costs. Brief information on canola varieties used in this trial is provided in the Methods section.

Seeding rate of canola cultivars for optimal yields is usually determined by field evaluation in weed-free conditions over the range of environments. In Australia use of larger hybrid seeds and their greater early vigour, has enabled growers to lower seeding rates in combination with available herbicides. However, since the rapid evolution of herbicide resistance, the optimal seed rate (crop plants/m^2) need to be reconsidered as weeds are likely be present in most crops. This field trial at Roseworthy was undertaken to investigate factorial

combinations of canola type (herbicide tolerance package), canola seed rate and herbicides on the management of ARG.

Methods

A brief description® of the 3 herbicide tolerant canola cultivars used in this trial has been presented below.

HYTTEC® TROPHY TT
An early-mid maturity hybrid canola with medium-tall plant height with tolerance to triazine herbicides. It has blackleg resistance rating of R (resistance group AD). Suited to the low to medium-rainfall areas. Bred and marketed by Nuseed.

INVIGOR® LT 4530P
An early-mid maturing triazine tolerant and LibertyLink® hybrid variety. It has blackleg resistance rating of RMR (resistance group BF). This cultivar is suited to medium to high-rainfall areas. PodGuard® technology makes it suited to later windrowing timings or direct harvest. Bred and marketed by BASF.

NUSEED® RAPTOR TF
An early-mid maturing TruFlex® hybrid. Blackleg rating R (resistance group AD). Medium height. Bred and marketed by Nuseed. TruFlex® varieties of canola allow use of higher rates of glyphosate and over a wider application window than the original Roundup Ready® cultivars.

Trial design: Factorial randomised block design
Replicates: 3
Measurements: crop density, ARG plant density, ARG spike density, ARG seed production, and canola grain yield and quality.

Table 1. Key management operations undertaken.

Operation	**Details**
Location	Roseworthy, SA
Plot size	1.5 m x 10 m
Fertiliser	At sowing – DAP (18:20:0) @ 120 kg/ha In season – 100 kg/ha urea (46:0:0) canola 2-3lf (30 July), 100 kg/ha urea canola 5-6lf (17 August), 100 kg/ha urea canola early bud formation (29 August)
Variety	HYTTEC® TROPHY INVIGOR® LT 4530P NUSEED® RAPTOR TF
Seeding rate	25 seeds/m^2 50 seeds/m^2
Crop sowing date	June 14, 2022
Herbicides	Refer to Table 3 for information on herbicide treatments.

Table 2. Details of active ingredients of herbicide products investigated in the triazine tolerant (TT), LibertyLink-triazine tolerant (LT) and glyphosate tolerant Truflex® (TF) canola cultivars.

Herbicides	**Active ingredient**	**Manufacturer**
Edge 900WG®	Propyzamide, 900 g/kg	Imtrade
Farmazine 900DF®	Atrazine, 900 g/kg	Adama
Factor®	Butroxydim, 250 g/kg	Nufarm
Grasidim®	Clethodim, 240 g/L	Sipcam
Liberty®	Glufosinate-ammonium, 200 g/L	BASF
Crucial®	Glyphosate, 600 g/L	Nufarm
Spray adjuvants	**Active ingredient**	**Manufacturer**
Hasten™	Ethyl and Methyl Esters of Canola fatty acids, 704 g/L + Non-ionic surfactants, 196 g/L	Victorian Chemical Company
Supercharge® Elite	Paraffin oil, 471 g/L	Nufarm

Table 3. Details of herbicide treatments investigated in the triazine tolerant (TT), LibertyLink-triazine tolerant (LT) and glyphosate tolerant Trueflex® (TF) canola cultivars.

Canola	**Herbicide strategy** *(HS)*	
TT *(HyTTec® Trophy)*	1.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS**
	2.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Farmazine 900WG @ 1.1 kg/ha + Hasten @ 1% wv **EP**
	3.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Farmazine 900WG @ 1.1 kg/ha + Hasten @ 1% wv **EP** fb Factor @ 80 g/ha + Grasidim @ 375 mL/ha + Supercharge Elite @ 1% wv **POST**
	4.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Farmazine 900WG @ 1.1 kg/ha + Hasten @ 1% wv **EP** fb Grasidim @ 500 mL/ha + Supercharge Elite @ 1% wv **POST**
LT *(Invigor® LT4530P)*	1.	Edge 900WG @ 0.56 kg/ha **IBS** fb Liberty @ 3 L/ha **POST-1** fb Liberty @ 3 L/ha **POST-2**
	2.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Liberty @ 3 L/ha **POST-1** fb Liberty @ 3 L/ha **POST-2**
	3.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Factor @ 80 g/ha + Grasidim @ 375 mL/ha + Supercharge Elite @ 1% wv **POST** fb Liberty @ 3 L/ha **POST-1** fb Liberty @ 3 L/ha **POST-2**
	4.	Edge 900WG @ 0.56 kg/ha + Farmazine 900WG @ 2.2 kg/ha **IBS** fb Grasidim @ 500 mL/ha + Supercharge Elite @ 1% wv **POST** fb Liberty @ 3 L/ha **POST-1** fb Liberty @ 3 L/ha **POST-2**
TF *(Nuseed Raptor)*	1.	Edge 900WG @ 0.56 kg/ha **IBS** fb Crucial @ 1 L/ha **POST-1** *(Roundup Ready® Crucial application)*
	2.	Edge 900WG @ 0.56 kg/ha **IBS** fb Crucial @ 1.5 L/ha **POST-1** fb Crucial @ 1.5 L/ha **POST-2** *(TruFlex® Crucial application)*
	3.	Edge 900WG @ 0.56 kg/ha **IBS** fb Factor @ 80 g/ha + Grasidim @ 375 mL/ha + Supercharge Elite @ 1% wv **POST** fb Crucial @ 1.5 L/ha **POST-1** fb Crucial @ 1.5 L/ha **POST-2** *(TruFlex® Crucial application)*
	4.	Crucial @ 1.5 L/ha **POST-1** fb Crucial @ 1.5 L/ha **POST-2** *(TruFlex® Crucial application)*

Table 4. Application notes for different herbicide treatments investigated in the triazine tolerant (TT), LibertyLink-triazine tolerant (LT) and glyphosate tolerant Truflex® (TF) canola cultivars.

Canola	Herbicide treatment application notes
TT *(HyTTec® Trophy)*	**IBS** - Immediately before seeding application (IBS), applied to soil 14 June, (propyzamide, atrazine)
	EP – Early post emergent application (EP), applied to canola 28 July, canola 2-2.5 leaf stage and annual ryegrass (ARG) Growth stage (GS) 12-13, (atrazine)
	POST – Post emergent application (POST), 8 August, canola 4-5 leaf stage and ARG GS 13-22, (butroxydim, clethodim)
LT *(Invigor® LT4530P)*	**IBS** - Immediately before seeding application (IBS), applied to soil 14 June, (propyzamide, atrazine)
	POST – Post emergent application (POST), 8 August, canola 4-5 leaf stage and ARG GS 13-22, (butroxydim, clethodim)
	POST-1 – First post emergent application of Liberty® herbicide, 16 August, applied in west to east direction, canola 5-6 leaf stage and ARG mostly GS1-22 (late cohorts GS11-12), (glufosinate)
	POST-2 – Second post emergent application of Liberty® herbicide, 26 August, applied in east to west direction, canola at start of bud formation and ARG mostly GS21-22, (glufosinate)
TF *(Nuseed Raptor)*	**IBS** - Immediately before seeding application (IBS), applied to soil 14 June, (propyzamide)
	POST – Post emergent application (POST), 8 August, canola 4-5 leaf stage and ARG GS 13-22, (butroxydim, clethodim)
	POST-1 – First post emergent Crucial® application for Truflex® and only application for Roundup Ready® equivalent treatments, 16 August, canola 5-6 leaf stage and ARG mostly GS1-22 (late cohorts GS11-12), (glyphosate)
	POST-2 – Second post emergent Crucial® application for Truflex® equivalent treatments, 6 September, canola start flowering (1-2 flowers per plot), (glyphosate)

All data collected during the growing season was analysed using the Analysis of Variance function in GenStat version 19.0.

Rainfall at Roseworthy during the growing season was 30% above the long-term average. Total annual rainfall was 46% above the long-term average for the site. The year (2022) was characterised by a very dry autumn, only breaking with reasonable rains at the end of May, July had below average rainfall, while October and November had well above average rainfall. The November rainfall, though classed as outside of growing season (April-October), could have been used by the crop due to exceptionally mild weather in 2022 (Table 2).

Table 5. Rainfall received at Roseworthy in 2022 and the long-term (1997-2022) average for the site.

	Rainfall (mm)	
Month	**2022**	**Long-term rainfall**
Jan	64.6	18.3
Feb	5.8	19.0
Mar	11.4	16.7
Apr	6.8	29.9
May	78.8	39.5
Jun	52.8	45.5
Jul	26.0	43.7
Aug	49.2	45.9
Sep	56.8	45.5
Oct	99.8	34.7
Nov	107.0	29.6
Dec	14.0	23.8
Annual total	573.0	392.3
GSR total	370.2	284.7

Results and Discussion

Canola plant density

Canola seed rate had a significant effect on crop density ($P<0.001$). Crop density achieved was 30 plants/m^2 for the low seed rate and 50 plants/m^2 for the high seed rate. Canola establishment was close to the target and crop density achieved in various treatments allowed investigation of the benefits of increased crop competition for ARG management.

Annual ryegrass plant and spike density

ARG plant density in various canola cultivars x weed management strategies was <100 plants/m^2 (Table 6). Among herbicide tolerant crops, TF and LT canola had a significantly lower ARG plant density ($P=0.019$) than the TT canola (Table 6). Within a canola cultivar, differences in ARG plant density were only observed in TT canola where application of clethodim alone or clethodim + butroxydim significantly improved ARG control as compared to pre-emergent herbicides alone (HS 1 and 2).

There were significant differences between canola cultivars in ARG spike density (Table 6). Application of propyzamide before sowing followed by two applications of glyphosate in TF canola reduced ARG spike density to less than 1 spike/m^2. In contrast, spike density of ARG in TT canola was significantly greater (42-191 spikes/m^2) (Table 6). As the ARG population present in the trial paddock was glyphosate susceptible, use of this herbicide on TF canola proved extremely effective for ARG control. This variety is also extremely vigorous and suppressive of ARG.

Table 6. The effect of herbicide strategies on annual ryegrass plant density in TT triazine tolerant (HyTTec® Trophy), LT glufosinate and triazine tolerant (Invigor® LT 4530P) and TF glyphosate tolerant (Nuseed Raptor TF) canola cultivars. Refer to Table 3 for details of herbicide strategies.

Canola cultivar	**Herbicide strategy (HS)**	**Annual ryegrass density (plants/m^2)**	**Annual ryegrass spikes/m^2**
HYTTEC® TROPHY TT	1	84.8	191.5
	2	77.7	118.5
	3	42.5	54.2
	4	48.7	42.2
INVIGOR® LT 4530P	1	24.2	118.5
	2	17.2	59.5
	3	20.7	27.5
	4	10.8	17.0
NUSEED® RAPTOR TF	1	19.7	9.7
	2	5.5	0.3
	3	5.7	0.7
	4	11.2	8.2
P		0.017	0.019
LSD (P=0.05)		17.88	66.25

Canola grain yield

When averaged across the four weed management strategies, TF (Nuseed Raptor) canola (4.338 t/ha) produced significantly higher yields than TT (HyTTec® Trophy, 3.669 t/ha) and LT (Invigor® LT4530P, 3.523 t/ha) ($P<0.001$; LSD = 0.189). In this trial, glyphosate application in the TF canola not only provided excellent ARG control, but it also had excellent agronomic features, which resulted in grain yields well above 4 t/ha (Table 7). Even though the differences between the herbicide treatments in TF canola were small, application of propyzamide pre-sowing gave a significant increase in yield relative to sole reliance on post-emergent glyphosate (HS 2 vs 4). Use of pre-emergent herbicide is likely to have reduced competition from ARG during the early vegetative stages prior to the use of glyphosate. Use of multiple modes of action is also beneficial for delaying the evolution of herbicide resistance in ARG populations.

In eastern Australia, the oil standard in canola is 40% with the 1.5% price premium for each 1% higher oil content than the baseline at the same moisture level. In this trial, all three canola varieties produced greater than 46% oil content. TF canola (47.91%) had a significantly higher ($P=0.002$) oil content than LT (46.65%) and TT (46.57%). It is important to note that good agronomic management used in this trial produced high yields and high oil content.

Table 7. The effect of herbicide strategies on grain yield of TT triazine tolerant (HyTTec® Trophy), LT glufosinate and triazine tolerant (Invigor® LT 4530P) and TF glyphosate tolerant (Nuseed Raptor TF) canola cultivars. Refer to Table 3 for details of herbicide strategies.

Canola cultivar	**Herbicide strategy (HS)**	**Grain yield (t/ha)**
HYTTEC® TROPHY TT	1	3.267 d
	2	3.640 cd
	3	3.816 c
	4	3.952 bc
INVIGOR® LT 4530P	1	3.259 d
	2	3.496 d
	3	3.599 cd
	4	3.737 c
NUSEED® RAPTOR TF	1	4.377 ab
	2	4.444 a
	3	4.367 ab
	4	4.165 b
P		<0.001
LSD (P=0.05)		0.241