Compensatory and competitive ability of two canola cultivars

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ABSTRACT

The ability of canola to compensate for poor establishment and to compete against weeds was investigated in a field experiment comparing cultivars differing in seedling vigour. The experiment investigated three sowing rates, applied nitrogen and competition with annual ryegrass. Weed competition reduced the yield of the less vigorous Pinnacle cultivar at all plant densities. The yield of the more vigorous Dunkeld cultivar was reduced by weed competition only at low density. In the absence of weeds, the yield of Pinnacle at low density was less than at normal and high density, whereas for Dunkeld, yield was unaffected by sowing rate. The addition of nitrogen fertiliser increased the yield of both cultivars and enhanced the crop's ability to compete against weeds. The conclusion is that Pinnacle could not compensate as much as Dunkeld for low plant density and was more affected than Dunkeld by weed competition.

Key words

Canola, compensation, management, yield, cultivars.

INTRODUCTION

Conventional canola (CC) cultivars are able to produce similar grain yields across a range of plant densities in weed-free situations (6, 8, 9). The ability to compensate for low plant density is achieved mainly through an increase in pod numbers per plant (2). However, this ability is reduced in the presence of weeds (9). There is no work reported on the compensatory ability of triazine-tolerant (TT) canola cultivars when sown at different densities. When compared to CC cultivars, TT cultivars may have reduced compensatory ability because of lower photosynthetic rate and slower growth, resulting from a modification of chloroplast proteins involved in photosynthesis (1).

CC cultivars are known to vary in competitive ability (5). Comparative studies of TT and CC cultivars under weed competition have shown that at a normal crop density, TT cultivars have lower yields than CC cultivars (3, 7). The aims of this study were to compare the ability of two cultivars differing in vigour to compensate for low plant density and to compete against a weed (annual ryegrass).

MATERIALS AND METHODS

An experiment was sown at Longerenong College, Dooen, Victoria (latitude 36 39' S., longitude 142 16' E, elevation 151 m) in 1999, using the vigorous cultivar Dunkeld, and the less vigorous TT cultivar Pinnacle. The treatments consisted of 3 sowing rates (plant densities of 32, 95 and 162 plants m^{-2}), 2 nitrogen levels (0 and 100 kg N ha^{-1} applied as urea before sowing) and with and without weed competition (annual ryegrass *Lolium rigidum* at 450 plants m^{-2}). The experiment was a randomised complete block design (4 replications). The soil type was a grey vertisol (grey, self-mulching, cracking clay, Ug5.2) and pre-sowing soil nitrate 6.6 ug g^{-1} to 50 cm. Prior to sowing 19.5 k P ha^{-1} and 9.1 kg Sha^{-1} were applied as well as 500 kg ha^{-1} gypsum. Wild oats, vetch and thistles were sprayed with commercially available herbicides. The weed free plots were maintained by hand weeding.

The April to November rainfall was 234 mm (decile 2).

Sampling at the 4-5 leaf stage (stage HB 2.4-2.5, Harper and Berkenkamp (4)) and at maturity was carried out on all treatments, and also for high and normal densities at the bud visible (stage HB 3.1), the beginning of flowering (stage HB 4.1) and the end of flowering (HB 4.4). Sampling areas were 1 m^2 per plot for the crop plants and 0.5 m^2 for the weed. A sub-sample of at least 15 plants or 15% fresh weight was used for tissue dissection (leaves, buds, stems, etc), and leaf and pod areas were measured. A 2 m^2 sample was taken at maturity to determine yield and yield components.

Canopy light interception was assessed every 15 to 20 days from the bud visible stage using a sunfleck ceptometer.

RESULTS

Yield of Pinnacle was 18% less than Dunkeld at high and normal densities and in the absence of weeds. Weed competition reduced the yield of Pinnacle at all densities compared to the weed-free treatment (Figure 1). However, the yield of Dunkeld was significantly reduced by weed competition only at low density. In the absence of weeds, the yield of Pinnacle at low density was less than the normal and high density. In contrast, Dunkeld yield was unaffected by sowing rate.

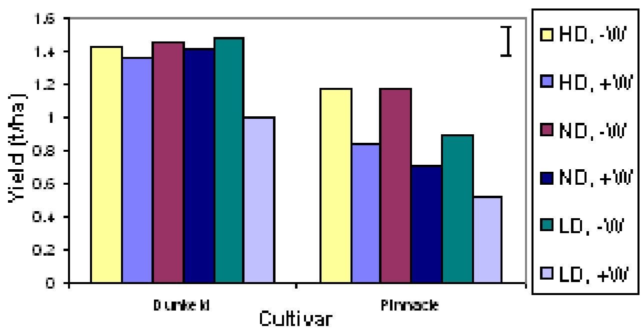

Figure 1. Yield of Dunkeld and Pinnacle at high, normal and low densities (HD, ND, LD) with and without weed (+W, -W) competition. The vertical line on the graph indicates the LSD (P=0.05).

There was an interaction effect found for yield between nitrogen and weed competition. The addition of nitrogen fertiliser increased the yield of both cultivars and enhanced the crop's ability to compete against weeds (Table 1).

Table 1. The effect of nitrogen and weed competition on the mean yield of Dunkeld and Pinnacle canola.

Nitrogen	Weeds	Yield (t ha^{-1})	% yield loss due to weeds
+	+	1.19	14.3
+	-	1.39	
-	+	0.75	34.2
-	-	1.14	
LSD (P=0.05)		0.11	

The differences in yield observed in Figure 1 and Table 1 reflected higher harvest biomasses, as the harvest index was not affected by any of the treatments (data not shown).

Table 2 shows how cultivar, density and nitrogen treatment affected the weed dry weight at crop maturity. There were no significant interactions between these treatments. There were fewer weeds under cv. Dunkeld, which suggests that it was more effective at suppressing weeds than Pinnacle. Increasing plant density, or applying additional nitrogen, also reduced the weed mass in the crops.

Table 2. The main effects of cultivar, density and nitrogen treatment on the dry weights of weeds (DWW) at maturity. DWW is expressed in g m^{-2}.

Cultivar	DWW	Density	DWW	Nitrogen	DWW
Dunkeld	109.4	High	108.2	+	149.4
Pinnacle	260.5	Normal	164.2	-	220.5
		Low	282.4		
LSD (P=0.05)	38.2		46.8		38.2

The competitive advantages that led to the differences found in yield could be seen from early in the growing season. At the 4-5 leaf stage Dunkeld had a leaf area index (LAI) of 0.53 and a shoot dry weight of 20.3 g m^{-2}, which were twice the values for Pinnacle (0.26 and 10.2 g m^{-2}, respectively).

Differences in LAI and shoot dry weight were also measured between the various densities at 4-5 leaf stage. The LAI for the high, normal and low density were 0.73, 0.36 and 0.09, while the shoot dry weight were 34.3, 17.5 and 4.9 g m^{-2}.

Additional nitrogen applied at sowing showed no effect at the 4-5 leaf stage. However, by bud visible, effects were apparent between cultivars and nitrogen for LAI and shoot dry weight. At this stage, Dunkeld responded to applied nitrogen while Pinnacle did not. Table 3 shows how the LAI of Dunkeld with additional nitrogen was significantly higher than without nitrogen, while Pinnacle had the same LAI for both treatments. A similar response was seen in shoot dry weight (data not shown).

Table 3. Leaf area index of Dunkeld and Pinnacle with and without nitrogen application at the bud visible stage. Values presented are the means of the normal and high density treatments.

Cultivar	Nitrogen	LAI
Dunkeld	+	2.59
	-	1.63
Pinnacle	+	1.23

	-		1.07
LSD (P=0.05)			0.26

These differences in LAI resulted in significant differences in radiation interception between cultivars, densities and nitrogen applications and these factors did not interact (Table 4).

Table 4. Light interception (%) of Dunkeld and Pinnacle, normal and high density and nitrogen treatment at the bud visible stage.

Cultivar	Li (%)	Density	Li (%)	Nitrogen	Li (%)
Dunkeld	0.80	High	0.73	+	0.76
Pinnacle	0.60	Normal	0.67	-	0.64
LSD (P=0.05)	0.04		0.04		0.04

By the beginning of flowering, the height of the top layer of leaves in Dunkeld was 12 cm higher than Pinnacle (50.8 and 38.9, respectively). Nitrogen application also increased the height of the top layer of leaves (48.7 and 41.0 cm with and without nitrogen, respectively).

DISCUSSION AND CONCLUSION

From the results shown above, it can be seen that the CC cultivar Dunkeld was more vigorous in its growth from early in the growing season (4-5 leaf stage) when compared to the TT Pinnacle. Dunkeld developed leaf area more rapidly than Pinnacle. Dunkeld responded earlier to nitrogen at sowing, grew taller and also captured more light than Pinnacle. We propose that these characteristics enabled Dunkeld to compete more strongly than Pinnacle against weeds. The higher leaf area and biomass also enabled Dunkeld to better compensate for low plant density than Pinnacle.

The less vigorous cultivar Pinnacle could not compensate as well as Dunkeld when sown at low density and in the presence of weeds. Our results agree with those of other workers (7), who found that TT cultivars had a greater yield reduction in the presence of weeds (17-37%) compared to CC (2-16%).

Another study (3) has shown that the yield difference between a TT and a CC (triazine-susceptible) biotype of cv. Tower was always the same or smaller over a range of weed densities compared to the weed free treatment. This suggests that at high density (4 plants pot^{-1} or ca. 128 plants m^{-2}) the yield penalty of the TT biotype was not increased by the presence of weeds. This result could be attributed to: a) the similar genetic background between both cultivars used in that study (3) or b) differences in the experimental environments (pot trials (3) compared to field experiments). However, since Dunkeld and Pinnacle have quite different genetic background, and differ in dry matter partitioning as well as in growth, their differences in compensatory and competitive abilities should be attributed only in part to the mechanism conferring triazine tolerance to Pinnacle. As Lemerle *et al*. (5) have shown in their work, there are significant differences in the competitive ability between different CC canola cultivars. Our results extend those findings to the common Australian cultivars Dunkeld and Pinnacle.

Other authors (6, 8, 9) have found that CC cultivars are able to compensate for low plant density during crop establishment. The results reported here show that Pinnacle is so much slower in its growth that, when sown at a low density, it cannot compensate even in a weed free situation.

The findings of this work suggest that Pinnacle will be more affected than Dunkeld by weed competition and under low plant density. The TT cultivar should not be sown at low seeding rates and weeds should be rigorously managed to enable its full yield potential to be realised.

ACKNOWLEDGMENTS

Sincere thanks to Peter Howie for his technical assistance and to Dovuro for supplying the seed.

BL was supported by a postgraduate scholarship from The University of Melbourne and the Consejo Nacional de Investigaciones Cient?ficas y T?cnicas de Argentina (CONICET).

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