Productivity of wheat and canola in rotation with lucerne/sub-clover or sub-clover pasture

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Abstract

In a long term rotation trial, production from canola and wheat following either canola, wheat, sub-clover or lucerne/sub-clover at Wagga Wagga, New South Wales was studied over seven seasons. Annual rainfall varied considerably (375 mm to 688 mm) over the period 1996 to 2002.

Mean establishment of canola following sub-clover was similar to lucerne/sub-clover (90 cf 86 plants/m^2). However, the seasonal variation in establishment was considerable (39 to 150 plants/m^2). Consistently higher (0.1-0.81 t/ha) canola grain yields were produced following sub-clover rather than lucerne/sub-clover. Over-all, similar oil% and grain protein were recorded after lucerne/sub-clover and sub – clover though seasonal differences did occur.

Though wheat as a second crop received 50 kg N/ha as urea, higher (mean 0.32 t/ha) wheat yields and grain protein (mean 0.6%) were obtained when wheat was the first crop after pasture compared to a second wheat crop. When wheat was the second crop and receiving 50 kg N/ha as urea, there was no difference in wheat grain yields following either canola or wheat with stubble burnt. However, grain protein was usually higher after lucerne/sub-clover - canola (mean 13.7%) compared to both lucerne/sub/clover - wheat (mean 13.0%) and sub-clover – canola (mean 13.1%).

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Productivity over seven years from wheat and canola in rotation with sub-clover or lucerne/sub-clover, wheat and canola at Wagga Wagga, NSW, is presented

Key Words

Rotations, canola, wheat, lucerne, sub-clover, long-term

Introduction

Biologically stable farming systems where soil carbon and nitrogen, depleted by cereal cropping, were maintained by periods of leguminous pasture, set the basis for profitable farming in southern Australia in the 1950's (Greenland 1971). However, cropping became more profitable than livestock in the 1980's and new crops such as grain legumes and canola were adopted. Lucerne is being recommended to alleviate salinity, boost soil fertility and provide feed throughout the year. The potential growth and benefits of these legumes to following crops can vary from season to season so it is important to compare legume effects over a number of years. Similarly, benefits of canola, considered to have exceptional break crop effects, were dependant on seasonal conditions (Kirkegaard et al 1994). This paper presents recent results on crop productivity from different rotations involving wheat, canola, sub-clover and a sub-clover lucerne mix.

Methods

This trial is part of a long term study which commenced in 1979 on a chromic luvisol (Oxic Paleustalf). The treatments reported here commenced in 1993 when certain 'old' treatments were discontinued and replaced by six phase rotations which were more relevant to the cropping practices used by farming community.

A list of main treatments between 1979 to 1990 was reported in Heenan et al 1994. Each plot was split for lime (1.5 t/ha) in 1991-2 before the wheat phase of the rotations. A number of treatments were terminated in 1992 and new treatments commenced. Here we discuss results of wheat and canola production from the 'new' treatments between 1996 and 2002 (Table 1)

Table 1. Rotations investigated

Symbol	Rotation
PPCaWLWu	Pasture[1], Pasture, Canola, Wheat, Lupin, Wheat undersown
PPWWLWu	Pasture, Pasture, Wheat, Wheat, Lupin, Wheat undersown
CCCaWLWu	Sub-clover, Sub-clover, Canola, Wheat, Lupin, Wheat undersown

[1]Pasture, Lucerne-sub/clover mix

The pasture phase containing lucerne (P) was terminated early autumn with herbicide and one pass scarification. While earlier termination could provide higher mineral N and moisture to following crops (Angus et al 2000), we adopted late removal to allow for feed for stock and also prevent damage such as erosion and leaching which could lead to acidification and accessions to the water table from summer rain. Sowing of all treatments was done with a 24 run drill with narrow sowing points. The second wheat crop in PPWWLWu was sown into burnt wheat stubble but stubble was retained in other cases. Stubble was burnt in early autumn prior to sowing. Wheat following wheat or canola received 50 kg N/ha as urea in a split application at the early seedling stage and again at stem elongation.

Weed control in wheat was achieved by use of Trifuralin, and post emergent applications of terbutryn or bromoxynil. For canola Trifuralin and post emergent applications of Clopyralid were used.

Grain yield was measured by mechanically harvesting a 1.8 m strip in the centre of each plot. A quadrant (0.5 m^2) was used to measure early plant number. Main plot size was 4.3 m by 50 m and each plot separated by a buffer of the same size in which sub-clover was grown.

Five composite soil samples were taken at 5 cm depth intervals to 20 cm prior to tillage for nitrate analysis. Data at each depth were expressed as absolute values using relevant bulk density measurements to allow for summation.

Treatments were replicated twice. From 1996 to 1997 the wheat cultivar Dollarbird was grown while the cultivar Diamondbird was used until 2002. Canola cultivars were Oscar (1996-2000) and Pinnacle (2001-2002).

Results and discussion

Only the main effects of crop sequence will be discussed as lime effects were minimal.

Table 2. Effect of previous crop or pasture on wheat grain yield (t/ha).

	PPCa/	CCCa/	PP/	PPW/	s.e.d

1996	4.25	4.16	4.75	4.21	0.34
1997	2.4	2.98	2.46	2.71	0.33
1998	3.65	4.61	4.47	4.26	0.45
1999	4.71	4.56	5.26	4.86	0.29
2000	3.57	3.58	3.30	3.33	0.42
2001	2.48	2.25	3.00	1.81	0.28
2002	0.66	0.62	0.75	0.60	0.26
Mean	3.10	3.25	3.43	3.11	

Wheat grain yields varied considerably between seasons. Low yields in 1997, 2001 and 2002 were the result of low rainfall while frost damage in 1998 and 2001 slightly curtailed yields. High yields for wheat immediately after PP/, compared with other wheat crops, were produced in four out of seven years. The advantage of being the first wheat crop after the pasture compared to other wheat crops may be related to less soil borne disease or higher soil N supply. The latter would appear to be less likely as wheat as a second crop following wheat or canola received urea fertiliser (50 kg N/ha).

There was no difference in wheat grain yields between PPCa/ and PPW/. Wheat stubble from the latter was burnt thereby reducing the transfer of the major wheat diseases take-all and eyespot (Murray et al 1991). Over recent years (1999-2002), $N0_3$-N was higher after canola (120 kg N/ha) than after the previous wheat (89 kg N/ha). However, topdressing with 50 kg N/ha as urea probably masked most of the potential yield response to soil N supply.

Highest grain protein occurred in the low rainfall years of 1997, 2001 and 2002.

Table 3. Effect of previous pasture or crop on wheat grain protein % over time

	PPCa/	CCCa/	PP/	PPW/	s.e.d
1996	11.6	11.2	10.8	10.9	0.52
1997	15.7	13.5	15.5	14.4	0.52
1998	12.4	13.3	12.6	12.3	0.37
1999	14.2	13.2	11.8	12.7	0.51

2000	14.1	12.9	13.3	11.9	0.8
2001	15.3	14.3	15.9	15.4	0.81
2002	12.8	13.5	15.0	13.3	0.33
Mean	13.7	13.1	13.6	13.0	

PPCa/ produced higher grain protein than PPW/ in most years despite the lack of response in grain yield. Possible reasons for this difference could be a greater soil N supply despite the N fertilizer addition in both cases or less root disease from a break crop effect with canola, though no diseases were visually detected **.** As noted above, over recent seasons the mean soil nitrate supply, prior to sowing wheat, was higher for PPCa/ than PPW/ (120 cf 89 kg N/ha, 0-20 cm**).**

Though higher mean grain protein was usually produced from the first wheat crop than the second crop, the low value in 1999 from PP/ was probably related to grain yield dilution.

In most years, wheat grain protein after PPCa/ was higher than after CCCa/. The exceptions were in the frost year of 1998 and the drought of 2002 when the reverse occurred. Possible reasons for the advantage of PPCa/ could be the lower yield of the relevant prior crop of canola combined with a slightly lower protein% in the canola grain (Table 4). There was also a slight difference in soil nitrate, taken prior to sowing the wheat, between PPCa/ and CCCa/ (120 cf 107 kg N/ha, 0-20 cm).

Table 4 Effect of previous pasture on canola yield, oil and protein.

	Grain yield (t/ha)		Oil %		Protein %	
	PP/	CC/	PP/	CC/	PP/	CC/
1996	1.42	1.52	43.2	42.8	30.3	33.3
1997	0.91	1.27	35.3	33.2	25.4	27.2
1998	2.56	2.72	39	39	36.4	36.5
1999	0.71	1.52	39.6	40.8	36.5	39.2
2000	1.56	2.11	41.3	41.1	38	41.1
2001	0.95	1.48	41.4	40.8	38.2	39
2002	0.24	0.47	32.5	34.7	44	44.2

Mean	1.19	1.58	38.8	37.4	35.5	36.9

Canola grain yield varied considerably with season but the over-all means and for each year were higher following sub-clover (Table 4). Similarly, in most years, total dry matter production was greater after CC (mean 9.24 t/ha) than after PP (mean 7.77 t/ha) though plant establishment was similar (90 cf 86 /m^2). Data for soil nitrate in the top 20 cm, following the pasture phases, are only available for 2001 and 2002 and differences were not consistent. Levels were higher for both PP and CC in 2001 (154 and 170 kg N/ha) than in 2002 (78 and 32 kg N/ha). These differences between PP and CC in soil nitrate levels could be due to marginally lower dry matter production from PP than CC in 2000 (7.0 cf 8.1 t/ha) but the reverse in 2001 (3.4 cf 2.9 t/ha) which was a low rainfall year. A further possible explanation for the differences in canola yield is a difference in soil moisture as lucerne was allowed to grow over the summer before cropping while sub-clover ceased growth before summer.

While there were differences in canola grain yields between pasture type, there was little difference in oil or grain protein concentration. High protein% but low oil% were produced in the drought of 2002 but the reverse occurred in 1996 (high rainfall) while in the low rainfall year of 1997 both oil and protein were low.

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