BREAK CROPS & CROP ROTATIONS: EFFECTS ON NITROGEN, PASTURE YIELD, GRAIN YIELD & PROFIT.

James Mwendw
Research Agronomist, Central West Farming Systems

Nigel Wilhelm
Research Scientist, South Australian Research and Development Institute

Tony Swan, Laura Watson, Mark Peoples, James Hunt,
CSIRO Sustainable Agriculture Flagship, CSIRO Plant Industry, Canberra ACT

Guangdi Li, Richard Lowrie; Graham Centre
(alliance between CSU and NSW DPI), Wagga Wagga, NSW

Paul Breust
FarmLink, Junee, NSW

SUMMARY

Crop sequence experimentation undertaken in Central West NSW in 2011 and 2012, has demonstrated that crop sequences which include a brassica or legume break crops can be as profitable as, and in many instances more profitable than, continuous wheat.

Growing pulses for hay was found to provide high quality feed as good as from cereals but hay from canola was less nutritious. However, canola hay provided an alternative option in cases where a possible crop failure is likely due to adverse weather.

Growing pulses for hay was found to be profitable across a range of season types, achieves excellent grass weed control and provides greater N inputs and higher carry-over of soil water than when the same crop is grown for grain.

Measurements of on-farm amounts of shoot N fixed per hectare in farmer-sown crops in 2011 varied from 13 to 42 Kg N/ha with field peas fixing the most N, and also yielding better than lupins and chickpeas

Canola was consistently the most profitable break crop option at Junee. However, the rotational benefits of canola were usually restricted to just the first subsequent wheat crop whereas additional wheat yields can occur for 2 years after a legume.

Growing pulses for brown manure loses money in the year they are grown, but achieves excellent grass weed control, high N inputs, residual carry-over of soil water, provides more ground cover, and requires less labour than when grown for hay or grain.

BACKGROUND

Most grain-growers recognise that they should include broadleaf species in their cropping program to reduce dis-ease incidence for cereals, help manage weeds and to improve soil nitrogen (N) fertility. However, the area sown to legume pulse crops or canola declined dramatically between 1999 and 2009. There were many good reasons why growers reduced the frequency of broadleaf species during that time which were related to late starts to the growing season, drought and risk aversion. Yet it appears that much of the decline can also be attributed to the wide-spread perception that broadleaf options are higher risk and not as profitable as cereals. The aim of the work de-scribed here was to challenge this notion, and to examine the impacts of break crops on the longer-term financial performance of following wheat crops.

Data collated from many field experiments indicate average yield improvements equivalent to 0.6-0.8 tonnes of wheat/ha when wheat is grown after canola or mustard compared to wheat on wheat, and between 1.1-1.8 t/ha by wheat grown following a grain legume compared to the yield of wheat on wheat in the absence of N fertilizer. Some of this increase in wheat yield can be derived from: (i) breaking of cereal disease cycles, (ii) changes in soil structural characteristics that encourage a deeper rooting depth, (iii) carry-over of residual soil water, or (iv) providing a range of weed contol options (Kirkegaard et al., 2008; Peoples et al., 2009; Kirkegaard and Hunt, 2010). In the case of legumes, rotational benefits can also be derived from specific effects on: (v) the composition of soil microbial populations, (vi) increased availability of soil N, and/or (vii) increased availability of phosphorus.

This article is an update on the crop sequencing project which started in 2011 and will finish in 2014. The update focuses on the impact of break crops on wheat and canola grain yield in 2012 from a single break crops grown in 2011 at Central west and Junee Reefs NSW. The project is funded by GRDC and the experimentation is undertaken in association with SARDI and CSIRO. The Trial results from Junee are provided through the courtesy of FarmLink and CSIRO Canberra.

The major trial was set up in 2011 at Condobolin with one or two year break phases which included pastures, pulses, canola and back to back wheat as the control. In addition 3 on-farm demonstration trials were also set up with a limited number of break crops on farms in Trundle, Forbes and Lake Cargelligo. The rotation phases were moni-tored for root diseases, nutrition, nitrogen fixation, weed seed bank, soil biology, biomass production, yield (both grazing, fodder and grain) and water use efficiency. However, in this update only hay yields and nutritive value, nitrogen fixation and the impact of one year break crop effects on wheat yield and quality in 2012 are discussed.

RESULTS AND DISCUSSIONS

1. Hay yield and Nutritive Value based on Dry Matter

In 2011, to investigate the value of different end uses on profitability, canola, cereal and some pulse crops were cut for hay at mid-pod/grain fill growth stages. Both hay yield and nutritional values are reported in the results below.

Table 1 shows hay yield and nutritive value from different crop varieties. Hay yield was similar between crops but nutritive values were quite different. Hindmarsh Barley yielded the most highly nutritive hay with the highest me-tabolisable energy (ME) of 12.2 and the best digestibility (DMD 80%) of all the crops reported here. Wheat and field peas had a similar hay yield, DOMD,

Crop Variety	Hay (Kg/ha)	DM	NDF	ADF	CP	DOMD	DMD	ME
Canola 44Y84CL	2946	94.8	52.0	37.7	10.5	46	47	6.5
Canola Hyola 575 CL	3039	95.0	49.7	37	9.8	45	46	6.2
Canola Hyola 575 CL	2987	95.0	48.3	34.7	11.5	53	54	7.7
Barley Hindmarsh	3492	94.5	39.3	19.7	9.5	75	80	12.2
Field peas Twilight	2939	94.8	35.7	22.3	12.8	73	78	11.8
Wheat Livingston	3183	95.1	42.0	22.3	9.0	71	76	11.4
Wheat Lincoln	3338	94.6	41.3	21.3	9.2	73	78	11.7
P- Value	NS	NS	P<0.005	P<0.005	NS	P<0.005	P<0.005	P<0.005
LSD-5%	993	0.57	5.36	3.70	2.81	9.0	10.5	1.8

Table 1: Comparison of crop hay yield and nutritive value from canola, field peas and cereals grown in 2011 at crop sequence core site Condobolin. The nutritive values are expressed as a percentage of the total Dry Matter (DM) and are described as follow; Neutral detergent fibre (NDF), Acid detergent fibre (ADF), Crude Protein (CP), Digestible Organic Matter in Dry matter (DOMD), Dry Matter Digestibility (DMD) and Metabolisable Energy (ME).

DMD and ME, however, field peas had higher crude protein. Canola had simi-lar hay yield to field peas but very low ME (maintenance level energy) and poor DMD which may suggest harvesting canola hay earlier (before mid-pod fill) could yield a higher nutritive hay feed for stock.

2. Measures of nitrogen (N) fixation by farmer-sown pulse break crops in 2011

The amounts of shoot N fixed per hectare by the farmer-sown legume crops varied from 13 to 42 kg N/ha (Table 2). The variation in the total N fixed is largely influenced by many factors such as type of crop, available soil nutrients, moisture, and levels of rhizobia in the soil, inoculant type and amount used. Any of these factors or a combination has been demonstrated through numerous studies to impact on the amount of N fixed. Provided that there are no major constraints to effective rhizobia function the major determinant of the amount of N fixed by a plant is largely driven by the above ground dry matter (DM) production.

As a rough rule of thumb, between 15-25 kg N is usually fixed for every 1 tonne of above ground DM produced. Of the 8 pulses examined in 2011, the amount of shoot N fixed fell within this expected range for 5 of the crops, while there was suggestion that some form of constraint limited N fixation by the re-maining 3 (Table 2). Not all the fixed N is available for the next season's crop. Some of the fixed N will be exported from the paddock in grain (see Table 2), and less than 20% of fixed N remaining in the shoot residues after grain harvest would be expected to become available for the following season's cereal crop through mineralisation, with only about 5% of the legume residue N then becoming available for subsequent crops thereafter.

3. Impact of one year break crop effects on subsequent 2012 wheat yield at Condobolin

The 2012 wheat was grown on 2011 break crop plots which had different end uses such as hay, grain or grazing. The control (wheat on wheat) was top dressed with an extra 23 units of N (50Kg Urea) at GS 30 while the rest of the treatments received no extra N.

Trial Site	Crop Variety	Total Crop tDM/ha	Shoot N Fixed? (kg N/ha)	Shoot N fixed(kg N/t DM)	Grain Yield t/ha	Grain N %	Grain Removed (kg N/
Condo PS	Field peas - Twilight	2.8	42	15	1.1	3.6	38
Forbes TF	Lupins - Luxor	0.9	20	21	0.5	5.8	28
Forbes TF	Chickpeas - Hat trick	0.8	14	17	1.1	3.3	36
Forbes TF	Field peas - Twilight	2.3	41	18	1.5	3.8	58
L. Cargelligo DD	Lupins - Mandelup	1.8	20	12	1.1	5.5	61
Trundle DW	Chickpeas - Hat trick	1.7	13	8	1.0	2.9	30
Trundle DW	Lupins- Luxor	1.7	26	15	0.4	5.5	19
Trundle DW	Field peas-Twilight	2.0	23	12	1.0	3.4	34

Table 2: N fixation comparison between different pulse farmer-sown crops grown at different commercial pad-docks in Central West NSW in 2011.

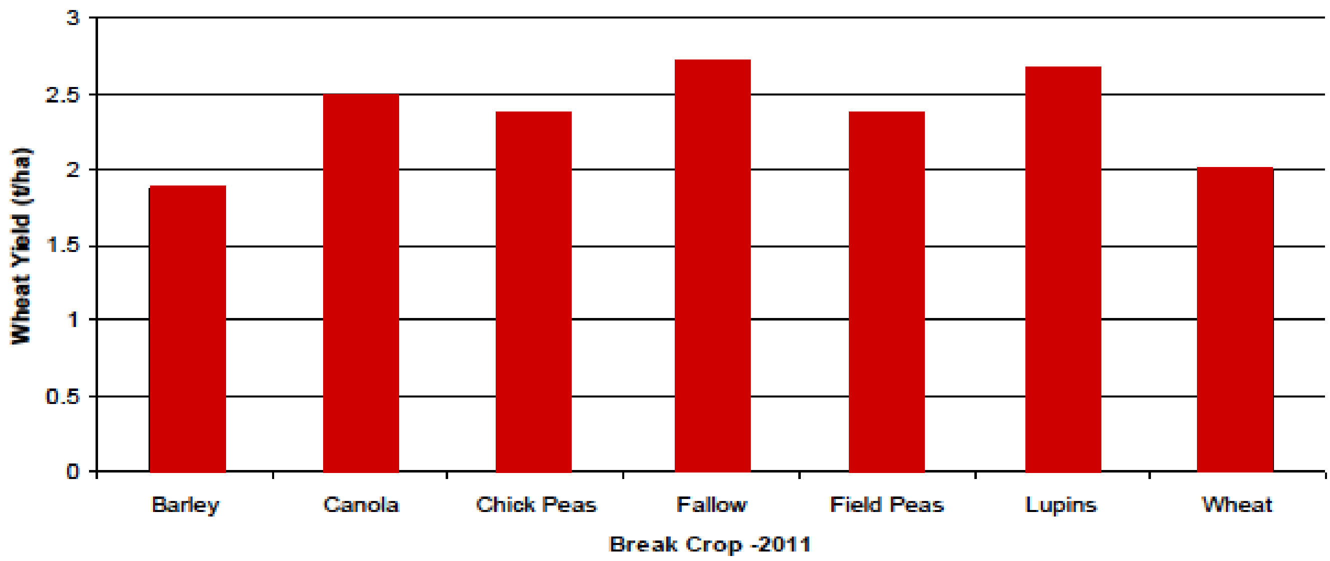

Figure 1: The 2012 wheat yield after 2011 break crop in farmer-sown paddocks at Condobolin, Trundle and Lake Cargelligo.

Break in 2011	End use in 2011	Crop 2012	Average Yield 2012 (t/ha)		Average Protein %	
Chickpea	Hay	Wheat	1.63	1.75	10.6	11.0
Chickpea	Grain	Wheat	1.87		11.3	
Canola	Hay	Wheat	1.74	1.59	11.1	10.8
Canola	Grain	Wheat	1.44		10.6	
Vetch	Grain	Wheat	1.83	1.89	10.9	11.0
Vetch	Manure	Wheat	1.94		11.0	
Lupin	Grain	Wheat	1.98	2.02	10.6	10.8
Lupin	Grain	Wheat	2.06		11.0	
Barley	Hay	Wheat	1.66	1.66	10.7	10.7
Barley	Grain	Wheat	1.67		10.7	
Oats	Graze	Wheat	1.46	1.55	10.3	10.5
Oats	Grain	Wheat	1.64		10.6	
Serradella	Graze	Wheat	1.32	1.35	11.6	11.5
Serradella	Graze	Wheat	1.39		11.5	
Wheat	Hay	Wheat	1.75	1.73	11.0	11.0
Wheat	Grain	Wheat	1.72		11.1	
LSD(5%)	Crop 2011 (CV - 8.4%)			0.23 (P<0.005)		0.5 (P<0.05)
	End use '11 (CV -9.8%)		0.28 (P<0.05)		NS	

Table 3: Impact of one year break crop effects on 2012 Livingston wheat yield and grain quality.

There were large differences in yield and protein levels for wheat growing on pulse break crops compared with those growing on pasture serradella, canola or cereals (barley, oats and wheat) see Table 3. For example wheat on lupins yielded 300 kg/ha more than back to back wheat, despite the extra 23 units of N applied on the back to back wheat. However, there was a low yield (1.35 t/ha) for the wheat growing on serradella but the protein levels were higher (11.5) compared with wheat growing on any other break crop. The low yield was probably due to the late spraying out of serradella prior to sowing in 2012. These late sprayed out plants likely utilised some of the summer moisture.

4. Impact of one year break crop effects on subsequent 2012 wheat yield at different commer-cial paddocks in the region.

The crop sequence demonstraion trials at commercial paddocks were done by respective landholders at Condobolin, Forbes, Trundle and Lake Cargelligo. Table 4 above shows the comparison in wheat yields after 2011 fallow and different break crops. The wheat following fallow and pulse had higher yield than back

Trial Site	Crop 2011	Crop 2012	Yield t/ha	Protein %	Harvest Index %
Condo BD	Barley	Gregory	1.9	11.9	42.3
Condo BD	Chick Peas	Gregory	2.4	12.9	44.5
Trundle DW	Chick Peas	Livingston	2.4	9.2	43.4
Trundle DW	Field Peas	Livingston	2.4	9.5	43.9
Trundle DW	Lupins	Livingston	2.7	11.1	35.7
Trundle DW	Wheat	Livingston	2.0	9.0	39.9
L. Cargelligo DD	Canola	Lincoln	2.5	8.9	43.0
L. Cargelligo DD	Fallow	Lincoln	2.7	8.8	44.8
L. Cargelligo DD	Lupins	Lincoln	2.6	10.5	43.1
L. Cargelligo DD	Wheat	Lincoln	2.1	9.3	41.9
L. Cargelligo DD	Wheat	Lincoln	2.0	8.5	40.4
L. Cargelligo DD	Wheat	Lincoln	2.0	9.5	37.8
LSD			0.3 (P<0.005)	0.9 (P<0.005)	5.9 P<0
CV %			5.7	3.5	5.3

Table 4: The impact of one year break crop effects on 2012 wheat yield and grain quality in commercial paddocks at Condobolin, Trundle and Lake Cargelligo. The statistics parameters apply across the sites and therefore the whole table.

to back wheat or following barley; the fallow and Lupin treatments yielded 0. 7 t/ha more than back to back wheat and 0.8 t/ha more than barley to wheat (Table 4). Wheat growing on chickpeas, field peas and canola yielded similarly but signicantly higher (0.4 t/ha) than the wheat growing on cereals (Table 4). There were also important differences between wheat protein levels. Wheat growing on pulse break crops had higher protein levels compared with wheat on wheat (8.5 vs 12.9 %).

CONCLUSION

All in all crop sequences with a break crop were more sustainable in terms of Livestock feed, root diseases and N inputs than continuous wheat, and provided cheaper, more effective strategies for controlling weeds and managing soil water. Wheat following break crops had lower costs of production and was consistently more profitable than wheat on wheat especially at the commercial paddocks. The bigger yield benefits for commercial paddock crops could be attributed to better performance of 2011 break crops and moisture conservation compared to small plots. Also the small 2011 break crop effects at Condobolin trial site could be attributed to nutritional constraints.

Therefore, break crop option and choice should be based on individual farm management and ability to manage the various break crops options in the rotation. If growers remain flexible in break crop and end-use decisions, and make suitable choices, risks associated with producing them can be greatly reduced.

Work within this project will now attempt to identify how break options will perform across a range of likely seasons in the central west region to further assess their risks and productivity.

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