PROFITABLE DOUBLE-CROPPING ROTATIONS INVOLVING CEREALS AND PULSES IN CENTRAL QUEENSLAND

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Abstract

Yields, grain proteins and gross margins of wheat or sorghum (with several N rates) followed by chickpea or mungbean (with and without P fertiliser) were determined at a trial near Biloela in Central Queensland. Nitrogen fertiliser increased grain protein and gross margin of wheat, only when irrigated. Application of P fertiliser increased dry matter production at flowering of the pulses but not the grain yield. The cereal-only rotation (0N) was the most profitable but not the most sustainable; N deficiency reduced yield and protein after three crops. The rotation with the cereal immediately followed by a pulse crop was profitable without the need for fertiliser N. When the pulses were grown on fallowed ground (with cereals being double-cropped) economic returns were as good as, and potentially greater than, the cereal/double-crop pulses rotation. Well-grown chickpea and mungbean crops contributed 51 and 41 kg N/ha, respectively, to the subsequent cereal.

Key words: Rotations, pulses, cereals, nitrogen fertiliser

Rainfall distribution in Central Queensland can be irregular and widely divergent from mean values. Hence crop rotations in Central Queensland are often in the category of ‘opportunity cropping’ *i.e* sowing when sufficient soil water has accumulated. Pulses have a reputation for poor returns in this environment compared to cereals. This trial aimed to compare the yields and gross margins from several rotations, especially looking for ways to make pulse production more reliable. Hence, one rotation involved sowing pulses on fallowed ground followed by double-cropped cereals which is opposite to the usual practice. The variable environment also makes high or regular N fertiliser application to cereals an unpopular strategy. The contribution of pulses to the N economy was determined together with identification of optimum N rates for the cereals.

Figure 1: Representation of treatments; sown on Callide alluvial soil, Jambin, Central Queensland

1. Cereals only, nil N, double crop changeover?

Year 1 (1995)		Year 2 (1996)		Year 3 (1997)	
Wheat	Fallow	Wheat	Sorghum	Fallow	Sorghum
0N		0N	0N		0N

2. Cereals on fallow, double-cropped pulses, various N rates

Wheat	Mungbean	Fallow	Sorghum	Chickpea	Fallow

0, 50, 100, 150N	0P, 10P		0, 50, 100, 150N	0P, 10P	

3. Pulses on fallow, double-cropped cereals various N rates?

Fallow	Mungbean	Wheat	Fallow	Chickpea	Sorghum
	0P, 10P	0, 50, 100, 150N		0P, 10P	0, 50, 100, 150N

Note: other phases not shown

Results and discussion

Effect of N fertiliser and pulse crop residues on production and gross margins

The rainfall variability and the resultant sowing regime is illustrated in Table 1 and Fig 2.

The 1995 winter crop was sown with 104 mm water (to 1.2 m) after the addition of 50 mm irrigation preplanting. This represented 53% of the possible starting soil water (Table 1). Without subsequent irrigations, the 1995 winter crops would have died, as happened to neighbouring commercial crops. The decision whether or not to sow with this starting soil water would not be clear-cut for a farmer and would

Figure 2: Rainfall and planting regime.

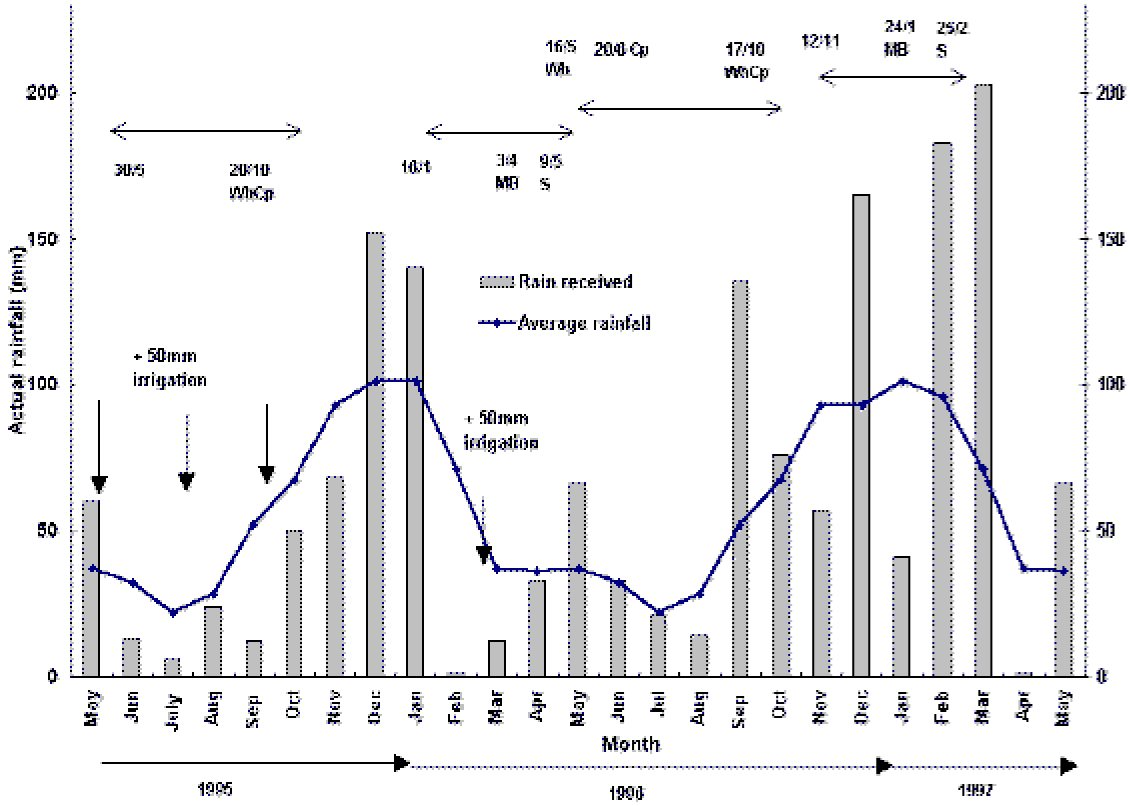

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Table 1: Starting soil water

Rotation sequence	Sample (mm)	% of total
?	?	?
Pre winter 95 | # |	104	53
Pre late summer 95/96 |Wh0 # |	170	86
Pre late summer 95/96 |Fall # |	160	81
Pre winter 96 | CP S0 | #?	91	46
Pre winter 96 | Fall S50 | #?	48	24

<table>
<tr><td>Pre winter 96 | Fall S100| #?</td><td>32</td><td>16</td></tr>
<tr><td>Pre winter 96 | Fall S150 | #?</td><td>42</td><td>21</td></tr>
<tr><td>Pre winter 96 | Wh0 Fall | #?</td><td>135</td><td>68</td></tr>
<tr><td>Pre winter 96 | CP Fall | #?</td><td>118</td><td>60</td></tr>
<tr><td>Pre summer 96/97 |Wh0 MB | Fall # |</td><td>198</td><td>100</td></tr>
<tr><td>Pre summer 96/97 |Wh0 S0 | Fall # |</td><td>193</td><td>97</td></tr>
<tr><td>Pre summer 96/97 |CP Fall |Wh0 # |</td><td>125</td><td>63</td></tr>
<tr><td>Pre summer 96/97 |CP Fall |Wh100 #|</td><td>112</td><td>57</td></tr>
<tr><td>Pre summer 96/97 |CP Fall |Wh150 # |</td><td>145</td><td>73</td></tr>
</table>

Key: Wh=wheat, CP=chickpea, S=sorghum, Fall=fallow, MB=mungbean (# =sampling)

depend on his attitude to risk. Prior to the 1995 winter crop, the soil NO_3 content was moderately high (99 kg/ha NO_3) measured to 1.2 m. Wheat grain yield was 3.2 t/ha and grain protein was 9.8% with nil N. With 50 kg N/ha grain yield was 3.6 t/ha (n.s.) with a protein concentration of 11.9% (Fig 3). This protein level suggests that N supply was adequate and further increases would have resulted in greater grain protein percentage rather than increased yield (2). The gross margin was increased even further with 100 kg N/ha with sufficient protein content to be categorised as Prime Hard grain.

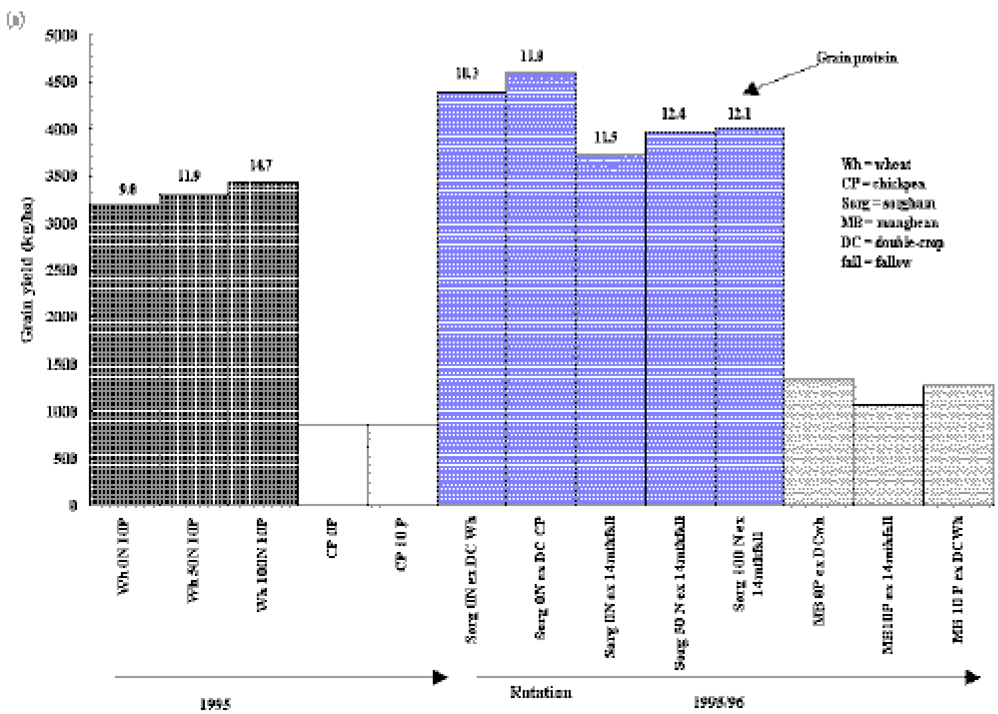
At sowing of the 1995/96 summer crop, the double-cropped plots were as wet (86% full) as the fallowed ground (81% full). Measurement of the starting soil water and water-holding capacity of the soil is vital in making the decision to double-crop. Double-cropping increased the financial return, and depleted the soil water which would reduce runoff during high intensity storms. This crop received one irrigation of 50 mm. The sorghum crop had sufficient N available (as indicated by the 10.3% grain protein level) even with the nil fertiliser treatment. Grain yield was 4.4 t/ha when double-cropped after wheat and 4.1 t/ha on the fallowed plots (11.5% protein). There was no significant yield or protein response to higher N rates. Sorghum double-cropped on chickpea plots produced the greatest yield (4.6 t/ha) and grain protein equivalent to the 100N treatment. It is possible that applied N fertiliser was stranded in the dry surface soil and the previous chickpea crop resulted in N co-located with water, deeper in the soil.

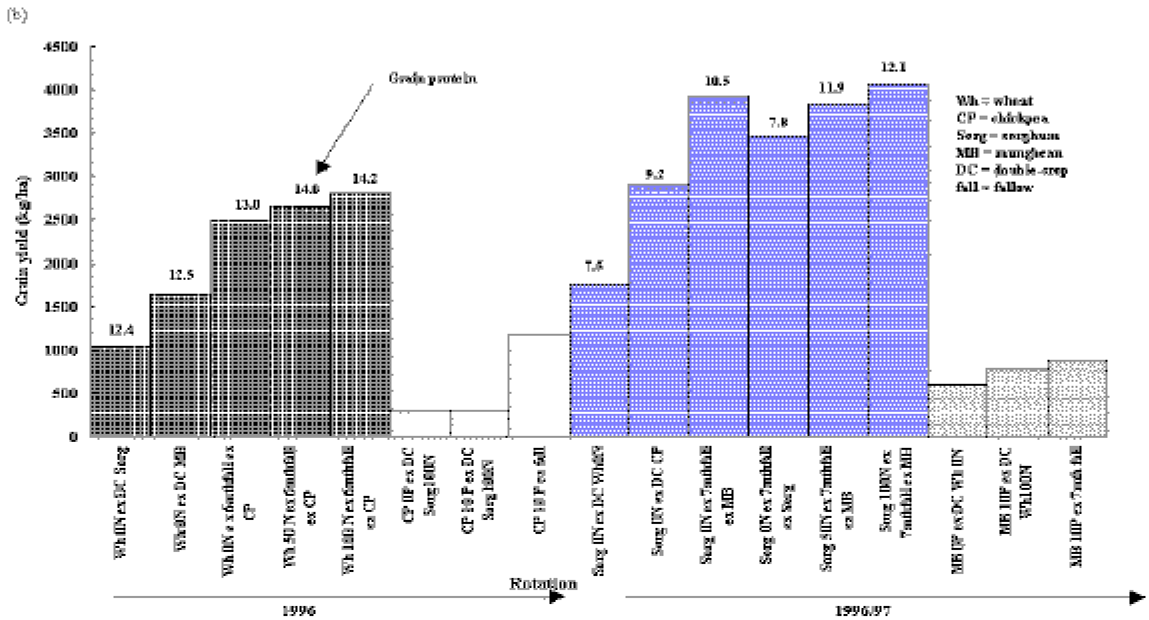
The soil profile prior to the 1996 winter crop immediately following sorghum was on average 20% full while the fallowed ground was 64% full (mean of wheat and chickpea plots). The former would normally represent a high risk of crop failure. However, wheat plots yielded 1.05 t/ha (12.4% protein) with a gross margin of $94/ha without applied N. Only 0.3 t/ha of chickpeas was produced (gross margin -$50 to -$90), a result of a late re-plant and damage from heliothis; this shows the high level of management required for pulses. A farmer would have been well-advised not to sow with this limited amount of stored soil water. When fallowed, from chickpea, the wheat produced 2.5 t/ha (13% protein) with nil N up to a maximum of 2.8 t/ha (14.2% protein) with 100 kg N/ha (both n.s.).

Above average rain in September recharged the soil profile to on average 64% full prior to summer crop 1996/97. The fallowed ground was fully wet. The sorghum produced up to 4 t/ha on the fallowed ground (with N fertiliser) but also a moderately high 2.9 t/ha following double-cropped chickpea, a similar result to the 1995/96 season. Note this chickpea crop was NOT the crop which yielded 0.3 t/ha but one which grew on a previous fallow, had 2 t/ha DM at flowering and yielded 1.2 t/ha. Sorghum double-cropped on wheat ground yielded only 1.8 t/ha ($P<0.01$) but was also probably limited by N deficiency as the grain protein was only 7.5%. The highest yield was 4.1 t/ha for sorghum fallowed from mungbean and with 100 kg N/ha applied. Positive ($P<0.01$) effects of N status on grain protein were evident in the 1996/97 crop between the cereal-only rotation (nil N applied) and treatments fallowed from mungbeans (both with and without N fertiliser) (Fig. 3b). The grain proteins from the cereal-only rotations, with nil fertiliser N application, indicated a severe N deficiency. The grain protein was 7.8% from plots fallowed from sorghum and 7.5% when double-cropped from wheat. The N fertilised treatments fallowed from mungbean resulted in grain protein up to 12.1% (with 100 kg N/ha) and 10.5 % with no N fertiliser applied.

The quantity of N supplied from mungbean residues was 41 kg/ha (data not shown) a result of a flowering DM yield of 5.4 t/ha and grain yield of 1.3 t/ha. The contribution from chickpea, was 51 kg/ha; the DM at flowering was 4.7 t/ha and the grain yield only 0.9 t/ha. This is more than the N contribution found in similar experiments in the Central Highlands region of Central Queensland (1)

Figure 3: Grain yield and proteins a) 1995/96, b) 1996/97





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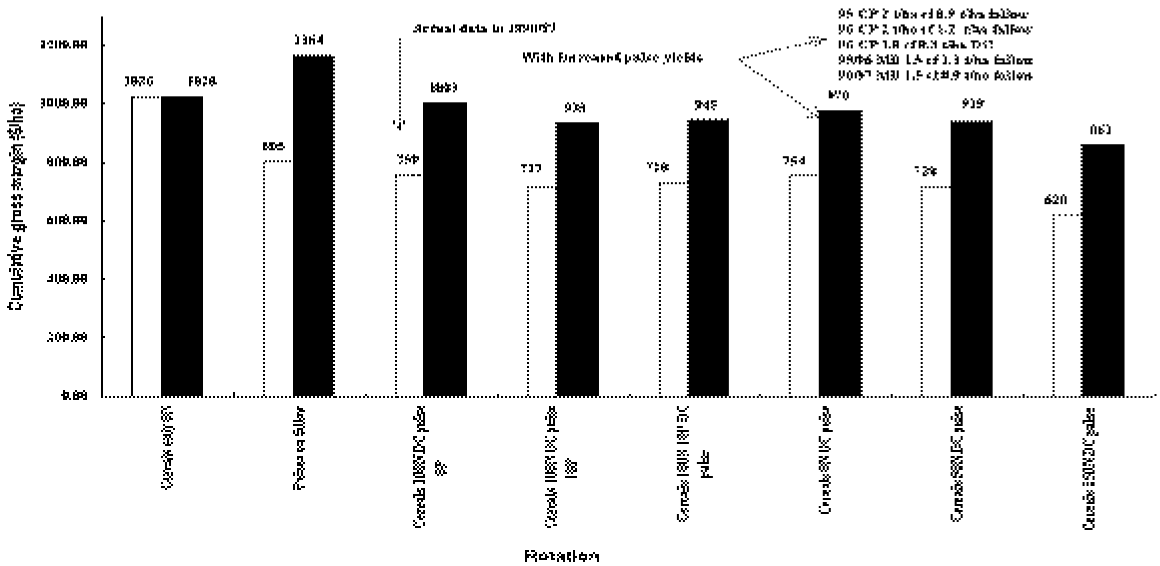
Gross margin benefits

The cumulative gross margins (GM) to the summer crop 1996/97 indicate the cereal-only rotation, with nil N, was the most profitable (Fig. 4). However, as previously shown, N limitation was only emerging in the latter years, evidenced by declining grain protein and the pulse grain yields were lower than expected because of the effects of two enforced late replantings and weed and insect competition. This analysis also ignores the longer-term effects of soil fertility decline. A scenario with increased pulse grain yields, is also presented in Fig. 4. The resultant GM indicated that the potential returns from a legume following fallow rotation may be quite high; $1164. Deleting the winter 1996 cereal (a likely scenario because of low starting soil water) would have decreased the actual GM by $4 but increased the potential GM to $1248. Pulses grown on fallowed ground can give excellent returns given good in-crop management. In the cereal-only rotation , deleting the 1996 winter crop would have resulted in an increase in GM from $1025 to $1070

The gross margins of the cereal double-cropped pulse rotations with 0, 50 or 100 kg N/ha were similar. Hence there is little to be feared from a strategy of continuous moderate N application to cereals in such a rotation. High yields and/or proteins would occur in better seasons (3) and soil fertility decline would be slowed. Carry-over of un-utilised N to the subsequent crop was high (Table 1).

Figure 4: Gross margins actual data and with increased pulse grain yields



Conclusions

Opportunity double cropping is essential in Central Queensland especially when the soil profile is almost full prior to the intensive rainfall period. Double-cropping especially with pulses after cereals should be encouraged, except when stored soil water contents are low. Another alternative is to grow pulses on fallowed paddocks and double-crop the cereals when appropriate. This would result in higher pulse yields, moderate N fixation if inherent soil N levels were low and possibly reduced denitrification if the contributed N can be quickly incorporated into the cereal biomass. Disadvantages include low stubble levels of pulses possibly increasing soil erosion risk and also a chance of greater price volatility.

Soil sampling, nutrient budgeting techniques and scenario analysis using crop models will increasingly assist decision making such as described in this paper.

References

1. Armstrong, R., Probert, M., McCosker, K., Millar, G., Spackman, G., Standley, J., Johnson, S., and Walsh, K. 1996. *ASSSI and NZSSS Nat. Soils Conf*. p. 7.

2. Strong, W.M. 1981. *Aust. J. Exp. Agr. Anim. Husb*. **21**, 424-431

3. Strong, W.M., Cahill. M.J., Dalal, R.C., Weston, E.J., and Cooper, J.E. 1996. *Proc. 8th Aust. Agron. Conf.* Toowoomba, p. 526