

## **Crop productivity in a chickpea-wheat rotation**

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*Summary.* The influence of one season of chickpea, wheat or long fallow on grain yield of two subsequent wheat crops has been investigated in six experiments in northern NSW. Increases in grain yield of wheat following chickpea ranged from 0.41 to 2.11 t/ha compared to wheat following wheat. In one experiment, the benefit of chickpea was equivalent to application of 60 kgN/ha as fertiliser. Rotation effects on a second wheat crop were small.

### **Introduction**

The winter cropping area in northern NSW expanded rapidly in the late 1960's from about 200,000 ha to over 700,000 ha. However, by the mid-1980's, soil nitrogen fertility had become limiting, and wheat grain yield and quality declined (2). Improvements in soil N fertility have been sought from fertiliser, legumes in rotation or long fallowing. Chickpea subsequently became the most important winter-grown grain legume in the region; plantings increased from nothing in the early 1980's to about 40,000 ha in 1991. Benefits from this legume in sequences with cereals have accrued from high prices, nitrogen fixation and disease reduction.

Agronomists and farmers have sought quantification of the benefits of chickpea, particularly its contribution to the soil-plant nitrogen economy. Increases in grain yield of wheat grown after chick pea compared with wheat after wheat have been in the range 40-50% (3,4), equivalent to the application of 50 kgN/ha or more as fertiliser in a wheat-wheat sequence. Yield increases in sorghum double-cropped after chickpea were equivalent to those achieved with the addition of 100 kg/ha of fertiliser nitrogen to sorghum following barley (1).

More data are needed from a wide range of situations likely to be encountered in the field to enable:

- Quantification of these responses over a range of environments, soil fertility, crop rotations and tillage practices.
- Measurement, prediction and management of chickpea nitrogen fixation.
- Use of simulation models.

In this paper, we compare grain yields from sequences of continuous wheat, chickpea-wheat, and long fallow-wheat in the northern cereal growing region of NSW.

### **Methods**

Data selected from fallow management treatments in 'tillage x rotation' experiments in northern NSW from 1986 to 1992 have been used to measure the benefits to wheat grain yields of chickpeas or long fallow in sequence with wheat.

Experiments at Croppa Creek, Gurley and Warialda have been maintained since 1981 to monitor the long term effects of tillage and residue management on wheat production. They comprised three main treatments (no-till, stubble burned after harvest and cultivation, and stubble mulching), split for eight sub-treatments devoted to variations in agronomy or crop. Results from stubble mulched main treatments, and the sub-treatments continuous wheat, chickpea-wheat-wheat and long fallow-wheatwheat for the period 1987 to 1989 are presented.

Another two experiments were commenced at North Star in 1989 (North Star A) and 1990 (North Star B) to rotation and tillage effects on crop production. There were two tillage main treatments (no-tillage and stubble mulching), split for chickpea, wheat and fallow, and again for three levels of N fertiliser in the first

year. All plots were sown to wheat in the following two years. Data from unfertilised treatments have been used in this paper.

In a sixth experiment at Croppa Creek (B), main plots of chickpea and wheat were sown in 1986. These were oversown with wheat in 1987, and split for application of N fertiliser in six increments from 0 to 116 kgN/ha. Plots were sown without additional N to wheat in 1988.

## Results and discussion

Grain yields of two wheat crops following prior treatments of chickpea, wheat or long fallow are shown in Table I. In all cases, the major effect of chickpea occurred in the following crop and, with the exception of the Croppa Creek B experiment (1986-88), residual effects on yield of the second wheat crop were small and mostly not significant. The long fallow effect was similar to that of chickpea. Increases in wheat grain yield in the year following chickpea varied from 0.41 to 2.11 t/ha, and were strongly associated with higher soil nitrate at planting following the legume (Table 1). Other factors such as available water and disease appeared to be involved in the differences in grain yield in second and third seasons. With the exception of the North Star B experiment, total crop yield for the three year period was highest or equal highest in the chickpea-wheat sequence. When initial soil nitrate-N levels were low, cumulative wheat production tended to be higher in the chickpea-wheat sequence (two wheat crops) than in the continuous wheat (three crops).

Insight into the possible role of N in the chickpea effect was provided from N-fertilised sub-treatments in the second year of the Croppa Creek B experiment (Fig. 1). Grain nitrogen yield (GNY) was highest in wheat after chickpea at all levels of applied N, and there was no N fertiliser by prior crop interaction. The net effect due to N can be gauged by determining the point on the wheat-wheat relationship where GNY equals that on the chickpea-wheat curve (A-B), and reading down to the fertiliser domain (C) to determine the fertiliser equivalent. In this case, it was approximately 60 kgN/ha for a 22 kg increase in GNY, or efficiency of almost 40%. There was still a 14 kgN/ha difference in GNY between prior crop treatments at the highest N rate, implicating some other factor in limiting yield at the highest N rate. One candidate is crown rot (*Fusarium graminearum*): We have observed a reduction in crown rot in wheat after chickpea to 10% and 40% of levels in wheat after wheat in consecutive seasons (Marcellos, Felton and Backhouse, unpublished data).

The chickpea effect on grain yield of the following wheat crop can therefore vary widely, depending on N<sub>2</sub>-fixation by the legume, N removed in yield and resulting N-balance. In only one experiment, Croppa Creek B, was there an increase in yield of the second wheat crop due to chickpea. The positive effect of chickpeas on N balance was therefore sufficient to benefit in most cases only the following wheat crop.

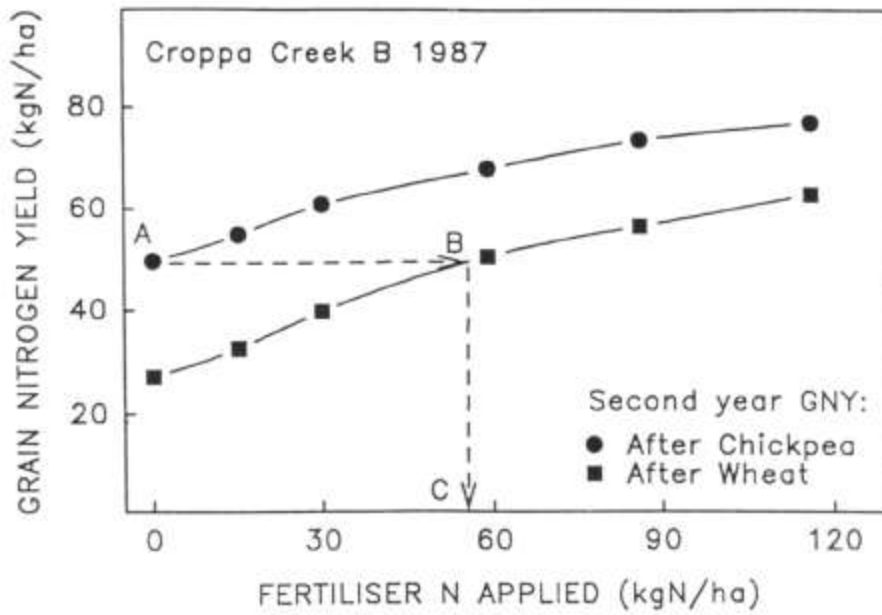


Figure I. The influence of applied N fertiliser on grain nitrogen yield in wheat following prior crops of chickpea or wheat.

Table I. Grain yields of chickpea and wheat in Year I, and wheat in Years 2 and 3 following chickpea, wheat or long fallow, the total wheat produced over the three-year period, and soil nitrate levels in plots having received no additional N as fertiliser.

Site and crop sequence	Soil nitrate-N at planting (kgN/ha/1.2m)				Grain yield (t/ha)				
	Year 1	Year 2	Year 3	Total Avail.	Year 1	Year 2	Year 3	Total Wheat	
<i>North Star A, 1989-91</i>									
Chickpea-wheat-wheat	43	115	53	211	<b>2.90<sup>a</sup></b>	3.92	2.39	6.31	
Wheat-wheat-wheat	43	57	52	152	1.71	1.81	2.46	5.98	
L/fallow-wheat-wheat	43	152	60	255	nil	4.08	2.24	6.32	
	<i>Standard error of wheat yields:</i>					<i>0.16</i>	<i>0.09</i>		
<i>North Star B, 1990-92</i>									
Chickpea-wheat-wheat	80	97	90	267	<b>1.81</b>	2.28	2.83	5.11	
Wheat-wheat-wheat	80	47	71	198	2.95	1.78	2.57	7.30	
L/fallow-wheat-wheat	80	132	111	323	nil	2.51	3.04	5.54	
	<i>Standard error of wheat yields:</i>					<i>0.14</i>	<i>0.13</i>		
<i>Croppa Creek A, 1987-89</i>									
Chickpea-wheat-wheat	37	84	n/a	n/a	<b>1.48</b>	3.24	2.12	5.36	
Wheat-wheat-wheat	37	35	n/a	n/a	2.09	2.52	2.08	6.69	
L/fallow-wheat-wheat	37	135	n/a	n/a	nil	4.16	2.25	6.41	
	<i>Standard error of wheat yields:</i>					<i>0.12</i>	<i>0.13</i>		
<i>Gurley, 1987-89</i>									
Chickpea-wheat-wheat	29	65	22	116	<b>1.29</b>	2.24	2.03	4.27	
Wheat-wheat-wheat	29	31	17	77	2.12	1.43	2.05	5.60	
L/fallow-wheat-wheat	29	107	20	156	nil	1.78	2.11	3.89	
	<i>Standard error of wheat yields:</i>					<i>0.08</i>	<i>0.07</i>		
<i>Warialda, 1987-89</i>									
Chickpea-wheat-wheat	45	84	66	195	<b>2.61</b>	4.31	3.39	7.70	
Wheat-wheat-wheat	45	64	62	171	2.77	3.63	3.15	9.55	
L/fallow-wheat-wheat	45	143	65	201	nil	4.34	3.40	7.74	
	<i>Standard error of wheat yields:</i>					<i>0.13</i>	<i>0.15</i>		
<i>Croppa Creek B, 1986-88</i>									
Chickpea-wheat-wheat	n/a	n/a	n/a	n/a	<b>1.06</b>	3.15	3.71	6.86	
Wheat-wheat-wheat	n/a	n/a	n/a	n/a	1.68	1.97	2.32	5.97	
	<i>Standard error of wheat yields:</i>					<i>0.06</i>	<i>0.07</i>		

<sup>a</sup> Grain yield of chickpea in the first year.

## References

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