Crop rotations increase productivity in no-tillage systems in northern New South Wales

W.L. Felton, H. Marcellos, and D.F. Herridge

NSW Agriculture, Tamworth, NSW 2340

Abstract

A failure to significantly increase yields under no-tillage in continuous cereal systems poses a major disincentive to the adoption of conservation farming. This is despite a potential to store more soil water under no-tillage. We have assessed a propo sal that crop productivity can be increased under no-tillage, compared with removal of stubble and tillage during the fallow, by diversifying the crops grown in the system, and increasing the availability of soil N by using fertiliser and pulse crops. Differences in cumulative grain yield and grain N yield over the period 1993-96 varied 2 and 3-fold across rotations. Cumulative grain yield was 0.6 t/ha less under no-tillage compared to stubble burning under continuous wheat, and 12 kg/ha less N was harvested in grain. The addition of fertiliser failed to eliminate the disadvantage of no-tillage, and increased the disadvantage to 0.8 t grain and 24 kg/ha of grain N. With one reservation, productivity of pulse-cereal sequences, under no-tillage exce eded that under cultivated treatments. In the case of a "faba bean-wheat-barley" system with additional N applied to the cereal, 1.6 t/ha more grain was produced by no-tillage plots than cultivated. It was concluded that the productivity of conser vation farming systems could be significantly increased, giving greater incentive for adoption, by implementing crop rotation and improving the N management of cereal components.

Key words: No-tillage, crop rotation, conservation farming.

The level of adoption of no-tillage fallow management in northern New South Wales is less than that required by the proponents of sustainable farming. A survey in 1989/90 showed that by mid-January, 65% of paddocks observed had inadequate stubble c over (<1000 kg/ha) to protect soil from erosion (2). In another survey, of attitudes and behaviour regarding conservation farming (4), half the respondents considered a lack of suitable and affordable machinery to sow into stubble as a major limitati on to adoption; unsuitable soils were mentioned by 25% of respondents and economic viability by 19%. Other impediments to the adoption of conservation farming included stubble-borne diseases, nitrogen tie-up, integration with sheep, and poor stubble co ver after a low yielding crop.

The influence of three fallow management treatments (no-tillage, stubble retained and cultivated, and stubble burned and cultivated) on productivity was studied in 5 experiments in northern New South Wales from 1981 to 1990 (2). Across all sites and se asons, grain yields were in the order stubble burned > stubble mulched ? no-tillage, with stubble retention having a greater effect than tillage. These outcomes were confirmed in a review of trends in wheat yield responses to conservation farming across 33 medium and long-term agronomic experiments throughout Australia which showed that the effects of tillage (no-tilled *v*. cultivated) were small, while stubble retention (stubble retained *v*. stubble burn ed) reduced yield (5).

More soil water is generally stored in no-till fallows in the northern grains region, when weeds are controlled, but levels of available soil N may be lower (2, 8, 9). As a result, cereal yields may be higher under no-tillage in dry years due to more w ater, and lower in wetter seasons due to N limitation. The foliar disease. yellow leaf spot (*Pyrenophora tritici-repentis*), is more prevalent under no-tillage and may reduce yield (7). It is therefore not surprising that adoption of n o-tillage in continuous cereal systems is not more widespread, given an experience of lower productivity than in tilled systems. A no-tillage, continuous cereal system is therefore not necessarily sustainable, as in other grain growing regions where cer eal monoculture would rarely be contemplated; the challenge becomes one to develop a system that is sustainable.

We have assessed a proposal that productivity under no-tillage may be increasing the level of soil N supply by introducing pulse crops, and N fertiliser.

Methods and materials

An experiment commenced at Croppa Creek in 1981 (2) was used to assess whether crop productivity under no-tillage fallow management was enhanced, in comparison with removal of stubble and tillage during the fallow, by diversifying the crops grown in th e system, and increasing the availability of soil N by using fertiliser and pulse crops. The site at Croppa Creek (29^{o}14'S, 150^{o}11'E) had a 600 mm annual rainfall. Its soil was a grey brigalow clay (U g 5.17; lower drained limit of soil water 19% gravimetric).

Three main treatments comprising no-tillage (NT), stubble retained and fallow cultivated (SM), and stubble burned soon after harvest and fallow cultivated (SB) were each split into 8 sub-plots (A-H) measuring 10 x 40 m, to allow rotation and nutrition s ub-treatments. There were 6 replicates. Tillage involved 2-4 cultivations during the fallow by the cooperating farmer using tined implements. Treatments were sprayed primarily with glyphosate 3-5 times as required during the fallow to eliminate weeds.

Treatments in the period 1981-90 were mainly wheat, but some alternative crops were assessed in 1987 (2). A new phase was implemented in 1993, when a range of cereal-pulse rotations, with and without N fertiliser were introduced (Table 1). The sequence s in sub-plots C, D and G were 2 year cycles, with 50% pulse, whereas sub-treatments E, F and H are 3 year sequences with 33% pulse component.

Table 1. Schedule of sub-treatments, Croppa Creek, 1993-96

Sub-plot	Comment	1993	1994	1995	1996
A	Continuous wheat - N	W[1]	W	W	W
B	Continuous wheat + N	W_N	W_N	W_N	W_N
C	Chickpea-wheat, - N	CP	W	CP	W
D	Chickpea-wheat, +N to wheat	CP	W_N	CP	W_N
E	Barley-chickpea-wheat, - N	B	CP	W	B
F	Barley-chickpea-wheat, + N	B_N	CP	W_N	B_N
G	Faba bean-wheat + N	FB	W	FB	W_N
H	Faba bean- wheat-barley, - N	FB	W	B	FB

[1] Abbreviations: N = nitrogen, W = wheat, B = barley, CP = chickpea, F= faba bean.

Plant variables measured and presented in this paper were grain yield (by plot combine, t/ha) and grain N yield (kg N/ha = yield x grain N% determined by Kjeldahl procedure).

Results and discussion

The data presented in this paper (Table 2) reflect progress in assessing the productivity of 8 crop sequences in relation to 3 fallow management treatments, and will terminate when several cycles of each sequence have been completed. Due to limits on s pace, cumulative yields for the period 1993-96 have been presented to summarise system performance in time.

Differences in grain yield and grain N yield varied 2 and 3-fold respectively across rotations. Care must be exercised in making comparisons between sequences at this early stage since different synchronies of species and seasons are involved. This wil l become more meaningful at the end of the experiment, when several crop cycles have been completed, and the full extent of variation in productivity can be assessed. It will also be necessary to analyse the data in economic terms as different commodit y prices are involved. At this time however, comparisons of fallow management and N effects within systems are most relevant.

Continuous wheat systems.

Consistent with previously reported experience (2), grain yield and grain N yield of wheat were lowest under no-tillage. Over the 3 years of experience, cumulative grain yield was 0.6 t less under no-tillage compared to stubble burning, and 12 kg/ha les s N harvested in grain.? The addition of fertiliser failed to eliminate the disadvantage of no-tillage, and indeed increased it to 0.8 t grain and 24 kg/ha of grain N.

Table 2. Cumulative yields for grain dry matter and grain N yield for the period 1993-96.

Sub-treatments	Total grain yield (t/ha)				Total grain N yield (kg N/ha)			
	NT	SB	SM	NT-SB	NT	SB	SM	NT-SB
Continuous Wheat, No N	5.70	6.58	6.25	-0.55	110	131	122	-12
Continuous Wheat, + N	6.84	7.77	7.66	-0.82	143	167	167	-24
Chickpea-Wheat, No N	7.81	6.70	7.12	0.69	214	184	201	13
Chickpea-Wheat, + N	7.83	7.42	7.34	0.49	218	206	214	4
Faba Bean-Wheat , + N	8.12	7.27	7.24	0.88	248	229	230	18
Barley-Chickpea-Wheat, No N	8.34	8.78	8.84	-0.50	128	134	130	-2
Barley-Chickpea-Wheat, + N	11.21	9.91	10.49	0.72	179	181	177	2
Faba bean-wheat-barley, +N	9.03	7.55	7.42	1.59	295	257	255	40
Treatment Mean	8.11	7.75	7.80	0.31	192	186	187	5

Pulse-cereal sequences.

With one reservation, productivity under no-tillage exceeded that under cultivated treatments. The exception was the "barley-chickpea-wheat" system, without fertiliser N, where no-tillage produced 0.5 t/ha less grain over the 4 seasons. In the case of the "faba bean-wheat-barley" system with additional N applied to the cereal, 1.6 t/ha more grain was produced by no-tillage plots than those that were burned.

No-tillage versus stubble burning

Cumulative grain yields and grain N yields under no-tillage, were less than the stubble burned treatments for the sequences of continuous wheat, and 2:1 cereal -chickpea (A and B, E; Table 1). However, when N fertiliser was introduced to the 2:1 cereal -chickpea sequence (F), and cereal-faba bean sequences (G, H), no-tillage outyielded the cultivated treatments by as much as 0.7 and 1.6 tonnes, respectively.

Although the experiment has not run its full course, the evidence supports the proposal that no-tillage systems may be more productive than their conventionally cultivated counterparts when diverse crops are introduced and soil N fertility is increased. Yields of pulses like chickpea and faba bean may be 10-20% higher under no-tillage compared with cultivated practice (6) and are well suited to being planted in wide rows (50 cm spacing) in no-tillage systems (3).

A full analysis and interpretation of the improvements in the productivity, and economics of no-tillage systems compared with cultivated will be possible when this and an additional duplicate experiment at Warialda are completed in 2001.

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