SUSTAINABILITY AND PROFITABILITY: A CASE STUDY FROM THE WARRA EXPERIMENT

R.C. Dalal[1], W.M. Strong[1], E.J. Weston[2], M.J. Cahill[2], J. Gaffney[2],
J.E. Cooper[1], K.J. Lehane[2], and A.J. King[1]

[1]Queensland Wheat Research Institute, PO Box 102, Toowoomba Qld 4350
[2]Department of Primary Industries, PO Box 102, Toowoomba Qld 4350

Summary. Management options involving legume-based leys, pulses and N fertiliser application for wheat cropping on brigalow land (Vertisol) were examined for their effectiveness in increasing soil organic matter, wheat grain yield and quality, and farm profitability. Only grass+legume leys significantly increased soil organic matter. Wheat grain yields and protein levels increased by up to 50% following grass+legume leys, lucerne, medics and nitrogen fertiliser, and yields by up to 60% following chickpea as a pulse crop. Compared to continuous wheat cropping, average annual farm profitability in contrasting seasons in 1990, 1992 and 1994 increased by $23,500 from the medic/wheat rotation, $27,500 from the annual application of 50 kg N/ha/yr, $40,200 from the lucerne/wheat rotation, $42,700 from the chickpea/wheat rotation, and $41,300 from the grass and legume ley/wheat rotation on a mixed farm (1200 ha native pasture and 800 ha cultivation). Thus, both sustainability and profitability can be achieved with soil restorative practices.

INTRODUCTION

The once-fertile soils of the Darling Downs and brigalow lands of subtropical eastern Australia have become less productive under continuous cropping. Protein levels in wheat, originally 16-17%, have dropped to 10% after 25 years of cropping and 8% after 50 years (2). Yield potential has decreased by as much as 50%. Organic matter in the soil has declined by as much as 70%, adversely affecting its nutrient reserves, biology and structure, while increasing the risk of erosion and further land degradation, and hence making the land use unsustainable.

Sustaining productivity requires soil and crop management practices that maintain or increase soil organic matter and have no adverse impact on the environment. Farm profitability can be based on grain and pastoral systems, which are directly linked to soil productivity, and hence sustainability. Reducing costs of production or applying strategic inputs such as fertilisers can also maintain farm profitability. The results from the long-term Warra Experiment provides a basis to examine sustainability and profitability issues in the north-eastern Australian grainbelt.

METHODS

The detailed description of the Warra Experiment is given by Dalal *et al.* (1). Briefly, a long-term field experiment was established in 1986 on a fertility-depleted brigalow grey clay (Typic Chromustert) at Warra (26? 47’S, 150? 53’E), Queensland. The soil at the site contains 52% clay, 0.7% organic C and pH 8.5 (0-10 cm) and has been cultivated for cereal cropping since 1935. The brigalow lands provide currently in excess of one million hectares of cultivated soils in eastern Australia.

The following treatments were examined:

1. Grass+legume ley/wheat rotation: A mixed grass+legume pasture consisting of purple pigeon grass (*Setaria incrassata* Stapf cv. Inverell), Rhodes grass (*Chloris gayana* Kunth. cv. Katambora) lucerne (*Medicago sativa* L. cv. Trifecta) and annual medics (*M. scutellata* L. Mill. cvs. Sava and Kelson, *M. truncatula* Gaertn. cv. Jemalong, Cyprus, Paraggio and Sephi) grown for 3.75 years followed by wheat (4 crops).

2. *Legume ley/wheat rotation*: A 2-year rotation of wheat (*Triticum aestivum* L. cv. Hartog) and lucerne (lucerne/wheat rotation) and wheat and annual medics (medic/wheat rotation) provided short term legume ley and cereal rotations.

3. *Pulse/wheat rotation*: A 2-year rotation of chickpea (*Cicer arietinum* L.) and wheat was established as chickpea/wheat rotation; chickpea was planted at 60 kg/ha using phytophthora (*Phytophthora megasporium*) tolerant lines or cv. Barwon.

4. *Continuous wheat cropping with fertiliser N application*: After two to four conventional till (CT) operations during the fallow period, wheat was planted at the rate of 40-50 kg/ha and in the same operation fertiliser urea was applied at the rate of 0 and 50 kg N/ha/year. Zero tilled (ZT) wheat was similarly planted and fertilised on untilled plots except for the sowing operations. Weeds were controlled by herbicide spray (1.2 L/ha glyphosate and 1.2 L/ha 2,4D amine) two to four times during the fallow period.

The treatments was arranged in a randomised block design with four replications. Plot dimensions were 25 m long and 6.75 m wide.

The grass+legume ley was established in January 1986. Lucerne was planted with wheat during the May-July period at the rate of 2 kg/ha. After harvesting wheat, lucerne was grown for one year. Annual medics (5 kg/ha) were also planted under wheat but only in the first crop because of their self-generating nature. The grass+legume ley and lucerne were harvested four times annually but annual medics only once a year at the end of their growing period in spring. At each harvest, surplus dry matter was either removed or grazed with essentially similar effects on soil organic matter. The grass+legume and legume leys were terminated by blade ploughing in October, about six months before wheat planting to allow water recharge of the soil profile during the summer-autumn period.

Wheat and chickpea grain yields were measured by harvesting 1.75 m x 23 m of the central areas of all plots, and reported at 12% water content.

Farm profits were calculated from different management options on the whole farm level of a 2000 ha property on the Western Downs, Queensland, with 800 ha of cultivation and the remaining land under native pasture. Associated with the cropping was a 165 cow beef herd turning off 2 year old steers. It was assumed that the 1992 year wheat prices prevailed during the experimental period.

RESULTS AND DISCUSSION

Soil organic matter

The grass+legume pastures consistently increased soil organic matter content in the soil (Table 1). However, in the cropping phase, organic matter declined. Organic C declined much faster than total N, so much so that after 4 years of cropping, organic C levels were similar to that of CT continuous wheat although soil total N still remained significantly higher (Table 1). This was mainly due to C additions through root biomass during the ley phase since root biomass during cropping was less than half of that of pasture ley (1).

Table 1. Soil organic C and total N in grass+legume ley/wheat treatment. Soil organic matter contents in other treatments generally remained similar to that of CT continuous wheat treatment (data not shown for all years).

Period (years)	Pasture phase (year)	Cropping phase (year)	Organic C (%)	Total N (%)
1	1		0.76 (0.72)[a]	0.074 (0.070)[a]
2	2		0.79	0.080

3	3		0.81	0.083
4	4		0.82	0.086
5		1	0.81	0.086
6		2	0.79	0.085
7		3	0.76	0.085
8		4	0.72 (0.69)[a]	0.082 (0.069)

[a] Conventional tilled continuous wheat treatment.

Wheat grain yields and protein contents

Grain protein contents increased in all treatments and wheat grain yields increased in most years compared to CT continuous wheat. Contrasting seasons are 1990 (good cropping season), 1992 (cropping after long fallow) and 1994 (cropping in a dry season) (Table 2). In 1990 and 1994 grain yields increased by up to 60%.

Table 2. Wheat grain yields and protein contents in 1990, 1992 and 1994.

Treatment	Grain yield (t/ha)			Grain protein (%)		
	1990	1992	1994	1990	1992	1994
Grass+legume ley/wheat	3.4	3.7	1.5	13.0	13.2	12.3
Lucerne/wheat	3.4	3.4	1.7	11.7	11.6	11.3
Medic/wheat	3.6	3.8	1.3	12.1	12.7	12.0
Chickpea/wheat	3.6	4.2	1.6	9.4	12.4	10.0
CT wheat + 75 kg N/ha/y	3.4	3.7	1.5	11.8	13.5	13.2
CT wheat (control)	2.2	3.5	1.0	8.3	10.8	8.6
l.s.d.	0.3	0.5	0.2	0.8	1.0	1.0

Grain protein increases to *prime hard* (PH) grade were attained only after grass+legume leys (1990 and 1992) and fertiliser N applied at 75 kg N/ha/y in dry seasons (1992 and 1994). Wheat following medics were consistently over 12% protein. Unless the grain yields were constrained by water, all other treatments would have required additional N supply to attain PH wheat.

Farm profits

The increase in profits in 1990, 1992 and 1994 differ considerably; the highest profits were obtained from the grass+legume ley/wheat treatment in 1990, from the chickpea/wheat rotation in 1992 and from lucerne/wheat rotation in 1994 (Table 3). Striking farm profits were obtained from the restorative practices even in a very dry season in 1994.

Average annual profits in 1990, 1992 and 1994 seasons were similar from grass+legume ley/wheat, chickpea/wheat and lucerne/wheat rotations ($40,000 - 42,000). Lowest profits were obtained from medic/wheat rotation ($23,000). Additional annual profit from fertiliser N applied at 50 kg/N/ha/year was $27,450/year (Table 3). Inclusion of 1991 (drought) and 1993 seasons did not substantially alter the relative economic performance from various restorative practices. However, increased farm profitability was attained from all the soil fertility restorative practices used in the Warra Experiment. For grain cropping enterprises only, it was still profitable to include pulses or apply fertiliser N to cereal cropps compared to continuous cereal cropping although organic matter levels are unlikely to be sustained (1).

As with all budgeting analyses the outcomes apply only for the defined circumstances, including soil fertility status, farm size, kind of enterprise, seasons and commodity prices. However, the results from the Warra Experiment have provided reliable information on system performance across wide range of options.

Table 3. Annual operating profits from restorative practices.

Treatment	Operating profits ($)			Average additional profit
	1990	1992	1994	($/year)
CT-wheat (control)	59078	146084	-3966	-
Grass+legume ley/wheat	138181	154560	32293	41279
Lucerne/wheat	133923	133280	54712	40239
Medic/wheat	109440	140045	22152	23481
Chickpea/wheat	104893	178644	45742	42694
CT wheat+50 kg N/ha/y	94948	175451	13150	27451

CONCLUSIONS

Understanding the economic implications of various management options requires research at several levels of aggregation, including the individual component of a crop and/or livestock enterprise, a whole farm, commodity markets, and trends in national and international economies (3). Systems analysis is required to evaluate the efficacy of various restorative practices in terms of trends in productivity, stability in production, trends in natural resource base, and ecological and economic indicators.

This study demonstrates that farm profitability can be improved using any one of the fertility restorative practices although stability of the natural resource base (soil, biota, water), environment and profits (3), hence sustainability is likely to be attained with a combination of restorative practices, especially those include grass+legume leys.

ACKNOWLEDGMENTS

The authors are grateful to Grains Research and Development Corporation for financial support.

REFERENCES

1. Dalal, R.C., Strong, W.M., Weston, E.J., Cooper, J.E., Lehane, K.J., King, A.J. and Chicken, C.J. 1995. Aust. J. Exp. Agric. 35 (7) (in press).

2. Dalal, R.C., Strong, W.M., Weston, E.J. and Gaffney, J. 1991. Trop. Grasslands 25, 173-180.

3. Madden, J.P. and Dobbs, T.L. 1990. In: Sustainable Agricultural Systems (Eds C.A. Edwards *et al*.) pp. 368-386. (Soil and Water Conservation Soc., Ankeny: Iowa).

4. Robertson, F.A., Myers, R.J.K. and Saffigna, P.G. 1993. Aust. J. Agric. Res. 44, 1323-1336.