SUSTAINABILITY OF DRYLAND CROPPING SYSTEMS
IN THE WIMMERA REGION OF VICTORIA

by

YVONNE L. POSTLETHWAITE

FACULTY OF AGRICULTURAL AND NATURAL RESOURCE SCIENCES
DEPARTMENT OF AGRONOMY AND FARMING SYSTEMS
THE UNIVERSITY OF ADELAIDE
ROSEWORTHY CAMPUS
SOUTH AUSTRALIA

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ABSTRACT

Sustainability of dryland cropping systems in the Wimmera region of Victoria is dependent on many factors. All these systems generate income through production of feed for livestock or human consumption for local and export markets. There are many systems used in the Wimmera and each has strengths and weaknesses. Some systems increase soil organic matter with residue retention or pasture, improve soil structure, prevent soil surface sealing, increase water infiltration and retention, reduce run-off and drainage to the water-table, eliminate wind and water erosion, increase yield and water use efficiency. These systems are sustainable. Alternatively, there are systems which, through cultivation and residue burning, degrade soil structure causing compaction and soil surface sealing, reduction in water infiltration and increased water run-off resulting in pollution by soil and nutrients in rivers and streams. These systems are unsustainable. A third group of systems use phase farming techniques which alternate between the former two systems, but because of soil and nutrient loss by wind and water erosion during the cultivation phase, they are unsustainable in the long term.

In this thesis two systems were studied, namely a conventional and a conservation dryland cropping system run sequentially on the same farm over a period of 10 and 14 years respectively. Although there were variations over these periods within each system, overall the conventional cropping system (during period 1963 to 1982) was based on a cultivated fallow which served to manage and conserve water, nitrified organic matter and controlled weeds. Stubble was burnt prior to cultivation for the fallow phase. The pasture phase was rotated with a cropping phase and livestock grazed the pastures for financial benefit during the pasture phase. Cultivation for nitrification of organic matter increased grain yields, but this rapid exploitation of stored nitrogen resulted in a steady decline of soil fertility.

Stubble was nearly always burnt prior to cultivation because of the mechanical difficulties experienced with handling the residue and to kill soil borne pathogens and weed seeds. This regular removal of organic matter plus the rapid mineralisation of stored organic nitrogen by cultivation added to the loss of soil fertility and according to Chan et al. (1992) was likely to be unsustainable in the long term. To overcome the loss of soil organic matter and soil structural degradation, a phase system consisting of several years of cropping followed by several years of pasture was introduced. However the inability of
pastures to provide sufficient feed for livestock during winter, summer and many autumn seasons resulted in supplementary feeding of livestock during those periods. Therefore increased profitability of livestock production was not possible through increased livestock production unless in a lot feeding situation. Although the pasture phase increased the soil organic matter and improved soil structure, grazing livestock compacted the soil and cultivation during the cropping phase destroyed the soil structure again.

The soils used in this research were Wimmera self-moulching cracking grey/brown clays (Ug 5.1 to 5.3) and Callawadda duplex red-brown earth (Dr 2.13). Physical degradation of both these soils was closely linked to tillage practices. Conventional cultivation with stubble burning caused soil degradation through reduced organic matter levels, and soil structural breakdown which lead to hardsetting, waterlogging and compaction of soil. Red duplex soils were particularly affected (Lorimer and Rowan, 1982), however, the Wimmera sodic clays were also susceptible to degradation (Imhoff et al., 1996). To reduce soil degradation fewer cultivations were done. However, similar losses in organic matter and soil structural degradation occurred with one cultivation as with several cultivations.

Overall, deterioration of soil structure and continual soil loss through wind and water erosion during the cropping phase had a negative effect on the environment by causing soil and nutrient pollution of the atmosphere and water ways. Use of a cultivated fallow for water conservation was found to result in inefficient use of rainfall. Low water use efficiency by the crops resulted in unused water draining through to the water table. In dryland farming situations unused water indicates loss of potential productivity and possible environmental damage. By 1982 it was clear that changes were needed to increase production and water use efficiency in order to create a more profitable and sustainable farming system.

The conservation farming system (during the period 1983 to 1996) was based on the absence of soil tillage, stubble retention, rotation of a variety of crops and chemical control of weeds. In contrast to the conventional system, water conservation for plant use was achieved through increased water infiltration by improved soil structure, avoidance of compaction from livestock or machinery traffic, reduced water runoff and reduced soil water evaporation by stubble retention. Stubble residue left on the soil surface reduced soil surface sealing and prevented soil erosion by wind or water, reduced phytotoxic effects and reduced tie up of nitrogen. All these factors together resulted in increased grain yields and
increased soil and water resource quality. Water storage was between 30 and 50 mm higher in the conservation farming system than in the conventional farming system.

Crop rotation and selection are major factors in any cropping system, for control of diseases and weeds. Crop rotations were more intense in the conservation cropping system because of the greater reserves of available soil water with that system. Rotation of cereals and broadleaf crops gave diversity in plant types, sowing dates and harvest periods. Crop rotations plus stubble retention effectively reduced cereal root diseases such as rhizoctonia, take-all and cereal cyst nematode. Diseases such as strip rust in wheat and blackleg in canola, were reduced with selection of a resistant variety, together with rotation with crops that were not susceptible to the diseases.

Weed control is a major factor in crop production, as weeds compete with crops for water and nutrients and can be hosts to diseases. Conventional farming used cultivation, rotation and chemicals for control of weeds. In contrast, conservation farming used rotations and chemicals for control of weeds. In addition, cropping intensity was increased in the continuous cropping system to increase competition with weeds; weed seeds were left on the soil surface instead of burying them; and weed seeds were left where they grew and not spread in machinery, stock and hay.

Herbicide resistance in weeds is becoming an increasing problem throughout Australia with both conventional and conservation farming systems. Chemical fallow eliminates the degrading effect of cultivation and permits the control of winter weeds and potentially herbicide resistant weeds during the winter fallow period, however there is no income during this period, and new options are required to control these weeds whilst providing a profit. One such option, which was tested in this research project, was to grow a summer grass, namely sorghum in rotation with winter crops to control winter weeds. Sorghum was sown after the growing season of winter weeds and chemicals were used to control these weeds during the winter fallow period. Although very little sorghum is grown in Victoria and nearly all with irrigation, increased available soil water with zero tillage and stubble retention made sorghum production a management option.

Following two years of growing sorghum to determine the correct variety for the Wimmera, research was carried out in 1996 to determine the appropriate method of sorghum production. The experiment demonstrated that sorghum can be grown in the cracking clay soils in the Wimmera region of Victoria as part of a sustainable farming system using zero tillage and stubble retention techniques. Highest yields (> 2.00 t ha\(^{-1}\)) were obtained from a crop sown in November with 65 kg of N ha\(^{-1}\) into retained residue.
However, if summer rainfall events occur through the growing season, higher rates of N are likely to be beneficial with soil water content at field capacity at sowing. In fact, in 1995, yields of 3.0 t ha$^{-1}$ were obtained when soil water was at field capacity at sowing and several summer rainfall events occurred during the growing season.

Grain sorghum provided the opportunity for improving productivity, profitability and ultimately sustainability by controlling winter weeds, and potentially herbicide-resistant weeds. The current recommendations for growing sorghum in self-mulching clays in the Wimmera region of Victoria are summarised below:

1. Zero tillage.
2. Sorghum to be sown into retained cereal stubble.
3. Sowing date - November 1.
4. Sowing rate - 4 kg ha$^{-1}$ (to achieve 6 to 7 plants m$^{-2}$)
5. Sowing depth - 100 mm below soil surface with 50 mm soil cover (after compression with press wheel).
6. Fertiliser - Nitrogen - 65 to 130 kg N ha$^{-1}$ (dependent on availability of soil water)
   - at least 40 mm below and to side of seed.
   - Phosphorous - 10 kg P ha$^{-1}$ (recommended other sources)
7. Row spacing - dependent on availability of soil water - at least 1000 mm
8. Weed control - non-selective knockdown herbicide prior to sowing.

Farm profit is determined by the margin between farm cash surplus (gross income less variable and fixed costs) and working capital interest, depreciation costs and operators allowance. The increase in farm cash surplus due to the change to continuous cropping demonstrated the strong ability of the system to generate profit under normal seasonal conditions and average prices. Although decline in real commodity prices when compared to cost of production resulted in a decline in terms of trade during the period 1990 and 1994. This in turn, demonstrated the negative impact on profitability of a simultaneous decrease in yields (due to below average rainfall years) and collapse in world grain prices.

Paddock gross margins varied between paddocks due to many inter-related factors, such as temperature, inadequate past or disease control and price fluctuations. There was no fixed rotation, although, over an eleven year period there were four cereal, five legume and two oilseed crops in most paddocks. During that period the paddocks with the lowest gross margins included a year of cultivated fallow, leading to the conclusion that fallow
did not increase profitability in those paddocks. Overall livestock accounted for only 10% of total farm income derived from approximately 40% of total farm area. Elimination of pasture from rotation did not increase livestock gross margin, but, change to conservation farming practices on a continuous cropping basis did not increase grain gross margins.

Wheat was not as profitable as canola or chickpeas, however, neither was the profitability of wheat as variable as canola or chickpeas. In fact during the 1994 drought, wheat was the only crop which covered the cost of production. Fababean made a loss on low rainfall years, however, there could be a beneficial effect on yield of other crops in the following year with elimination of diseases such as root diseases in cereals. Variable costs were static until 1978 and have steadily risen since that time regardless of farming system employed. Canola, linola, chickpeas and fababean crops had the highest variable costs making them high risk crops to grow, whilst wheat and barley had lowest variable costs and hence were lower risk crops.

Overall, there was a rising trend in farm cash surplus in relation to growing season rainfall during the period 1971 and 1995, regardless of which farming system was used. However, during the period of the conventional farming system there were two financial extenuates, namely the high rainfall period of 1973 to 1975 resulted in a large increase in profitability whilst the low rainfall of the 1982 drought resulted in a large financial loss. Alternatively with the conservation farming system there was a loss due to the effect of the low yields and low prices of the early 1990s, however, this effect was not as extreme.

The sustainability of both dryland farming systems therefore was determined by whether the farming practices maximised the availability of water for crop production, was profitable and was beneficial to the environment. The conventional farming system as practised in the case study was proven to be unsustainable, however, the conservation farming system, using zero tillage and stubble retention with continuous cropping, was sustainable in terms of productivity, profitability and effect on the environmental resources of soil and water.
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