An evaluation of cereal zone rotations for achieving short term aims and long term sustainability

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Summary. Developments have occurred in Australian cereal zone rotations in the past 10 to 20 years which have increased crop diversification and improved the nitrogen status of soils and crops, the management of diseases and weeds and the conservation of soil. Substantial areas of alternative crops (especially grain legumes) were sown in some regions in the 1980s, while livestock numbers and pasture areas also increased. In the 1990s continued improvements are needed in environmental adaptation and disease resistance of alternative crop and pasture species, in understanding the inter-relation of rotation components, in market intelligence and in community commitment to the conservation of soil and other resources.

Introduction

Crop and crop-pasture rotations have evolved over this century, in the Australian cereal zones, to improve farm profitability, viability and income stability. For success, rotations must incorporate appropriate cultivars, technology and management. Their benefits include diversification of crops and enterprises and improvements in soil fertility and in the management of diseases, pests and weeds. Conservation farming has developed in close association with new rotations. This paper discusses some key features of a recent overview of cereal zone rotations (3). It also examines trends in crop and pasture sowings and livestock numbers in the cereal/ zone Statistical Divisions in the 1980s, to gauge progress in the sowing of alternatives to wheat.

Overvations and results

Some important changes in rotations and associated technology are apparent in the cereal zone of South Australia. The types of systems and their advantages are shown below, in chronological order:

Cereal fallow

- Stability of yield from moisture, nitrogen.
- Fallow control of weeds and cereal diseases.

Accompanying technology and management requirements: regular cultivation to control weeds in fallow.

Constraints and problems remaining or developing: bare fallow exposes soil to erosion risk and accelerated decline in soil organic matter, nitrogen and structure, leading to decline in yield.

Cereal-annual legume pasture (ley farming system)

- Diversity of enterprises.
- Spread of labour.
- Legume benefits stock, soil and livestock.
- Sheep graze cereal stubble and weeds.

<u>Accompanying technology and management requirements:</u> (i) machinery, plant and structures required for both cropping and livestock (mainly sheep) production; (ii) stocking rates and other pasture management must ensure high levels of legume seed production and accumulation as a soil reserve, for self-regeneration.

<u>Constraints and problems remaining or developing:</u> (i) annual grass invasion of legume pasture reduces nitrogen fixation and assists carryover of cereal root diseases; (ii) soil acidification; (iii) broad-leafed weeds in pasture; (iv) low prices for livestock products; (v) poor pasture management.

Cereal-grain legume (continuous cropping)

- Diversification of crops.
- Nitrogen fixation.
- Rotation assists weed and disease control.

Accompanying technology and managementre_q_uirements: (i) increased skill and chemicals for managing grain legumes; (ii) stubble retention, reduced or zero tillage and herbicide control of weeds with variation in weed management to avoid herbicide resistance; (iii) livestock to help manage crop stubble and weeds.

Constraints and problems remaining or developing: (i) grazing of grain legume stubble may increase erosion risk; (ii) grain legume cultivars need better climatic adaption, disease resistance and means of weed control; (iii) fertiliser nitrogen may still be required for cereals.

Pasture-cereal/oilseed-grain legume (modified ley farming system):

- Greater opportunity to alter emphasis of enterprises in response to price changes, weed problems etc.
- Soil nitrogen levels probably maintained.

Accompanying technology and management requirements: (i) as for ley farming and continuous cropping systems; (ii) keep cropping intensity less than 80% for soil nitrogen maintenance; (iii) replenish pasture legume seed reserves after extended cropping phase; (iv) control disease-carrying pasture grasses in year prior to cereal crop.

Constraints and problems remaining or developing: as for ley farming and continuous cropping systems except that combining grain legumes, pastures and livestock reduces reliance on herbicides and fertiliser nitrogen.

Some important changes in rotations and associated technology and constraints on the Northwest Plains of New South Wales have occurred from the time of land clearing to the 1980s (based on developments at the University of Sydney Livingston Farm at Moree (1)). There are two types of system:

Continuous cropping of wheat with summer fallow (first cropping system after original clearing of clay soil vegetation). The advantages of this system are:

- fertile soils give high grain yields and quality;
- production costs relatively low.

Accompanying technology and management requirements: (i) high powered tractors to clear trees and cultivate heavy soils; (ii) storage of summer rain in clean, cultivated fallow; (iii) fallow extended for extra year if rainfall too low; (iv) stubble burning or burial to control wheat disease.

Constraints and problems remaining or developing include: (i) bare fallow increases erosion risk and rainfall runoff; (ii) winter weeds increase; (iii) soil fertility declines; (iv) reliance on a single crop creates economic risks.

Diversified rotation with wheat, barley, sorghum, chickpeas and oats for grazing after grazing of sorghum stubble

The advantages of this system are:

- double cropping (e.g., sunflowers) if rainfall favourable;
- livestock (cattle) add to income,assist management of stubble and weeds;
- reduction in wheat diseases.

Accompanying technology and management requirements: (i) stubble retention for erosion control, to conserve moisture, improve access when soil wet and facilitate timely and accurate sowing; (ii) chickpeas require well drained soils, early weed control.

Constraints and problems remaining or developing: (i) chickpeas susceptible to *Phytophthora* root rot; (ii) grain legume cultivars required with improved disease resistance and environmental adaption; (iii) in the absence of a vigorous pasture legume, soil nitrogen levels probably continue to decline.

Discussion

The observations and results section summarises features of important earlier and more recent rotations over the past half century which apply to the southern and northern wheat belt. The more recent rotations are not yet widely adopted. Some differences occur between regions in accordance with local needs. For example, in Western Australia, emphasis is often placed on the significance of soil type (Land Management Units) and the interdependencies of crops, pastures and livestock in defining optimum rotations. In north-east Victoria and southern NSW, management of rotations involves applications of lime and gypsum (with deep ripping) to counter acidification and deterioration of soil structure. Lucerne grown with annual pasture legumes uses summer rainfall and helps reduce nitrate leaching. In the northern cereal belt, management of rotations is related even more to climatic extremes than in the south. For example, cultivars and times of sowing may be chosen to avoid hot spells, frosts or dry spells at establishment and flowering; rotation sequences are flexible and opportunistic in response to rainfall and market variability; special care needs to be given to maintaining a soil cover of crop stubble to protect against high intensity summer rains.

Annual statistics on crop areas in cereal belt Statistical Divisions have been examined for the period 1979-80 to 1989-90 and some aspects presented in Table 1. In the 1980s, along with a decrease in wheat area, there was a substantial increase in the areas of alternative crops, particularly grain legumes, but with peaks about 1987-88 and a subsequent modest decline. In Western Australia, the largest increase has been in lupins, particularly in the Central and Midlands Divisions. In South Australia peas are the dominant grain legume (mainly in the York and Lower North Division) but still occupy an area only 7% of the wheat area. The figure for field peas in Victoria is 16% (mainly in the Wimmera and Mallee). In NSW the proportion of cropland sown to grain legumes is small. However, the area under lucerne increased two-fold in most Divisions in the 1980s. On the Northern Slopes it occupies an area half of that under wheat, though not all is in rotation with wheat. In Queensland, the area under cereals increased substantially in the 1980s. Areas of chickpeas and mung beans, though important, are still relatively small. Increases in sheep numbers in cereal areas of all States, of cattle in Queensland and of sown pastures in at least NSW and Queensland indicate the overall importance of livestock and pastures in dryland farming systems.

The availability of environmentally adapted and disease resistant cultivars has probably limited the expansion of grain legume areas in the 1980s although the situation is now improving.

Breeders of alternative crop plants need better access to world sources of germplasm and guidance from market intelligence (2). Grain legumes (especially lupins) can increase the soil nitrogen for following crops. However, perhaps only leguminous pastures can sustain soil nitrogen levels (3,4). Improvements in cultivars and management must continue, to make pastures more profitable.

The benefits of rotation practices for achieving farm profitability and income stability are limited by the intrusion of external factors as diverse as market availability and world prices, government policies, drought and flood incidence and the importation of new diseases and pests. Such intrusion may require rotations to be flexible in order for farms to remain economically viable. Research should assist in defining the scope for such flexibility (e.g., in relation to desirable soil properties). Farmers and farm systems need to be buffered against the adverse impact of external factors (e.g., with long range weather forecasting, market intelligence and a wide diversity of crop and pasture germplasm). Furthermore government policies should be compatible with the goals of sustainability and stability of farm systems which can be achieved through well-designed and managed rotations. This may require incentives through the tax system to encourage soil conservation and other practices which lead to longterm sustainability and not just short-term gain.

Table 1. Changes in crop and pasture areas in Cereal Zone Statistical Divisions (five States) at the beginning and end of the 1980s, and of alternative crops to wheat at the end of the decade. Numbers of cattle and sheep for the same Division.'

Crop ratios	Area of crop 1989-90[b] / Area of crop 1979-80					Area of alternative crop % 1989-90[c] / Area of wheat crop				
State	WA	SA	VIC	NSW	QLD	WA	SA	VIC	NSW	QLD
Wheat	0.8	1.1	0.8	0.7	1.3					
Barley	0.8	0.9	1.2	0.9	1.7	12	60	35	18	20
Rye	2.0	3.4				2	1			
Oats	0.9	1.5	0.8	1.6	1.8	10	11	13	22	2
Triticale	0.9	7.3	1.8	0.8	1.1	1	<1	2	1	
Sorghum				1.0	0.9	<1			6	25
Panicum, millet, canary seed					2.7				4	
Cereal hay	0.9	1.9				3	5			
Lupins	16.3	3.2	3.7	NA		20	2	3	2	
Peas	30.0	3.9	4.9			1	7	16		
Faba beans		4.9	50.0	30.0			1	2	<1	
Chickpeas		23.3	14.3	29.0	20.8		<1	1	1	5
Mung beans					7.3					2
Lucerne and/or pasture hay		1.2		2.1			1		11	
Sown lucerne				2.1					20	
Canola (rapeseed)			55.0	2.2				1	1	
Safflower			4.8	0.2				2	<1	
Sunflower			0.3	0.8	0.4			<1	1	4
Pasture seeds		1.3					1			
Sown pasture	NA	NA	NA	138	181	NA	NA	NA	159	324
Cattle (thousands)	61	77	73	87	163					
Sheep (thousands)	125	107	124	124	296					

[a]Source: Australian Bureau of Statistics.
[b]In the case of grain legumes and oil seeds, the ratio has been calculated using the earliest available data (usually early-mid 1980s) in the denominator.
[c]Ratios for New South Wales have been calculated using 1988-89 data, as 1989-90 data were not available.

References

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