Adopting profitable pasture:crop rotations: on-farm research across the high rainfall zone of Victoria

Summary

Project DAV374 showed that 1:1 pasture/crop systems in cool temperate areas could consistently produce high wheat yields and protein levels without applying additional fertiliser nitrogen (N). To demonstrate this, the system was established on 20 commercial farms in southern Victoria (VIC).

Wheat yields following legume pastures averaged 5.3t/ha and those after a continuous cropping rotation 4.1t/ha. Crude protein contents were 12.3% and 11.9%, respectively. Pasture self-regeneration after crop ranged between 400 and 2,000 plants/m².

Future work to improve the system should include management of herbicide resistance, alternative perennials to minimise leakage, and the effect of an animal component and mixes.

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Conclusions
The following conclusions can be drawn from the project:

1) From a pasture ecology point of view, the system works well. Annual pasture legumes can self regenerate at very high numbers after a year of crop, either cereals or canola.

2) On-farm wheat yields from the pasture/crop rotation were 29% higher than those from the continuous cropping rotation with N fertiliser applied.

3) Good results were obtained without applying N fertiliser in the 1:1 pasture/crop rotation. It is not known if higher yields can be obtained with tactical applications of N.

4) The farming community continues to use some of the sites. An example of this is a visit from Lake Bolac Southern Farming Systems (SFS) growers in early October.

5) As Arrotas clover flowers in December, it is possible to use spray topping, cutting and grazing in October and November to control herbicide resistance without affecting its seed yield.

6) Sixty percent of collaborating growers used the system successfully in terms of crop and pasture yields and self regeneration of the clover.

7) There are clear reasons for the 40% that failed, such as cutting for hay or grazing at inappropriate times, burying pasture seed too deep via cultivation, burning stubbles that contain arrowleaf seed and sowing small seeded pasture legumes too deep.

8) Both canola and wheat performed well in the system.

Recommendations
The outcomes of a workshop conducted with collaborating growers on future directions for this type of work recommended that further work was needed as follows:

1) It is necessary to monitor the animal component of the system in any future work.
2) Further work is needed on how to manage the system to control herbicide resistance of weeds.

3) Alternative perennial legumes for areas that are too acid or wet for lucerne should be tested.

4) Work with grazing wheats is necessary, especially in association with annual and perennial pasture legumes.

5) A system where the pasture phase is a mixture of legumes, in some instances with a grass, should be tested as the seed industry sells mainly mixtures.

6) There is a need to know when the N fixed from different legumes becomes available to the crop in our system.

7) The work should continue in some way as 2005 was only the first self regeneration of pastures after crop on collaborating farms.

**Outcomes**

This project and its predecessor have helped cropping in the high rainfall zone (HRZ) of south west Victoria increase from 100,000 ha in 1997 to approx. 450,000 ha by 2004. Potentially, the zone could have 1,000,000 ha under cropping, which would have a farm gate value of $900 million in today's dollar terms.

Wheat yields after pasture legume phases in the project averaged 5.3t/ha, 29% higher than the continuous cropping rotation. The wheat protein levels from the pasture/crop rotation were 12.3% compared with 11.9% in the controls. According to Knopke (2000), the average wheat yield for this zone was 3.4t/ha after improving by 4.7% per year over the past two decades. At this rate of improvement, yields should be at 4.08t/ha in 2004/05, almost exactly what was achieved in the continuous cropping treatment.

As the price of oil continues to increase, the option of not having to use bag N becomes more attractive as it would save approx. $50/ha in fertiliser, or approx. 15% of the cost of growing the crop. In addition, the use of pasture legumes in the rotation provides a disease break and helps to diversify farm operations. The late maturing arrowleaf clover Arrotas® in the rotation has extended the growing season until February, providing an excellent opportunity to finish lambs.

Environmentally, it could be argued that fixed N could contribute to acidification of the soil and leakage to groundwater systems. However, this certainly also happens with applied fertiliser N, so regardless of source, these problems will have to be managed. Systems using crop-livestock integration are more sustainable because they provide rotation diversity, nutrient recycling and greater energy efficiency. The quantity of water in the soil profile under Arrotas was not significantly different to that of lucerne and water use efficiency (WUE) of this variety was better than that of subterranean and balansa clovers. The use of early flowering genotypes of wheat produced 2.2 times more biomass than later flowering material during winter and early spring. This would have reduced the damaging effects of waterlogging and helps explain the superiority of early maturing material in this environment.

Weed, insect and disease control were also better under the pasture/crop rotation.

This project provided capacity building for producers in this region as most of the work was conducted on private farms and ‘seeing is believing’. Since the launch of the pasture/crop rotation management booklet in early August, there have been approximately 500 requests for copies. As the project helps increase the area of cropping but is part of a mixed farming system, it adds diversity to the farming business. The effects of the work continue as demand for the extension booklet increases and grower groups are visiting the sites near Hamilton.

**Achievements/Benefits**

Project DAV374 (1997-2002) showed that a 1:1 pasture:crop ley system could be extremely successful in cool temperate areas, both from the point of view of achieving high crop yields without applying N fertiliser and also high yielding legume pasture which self regenerates in high numbers after cropping. As this work was undertaken in plot scale experiments, it was considered necessary to test the results on a ‘pair paddock’ system on commercial farms, to validate the results and extend them to the farming community for rapid adoption.

The objective of Project DAV00021 was to emphasise grower participation, paddock scale testing and integration of
information for a close interlinking of scientific research and practical application at the farm scale. The project aimed to build the capacity and skills of growers to accelerate the adoption of research outcomes to improve the economic and environmental performance of the grains industry.

The work was carried out on 20 commercial farms situated in south west (SW) Victoria/south east South Australia (SE SA) between Lismore and Naracoorte from east to west and Ararat in the north. Pastures were established in autumn 2003 on a ‘paired paddock’ system and the pasture/crop rotation was compared with a continuous cropping rotation. Depending on soil type and preference, growers could choose to use subterranean, balansa, Persian or arrowleaf clovers in their rotation. Growers were asked not to use N fertiliser in the pasture/crop rotation and to direct drill the crop to avoid burying the pasture seed too deep.

The system was successful on 12 of the 20 farms. A range of activities led to failure in eight farms as follows; 1) cutting aerial seeding legumes for hay when flowering in the first year, which prevented seed set; 2) cultivating before sowing the crop in the second year, leading to burying the legume seed so that emergence was reduced; 3) not sowing a crop because of the excellent regeneration of pasture and the priorities on the enterprise being animal production (changing their minds); and 4) burning arrowleaf stubbles which resulted in the destruction of the seed bank.

In the 12 farms where the system worked, wheat yields after pasture legume averaged 5.3t/ha, 29% higher than the yields in the continuous cropping rotation (mean 4.1t/ha). The wheat protein levels from the pasture/crop rotation were 12.3% compared with 11.9% in the controls. According to Knopke (2000), the average wheat yield for the zone was 3.4t/ha after improving by 4.7% per year over the past two decades. At this rate of improvement, yields should be at 4.08t/ha in 2004/05, almost exactly what was achieved in the continuous cropping treatment.

Self regeneration of pasture legumes after crop, even after a partial false break in early February 2005, averaged 597, 1,823 and 878 plants/m² for subterranean, balansa and arrowleaf clovers, respectively. This highlights the robustness of the system in this zone.

Results of the water balance were varied and not conclusive. At Hamilton, the late maturing arrowleaf clover had less water in the soil profile than balansa clover but was not significantly different to subterranean clover in January. The annual water use result was similar, arrowleaf clover using fractionally more water than subterranean clover and significantly more than balansa clover. Dry matter production varied widely between clovers and this was reflected in the WUE where arrowleaf, subterranean and balansa clovers produced 30, 17 and 14kg of dry matter per mm of water used, respectively. At the Ararat site, there were no differences in the amount of water in the soil profile at the end of the season between subclover, arrowleaf clover, canola and subclover with perennial grass treatments, nor were there any differences in water use. At a farm near Hamilton, the soil profile under lucerne in January was wetter than that of the crop or arrowleaf treatments. There were no differences in water use between the arrowleaf and the crop, although the WUE of the crop was much higher (36kg vs 19kg of dry matter per mm, respectively). It is worth noting that the crop had a total biomass of 19.9t/ha at the end of the season and a grain yield of approx. 6t/ha.

At Hamilton, during 2003, there were no differences in water use between wheats of different maturity until December when the early wheat Silverstar had used 20mm more than Silverstar (P=0.01). The early genotype Silverstar yielded more than Chara and Rudd. The yields were low compared with previous years at 5.2, 3.8 and 3.0t/ha, respectively. Silverstar also had better WUE compared to Chara and Rudd at 26, 20 and 15kg/mm for total biomass and 10, 7 and 6kg/mm for grain. Between late August and late September, Silverstar had more than double the biomass of Rudd and a third more than Chara. This seems to confer the plant an advantage in tolerating waterlogging.

All four clovers used performed well in the rotation. In addition to this, the late arrowleaf clover Arrotas extended the season until February (at least six weeks longer than subclover). The advantage of this is the value of ‘out of season’ feed for growers and a possible ‘primer effect’ for subsequent crops that still needs to be examined in full.

Soil available N (0-60cm) content was measured each autumn on each farm. The average decrease in available soil N after crop was 53kg/ha and the average increase after pasture was 35kg/ha. The average increase in N in the profile after balansa, subterranean and arrowleaf clover was 51, 34 and 21kg/ha, respectively. It is important to note that arrowleaf clover does not senesce until February; consequently its N may become available to the crop later than that of the other clovers. This needs further study because if the fixed N becomes available later in the season, it will have important implications in production as well as sustainability since less N will be lost from the system. Microbial activity in the area in autumn may be less than in the extended season.
lower latitudes where most N dynamic studies have been made. If this is true, there may not be the N 'flush' experienced in other areas in autumn.

There is no doubt the system works on commercial farms. Areas that require further work are; 1) herbicide resistance - the late maturing Arrotas is showing promise as a tool to deal with herbicide resistance because it flowers after most weeds; 2) the use of alternative annual and perennial legumes in both ley and phase systems; 3) testing grazing wheats in a 'by-cropping' system where a perennial legume is always part of the system and can be grazed in summer after harvest or cut for silage; 4) testing the system using pasture mixes instead of monocultures; and 5) monitoring and measuring production from an animal component between crops so that the whole system is understood both in ecological and economic terms.

Reference

Other research
There are alternative perennial pasture legumes such as Lotus tenuis and Trifolium ambiguum, tested under the high rainfall component (HRZ) of the National Annual Pasture Legume Improvement Program (NAPLIP) which could play an important part in a by-cropping system in the HRZ, especially in areas that are too wet or acid for lucerne.

The use of T. diffusum or T. isthmocarpum in a pasture/crop rotation has not been tested (these two species evaluated under NAPLIP will become commercial in the near future). T. isthmocarpum is extremely hard seeded and it would be very important to have a crop or a short lived grass in the second year before allowing it to self regenerate in the third year in the HRZ.

A new strawberry clover may be registered from the HRZ NAPLIP work and this could be a useful component of a by-crop system.

There is a need to study when atmospherically fixed N becomes available to the plant in the HRZ.

Other areas to explore are listed in Recommendations.

Additional information


