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Pasture cropping

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Introduction

Intercropping or sod seeding winter cereal crops into perennial pasture has been practised in New South Wales since at least the 1960s. This technology has recently been rejuvenated by farmers in the Central West of NSW with the development of the Pasture Cropping System where winter cereal crops are sown directly into summer growing (C4) perennial native pastures (e.g. Redgrass (*Bothriochloa macra)* and Warrego summer grass (*Paspalidium jubiflorum*)) to exploit their complementary growth phases (Figure 1) without the need for a summer fallow. This system is increasingly being adopted and modified, but to date there has been little formal research.

In the mixed farming zone, conventional phase farming (crops and sown pastures in rotation) can be risky on lighter soils due to an increased chance of crop or pasture establishment failure. These soils do not support long cropping phases because of a lack of fertility and poor moisture holding capacity, while in the pasture phase few introduced perennial pasture species persist. It is under these conditions that the Pasture Cropping System was developed as a method of retaining native perennial grasses while allowing some crop production. Removal of a summer fallow has not largely affected crop production because soil water holding capacity is low and the non-seasonal rainfall pattern generally provides sufficient in-crop rainfall in the Central West of NSW

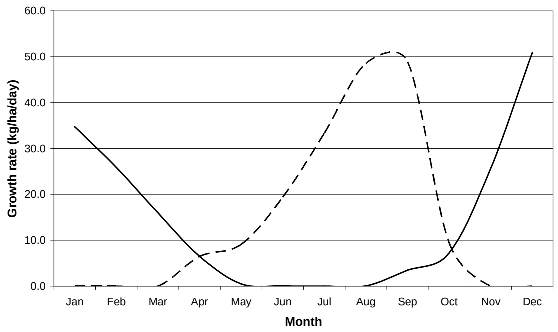

Figure 1. Average growth rates for Redgrass (solid line) and an annual pasture/cereal species (dashed line) at Wellington, derived from the Sustainable Grazing Systems Pasture Model (www.imj.com.au/sgs) from 1998 to 2004.

The Pasture Cropping System has since expanded to better soil types and to regions with different rainfall patterns and amounts, and there has been much debate regarding its suitability for these environments.

This Primefact defines Pasture Cropping and summarises the available information on the system, production, natural resource management (NRM) and profitability.

Definitions

In recent years Pasture Cropping has been widely promoted and the term has been used to describe any form of sod seeding of cereal crops into pasture. However, some existing and new practices involving variations of sod seeding are easily confused with Pasture Cropping as outlined above. To avoid this confusion the following definitions will be used throughout this publication.

Pasture Cropping*:* Winter cereal crops are sown directly into a summer active (C4) perennial pasture to utilise the difference in growth patterns, without a planned summer fallow (either chemical or by cultivation). Pastures are grazed up to sowing, with herbicide applied prior to sowing to reduce competition from emerging annual species.

The system is primarily aimed at grain production, but it can also be used for forage production.

Another variation that has been called ‘pasture cropping’ is sowing cereal crops into C3 (winter active) native perennial pasture, although this moves away from the major principle of complementary seasonal growth patterns of the crop and the pasture.

No Kill Cropping / Advanced Sowing*:* Winter cereal crops are sown dry, before the autumn break, into perennial pastures of varying composition without the use of herbicides. The aim of this system is to provide additional winter and spring forage for grazing, and grain is harvested only on an opportunistic basis. The system relies on the cereal having a greater growth rate than germinating annual weeds.

Perennial Intercropping*:* Winter cereal crops are sown into generally degraded temperate perennial pastures (e.g. lucerne or phalaris), for grain or forage production. As with Pasture Cropping, pastures are grazed up to sowing, and herbicide applied prior to sowing may be used to reduce competition from emerging annual species. This system has been used by dairy farmers and lucerne growers for many years and is often referred to as **Sod Seeding**, a general term for the sowing of crop or pasture species into existing annual or perennial pastures.

Pasture Cropping Systems*:* A general term encompassing Pasture Cropping, No Kill Cropping/ Advanced Sowing, Perennial Intercropping and Sod Seeding.

System objective

Pasture Cropping Systems produce cereal crops for grain or forage while retaining perennial grasses for grazing. There may also be potential Natural Resource Management (NRM) benefits such as regeneration of degraded pastures by encouraging perennial grass germination and recruitment, maintaining species diversity, and reducing nitrogen (N) leaching and deep drainage. **Management objectives (production and NRM elements) need to be clearly defined to help decide when Pasture Cropping Systems are more appropriate than conventional cropping or other pasture management techniques.** In some situations profit and NRM objectives may be complementary, but in others there may be trade-offs between short-term profitability and longer-term NRM objectives that are difficult to quantify in economic terms.

Production outcomes

Grain production

If crop production is a primary objective then in most situations there will be a yield penalty from retaining perennial grasses compared to conventionally grown crops with summer fallows. Research at Wellington on a good Redgrass pasture (25 plants/m^2) indicated that wheat yields can be up to 50% lower with Pasture Cropping compared to conventional No Till Cropping (Table 1).

Table 1. Wheat yield (t/ha) in 2005 and 2007 in a Redgrass paddock at Wellington, NSW. Drought in 2006 resulted in no harvestable grain.

Year	Cropping system	
	No Till Cropping	Pasture Cropping
2005	1.73	1.18
2007	2.68	1.34

Nitrogen appeared to be a major factor limiting grain yield. The grass dominant summer active pasture used much of the N that mineralised leading into the cropping phase (Figure 2). Nitrate-N in the top 10 cm averaged 23.4 mg/kg in the No Till Cropping plots compared to 14.4 mg/kg in the Pasture Cropping plots, and in 2007 grain yield under Pasture Cropping was half that of No Till Cropping. Although both Pasture Cropping and No Till plots received fertiliser (Pasture Cropping 50 kg DAP/ha, No Till 100 kg DAP/ha) at sowing, the amount was not sufficient to offset the effect of the perennial grass. An extra Pasture Cropping treatment had 100 kg DAP/ha applied in 2007, but the extra fertiliser did not increase wheat yield.

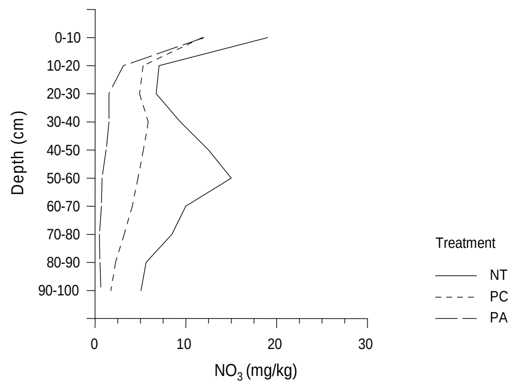

Figure 2. Nitrate measured after sowing in a Redgrass paddock at Wellington (July 2007) in conventional No Till Cropping (NT), Pasture Cropping (PC) and pasture only (PA) treatments.

In a severely degraded lucerne paddock at Wellington, with soil fertility not limiting, wheat yields from Perennial Intercropping were similar to No Till cropping, providing an in-crop annual grass herbicide was applied.

Replicated research at Trangie and Condobolin has examined crop yields in lower rainfall environments. At Trangie, Pasture Cropping produced a yield of 2.4 t/ha in 2005 (no conventional crop comparison), no harvest in 2006 and 0.4 t/ha in 2007 (not significantly different from conventional cropping). At Condobolin 1.2 t/ha of oats was harvested in 2005 but crops were grazed in 2006 and 2007. Pasture Cropping can thus be successful in lower rainfall environments, but profitability of the system over the longer term will depend on the number of years that grain is harvested.

The research at Wellington also indicated that wheat yield was not significantly affected by the frequency of Pasture Cropping (1, 2 or 3 years in succession). Understanding the relationship between paddock history (including fertiliser input), pasture composition and nutrient availability is essential for assessing potential crop yields under Pasture Cropping. Many paddocks have a lower perennial grass density than the Wellington study site, and nutrients may cycle in a similar way to an annual pasture. Crop yield potential may be greater than reported here. Alternatively, crop yields may be low despite high N fertiliser application, due to low amounts of available N mineralised through the profile or its use by the perennial grass. Since N availability can strongly influence the profitability of the system in the short term, an understanding of the N status of a paddock based on soil testing and pasture composition can aid in management decisions.

Forage production

Research into Pasture Cropping and Perennial Intercropping has shown that pasture production is influenced by the amount of summer-autumn rainfall, the frequency of the cropping activity and pasture composition. At all sites nearly all annual grasses and broadleaf weeds were replaced with a cereal crop.

In the Redgrass pasture at Wellington, continuous Pasture Cropping over three drier than average years (2005 to 2007) decreased the amount (biomass) of perennial grass compared to pasture-only plots. The reduction in perennial grass biomass was less when pasture cropped for only one year. However, perennial grasses recovered to production levels similar to continuous pasture within 12 months of the cropping activity. Pasture Cropping decreased the number of older Redgrass plants compared to pasture areas due to disturbance by the sowing activity, but there was enough recruitment of Redgrass to ensure there was no difference in the total plant numbers over time.

In the severely degraded lucerne paddock at Wellington, Perennial Intercropping reduced lucerne levels compared to uncropped treatments during the cropping phase, but lucerne biomass recovered to uncropped levels after cropping, even in the continuous Perennial Intercropping treatments.

While Pasture Cropping or No Kill Cropping can be used to replace conventional forage crops, it is important to ensure that the systems provide forage when it is of most value (e.g. mid to late winter), and that production is significantly greater than uncropped pasture. To ensure sufficient growth, winter forage crops must be sown early, particularly on the tablelands, before growth is limited by low temperatures. If a forage crop is sown late (e.g. May) the bulk of forage will be produced in spring when it is often not required.

No Kill Cropping does not use herbicides and relies on the ability of the crop to grow at a greater rate than the establishing weeds. If there is a high proportion of annual grass in a pasture then competition may limit crop growth. However, since annual grasses generally have higher winter production than most perennial grasses there is less need to sow a cereal crop. For example, replicated trials of No Kill Cropping in an annual dominant pasture at Trangie did not produce any additional biomass, but at a separate location that lacked annual grasses, sowing of the crop increased total biomass by 42%.

Natural resource management

Having both pasture and crop growing on the one area of land in the same year will change the amount and pattern of resource use by plants. This can result in a shortfall of resources at critical times in crop development.

Soil moisture and N are the two resources that largely determine crop and forage yield. Research at Wellington showed that soil moisture was a major factor limiting crop and pasture growth, but there was little difference between crop and pasture systems in soil moisture use at any time. This was due to limited summer–autumn rainfall over the three seasons (2005 to 2007) and the limited opportunity for soil moisture to accumulate in the conventional fallow. Conversely, N varied significantly between systems and paddocks (sites), and was a major constraint affecting crop yield in the Pasture Cropping treatments

At Wellington, Trangie and Condobolin, Pasture Cropping Systems with short-season wheat reduced the level of ground cover in the year of cropping, but it generally recovered to the levels of uncropped pasture within a year, except in 2006 when rain was severely deficient. On the other hand, conventional cropping greatly reduced ground cover. While the maintenance of ground cover may help maintain or enhance soil health, results at Wellington did not show any differences (over the short term of the experiments) between cropping treatments for soil organic carbon or other physical soil properties.

Anecdotal observations suggest that Pasture Cropping Systems can facilitate the regeneration of degraded pastures by encouraging perennial grass recruitment and provide other NRM benefits such as maintenance of species diversity, and reduced N leaching or deep drainage. Data for native perennial grass recruitment at Wellington were inconclusive during years with dry summer–autumn periods, and the recruitment mechanisms have yet to be fully investigated. However, there was enough Redgrass recruitment to replace the adult plants that were pulled out in the sowing process. There is also likely to be an interaction between grazing management or pasture rest periods and recruitment. Pasture Cropping Systems were developed in conjunction with grazing systems that have long rest periods, and this may also be a reason why increased pasture recruitment has been observed.

Profitability

As crop yields are generally lower with Pasture Cropping and Perennial Intercropping, a strategy to improve profitability is to lower inputs, particularly if low yields are expected or there is little or no stored moisture. To compensate for lower crop yields, production systems need to utilise the summer forage produced by the perennial grasses. Compared with conventional no-till cropping, these systems have lower preparation costs and there is less opportunity cost in lost grazing, due to the lack of a planned summer fallow. While conventional cropping usually produces the greatest returns, they are also the most volatile in nature and are greatly affected by environmental conditions. Pasture Cropping Systems may not give the same returns as conventional cropping in good seasons, but profit is less variable and flexibility is increased by removing the need to fallow. The lack of the planned fallow enables decision making on whether to crop or not dependent on seasonal conditions. However, this is not the case for No Kill Cropping, where the cereal is dry-sown early, and success is determined by suitable climatic conditions post sowing to promote the growth of the sown cereal.

A low annual input cost in Pasture Cropping Systems removes the need for large grain yields to recover costs and this, combined with the diversity in income steams, should lower risk in the overall system. In regions where the reliability of in-crop rain is low, then risk will increase. Alternatively, as the reliability of summer rain decreases then the relative gain in forage production from Pasture Cropping Systems may decrease, unless there is regularly soil moisture carried over from the winter cropping period.

The long-term profitability of the system depends on how the system performs over a range of seasons for a particular area. It is also important to note that a low input strategy may run down resources over a longer period. It is important to monitor whether the system is improving (e.g. stimulating perennial grass recruitment) or degrading the resource (e.g. running down available N).

Pasture Cropping Systems are likely to be more profitable for a grazier moving from a pasture system than for a farmer moving from a cropping system.

System components

As for any farming system, there are a number of decisions producers need to contemplate when considering a Pasture Cropping System. These include farm management objectives, climatic conditions, paddock selection, crop selection, cropping frequency, sowing technique, fertiliser, herbicides and forage utilisation.

Farm management objectives

Defining the objective for using a Pasture Cropping System is an important first step before further planning can begin. Your objective will firstly determine whether a Pasture Cropping System is needed, and then the type of system, in which paddocks it is suitable and how frequently it will be used. Pasture Cropping Systems can be used to maintain perennial ground cover, increase forage production, and produce grain in planned or opportunistic ways.

Climatic conditions

Pasture Cropping Systems were developed for and are best suited to central west NSW where there is not a strong seasonal dominance in rainfall. If stored soil moisture is required for cropping in most years then a Pasture Cropping System will not be suitable. If the chance of receiving in-crop rain is low then a Pasture Cropping System may be used on an opportunistic basis when soil moisture is high and there is adequate feed for livestock system to take paddocks out of production for cropping. As there is no planned fallow in a Pasture Cropping System, the decision to go ahead with a cropping activity can be delayed until seasonal conditions are better known.

Paddock selection

Farms are generally heterogeneous and there is often variability in soil type, pasture composition and topography. Given that country has to be arable, the decision on where to use Pasture Cropping Systems should be made on soil and pasture characteristics.

Pasture Cropping Systems are suited to marginal cropping soils that have low soil moisture holding capacity, as moisture is used when it falls. On heavier soils that are more efficient at storing moisture, the trade-off becomes how much can be made from livestock grazing the perennial grasses grown on summer–autumn moisture compared to the value of crop that could be grown on that stored moisture. There may also be environmental and/or financial considerations for maintaining perennial grasses.

Pasture composition is a good indication of soil N status and will also affect it. Annual pastures will have greater levels of available N than perennial pastures that use N over summer as it mineralises. Dense stands of C4 (summer active) perennial grasses without a significant fertiliser history will tie up available N, causing deficiencies throughout the profile and crop performance may be poor, even if higher rates of fertiliser are used. At lower perennial densities, the N cycle is similar to an annual pasture, even though perennials are present, and crop performance is likely to be better. If nitrophilous (N loving) weeds such as thistles and barley grass are present, available N should be high and better crop performance can be expected. However, as barley grass is a host for crown rot, better crop performance may not be an outcome.

Crop selection

The selection of crop depends on whether it is for forage, grain or both; soil nutrition; and weed and pest control issues. Many crops including canola and some pulses have been used in Pasture Cropping Systems, but cereals are the most common. High biomass cereals, such as oats, cereal rye and barley are often used to increase litter levels, particularly in degraded pastures. Broadleaf crops may be more susceptible to insect damage as insects can survive in undisturbed pasture. While research at Wellington has indicated little soil-borne disease risk when using Pasture Cropping Systems, this may need to be considered in other locations.

Cropping frequency

Research at Wellington has shown no significant effect on wheat yield by the frequency or position of Pasture Cropping or Perennial Intercropping in a crop–pasture rotation. However, continual Pasture Cropping Systems with low inputs may lead to ‘mining’ of resources (depletion of soil nutrients). If the farm management objective is to enhance perennial pastures then a five year rotation with one year Pasture Cropping and four years pasture may be appropriate. Higher cropping frequencies may be successful for a while, but once mineralisation levels decline, or perennial grasses increase to use the N that is mineralised, then crop yield will decrease. With the flexibility of a Pasture Cropping System not enforcing a cropping enterprise into a farm plan, strategies can change over time in response to the resources base and farming objectives.

Sowing technique

Pasture Cropping Systems have a shorter preparation period than conventional cropping, but this does not remove the need for the correct sowing technique. Conventional sowing principles to achieve accurate seed placement and optimum soil–seed contact are still relevant. The soil type and level of compaction will determine what form of sowing system will be appropriate.

Areas that have been in pasture for long periods may have a high degree of surface soil compaction, limiting crop root growth, which may reduce yield or cause crop failure. In compacted soils a suitable tined implement that can rip below the seed without smearing and/or fracturing the soil around it will help improve root growth of the emerging crop. Although some disturbance is needed, excess disturbance will damage perennial grasses. Disc seeders are used for No Kill Cropping and have been used for Pasture Cropping and Perennial Intercropping, although they should only be used if soil compaction is low or in soil types of low strength (e.g. a sandy soil).

Row spacing may also affect perennial grass survival. Wider rows are likely to result in less damage to grasses but may also reduce yield. In the dense Redgrass pasture at Wellington mortality was increased by 20% (compared with pasture alone) at a row spacing of 30 cm but additional recruitment resulted in no significant difference in total plant numbers.

Fertiliser

Crop nutrition needs to be matched to expected grain yield. The concept of pasture cropping having a lower fertiliser requirement is only because grain crop target yields are lower. The conventional rule of 3 kg P/tonne of target grain yield for cereal still applies (See Agfact P1.4.5 *Phosphorus nutrition for winter crops*). Research at Wellington on a dense Redgrass pasture has confirmed that N deficiency commonly limits winter cereal grain yields in pasture cropping systems, due to low amounts of available N mineralised through the profile or its use by the perennial grass over summer. Fertiliser applications should be based on soil testing and paddock history.

Herbicides

In a Pasture Cropping System it is still possible to use most herbicides, because weed control mainly occurs when the perennial grasses are not actively growing. The control of annual weeds prior to sowing can be achieved with glyphosate after frosts have begun if there are only summer growing perennial species, or with paraquat/diquat if winter growing perennial grasses are in the pasture or summer-dominants are still actively growing. Some herbicides (e.g. Group A) can cause mortality to native grasses, like Wallaby grass (*Austrodanthonia* spp.). Post emergence of grass and broadleaf weeds can be controlled as required using herbicides that do not damage perennial grasses. Seek advice from your local agronomist for post emergent control of specific weeds. Failure to apply post emergent weed control decreased crop yields by 36% on average at Wellington.

Establishing perennial grass seedlings are more susceptible to herbicides than established plants. Nevertheless most perennial grasses, whether summer or winter growing, should be able to recruit outside the cropping phase, provided herbicides do not have a long residual action.

Forage utilisation

Crop production is only part of Pasture Cropping Systems, and livestock systems are required to generate some of the profit. Retained summer growing native grasses can support a reasonable level of animal production through the summer months that is not available in conventional cropping systems with summer fallowing.

Feed quality can be an issue, with some species like Redgrass having a high proportion of stem compared to leaf. However, the additional forage production due to lack of fallow or from failed crops can be very useful and important.

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