Pastures have a key role in cropping systems

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Abstract. Pastures offer many potential advantages to farming systems, including sustainability, spread of profit risk, improved soil water use, higher soil organic matter, improved soil biological activity, less soil erosion risk, and more options to avoid weeds developing resistance to herbicides. These and other issues are discussed.

Introduction

Large areas of NSW are now predominantly 100% cropped. Some people predict this trend will continue. It is a big decision to turn a property over to 100% cropping. Inevitably, fences disappear, watering points break down and are not repaired, and sheds and yards fall into disrepair. Once a property has been exclusively cropped for a few years, it is almost impossible to change back to mixed cropping and pastures because of high restoration costs.

The case for pastures in a cropping system needs to be sound. Pastures need to be productive, high quality, and profitable. The pasture type selected must be capable of protecting the soil from erosion and other debilitating factors e.g. further soil fertility decline. Well managed pastures also commonly play an essential role in sustainable soil water use, and therefore are commonly used as a tool to reduce rising water tables which are often associated with salinity problems, for the entire rotation phase.

Good pasture phases can also restore depleted soil organic matter, build soil fertility (especially nitrogen, N), improve soil biological activity, and increase biodiversity. With the complexity of weeds developing resistance to herbicides in many rotations that are exclusively crop based, pasture phases increase the options and ability to reduce such risks. Roots of decaying perennial pastures, especially of tap-rooted species like lucerne, can provide channels for the roots of following crops to better access moisture and nutrients in difficult, sometimes hostile subsoils.

Profitability

Profitability of livestock enterprises varies greatly from year to year and among enterprises. Over the last few years well run prime lamb enterprises have returned gross margins of well above $30 a dry sheep equivalent (DSE, lambs $75 to $140/head) and some beef enterprises have returned around $30/DSE (see NSW Agriculture web site, www.agric.nsw.gov.au/reader/budget, for beef and sheep gross margins).

Stocking rate (DSE/ha) obviously varies according to average rainfall, soil type, and elevation (temperatures), as well as pasture type and management factors such as supplementary feeding. For many areas on the Northern Slopes, 10 DSE/ha is a reasonable stocking rate. At today's grain prices that represents a better return than an average wheat crop of AH quality with a yield of 3.0 t/ha. While many farmers average better crops than 3.0 t/ha, the average across NSW is well below this level (just over 2.2 t/ha on a 10-year average). Drought, frost, floods and hail have a big impact on achieving high crop averages. In addition, many soils are incapable of maintaining high average crop yields (e.g. shallow, hostile subsoils and acidic soils).

Droughts, floods, protracted wet weather at harvest, disease outbreaks like a new strain of stripe rust, or unseasonal late frosts can devastate crop income. Yet, well managed livestock enterprises which are insulated against adverse conditions (e.g. high drought reserves and opportunity feedlots to finish stock) can to a large degree continue to provide good income in all but the very worst of seasonal conditions.

Livestock enterprises also have their risk factors such as disease outbreaks and fluctuations. However inclusion of livestock in a farming system is a positive way to spread income risk, improve cash flow, as well as to be competitive on an income return basis.

Soil fertility

A good legume based pasture can build soil N by around 20-25 kg/ha for every tonne of legume dry matter produced. Research has shown that a 2 to 4 year legume pasture phase can increase soil N by 80 to 300 kg/ha (Holford 1997). In any economic analysis this needs to be considered (1.0 kg N is commonly worth 80 cents to $1).

One of the main issues facing cropping is high input costs, with fertiliser, especially N, often representing 25% of variable costs. Pulse crops often have a relatively low net N benefit to following crops. Yet legume pastures, especially for the first and second crop after the pasture phase, can largely reduce this expense.

Soil water use

Field research backed by modelling suggests that a 3-year lucerne pasture as part of a rotation with cropping can probably ensure that water tables remain relatively stable (Bond 2004). Lucerne can dry the soil profile to the extent that when followed by a cropping phase it will take some years for a situation of abnormally rising water tables (and often associated salinity) to again present a problem. In contrast, 100% cropping or 100% annual pastures can result in water, often >50 mm/year, leaking into the water table, resulting in rising water tables, and increased salinity problems, including leakage into river systems.

In northern NSW, cropping with shorter fallows (avoiding 12 month or longer fallows) and cropping according to available soil water (response farming) has also been shown as a better way to manage soil water. However, a cropping only rotation has never been shown to be as effective at reducing water leakage as lucerne or perennial grasses.

Some studies have also shown that where soil deficiencies are corrected in perennial pastures, water use efficiency (WUE) can be up to 5 times higher than when not addressed (Watson 2000). The improved WUE results in greater production, more options for sustainable grazing management (e.g. better ground cover), less water runoff, and probably less leakage of water into water tables, thereby avoiding possible serious impacts of salinity.

Soil organic matter

Soil organic matter levels, soil fertility, and soil biological activity are generally regarded as important parameters for measuring the health of a soil.

In many parts of Australia (e.g. central/southern NSW) research is finding that it is difficult to substantially improve soil organic matter other than via a pasture phase (Chan 2003).

No tillage cropping in many long term experiments commonly only slow the rate of organic matter decline. However, some northern trials showed that no-till when combined with very high soil fertility can result in small measurable improvements in soil organic matter.

A substantial amount of research has also shown that productive perennial based pastures are very good at building soil organic matter (Watson 2000). Organic matter decline caused by years of cropping can in some cases be restored to close to original levels by relatively short perennial pasture phases (e.g. 3 years). However, research indicates this improvement can be more quickly depleted by further cropping than was the case when the area was first cropped. This infers that regular returns to pasture phases are needed to maintain soil fertility.

Perennial grass based pastures have the best reputation for restoring soil organic matter. However well managed lucerne stands have also been shown to improve soil organic matter (Chan 2001).

Some scientists (e.g. Dr John Passioura, CSIRO Plant Industry, Canberra), warn us not to be preoccupied about seeking high soil organic matter levels beyond a certain point (Freebairn 2003*b*). Soil organic matter is important for soil fertility, friability, aeration, water infiltration and movement through the soil. But beyond a given level, perhaps 2.0-3.0% organic carbon, depending on soil type, high organic matter can increase soil acidity, increase the amount of tied-up nutrients such as phosphorus (P), sulfur (S) and N, and can increase the rate of N leaching through the soil profile with favourable seasonal conditions.

Soil biological activity

Soil biological activity measurements such as microbial biomass and microbial respiration rates are currently the most effective way of assessing the level of micro-organisms such as fungi and bacteria, which account for the majority of micro organisms in the soil.

Soil biological activity is generally related to soil organic matter levels. The higher the soil organic matter the higher the biological activity.

A number of studies (King 1994) have shown that healthy productive pastures, especially where soil nutrient deficiencies are corrected, are much higher in biological activity than poorer soils. Other studies have shown that where soil acidity is corrected by applying lime, soil biological activity improves.

Soil erosion

Pastures managed to retain 70% or better ground cover have a low inherent soil erosion risk (Freebairn 2003*a*). The required minimum ground cover varies according to slope, average rainfall and storm probability, soil type, groundcover type, and pasture type. On the Darling Downs studies showed erosion rates under well managed pasture averaged <1 t/ha/year, compared with <3 t/ha/year with cropping under conservation farming, and 30-50 t/ha/year when land was cultivated.

Perennials, especially grasses, generally provide the best ground cover protection. Lucerne is often accused of providing poor ground cover. Lucerne's effectiveness in erosion control is dependent on plant density, how short it is grazed, how much plant litter is present, including companion species, and soil type. By itself lucerne often does not provide high ground cover, but when combined with other species, where reasonable litter levels are maintained, it provides much better protection than annual pastures or bare soils that result from cropping. On hard-setting soils where lucerne is grazed hard, it often provides limited ground cover.

Good pasture can significantly build soil organic matter, helping the soil to be less erodable. If the pasture comprises the right species, including suitable perennials, and is well managed, then pasture phases improve the ability of agricultural systems to be protective of the soil and its quality.

Biodiversity

If we value native species in our ecosystem, and most of us do, the use of pastures as part of the farming system offer options to increase their presence.

A major challenge to Australian agriculture is to combine productive agricultural systems with a healthy level of native vegetation and animals. Where areas are used almost exclusively for cropping this is a particular challenge and can only be reconciled if significant areas are set aside for such purposes. The same can apply to pastures if only introduced species are used and managed so that natives are excluded (e.g. some phalaris dominant pastures on the Tablelands).

In central and northern NSW, and on Tablelands areas in most of the state, it seems possible to have productive sustainable pastures that also contain a good level of native species. For example, research undertaken by Inverell District Agronomist, Bob McGufficke, north of Inverell, has demonstrated that native pastures top-dressed with fertiliser to correct P and S deficiency, with subterranean clover added, were 3 times more productive than unimproved native pastures, and also had a greater diversity of native plant species (McGufficke 2003).

It is common for lucerne pastures in central and northern areas to be gradually reinvaded by native perennials as the pasture ages. Again, management is a vital consideration. Many pastures sown with introduced sub-tropical perennial grasses contain a good level of native perennials.

A property that I have regularly observed was one of the most overgrazed I can ever recall. For many years it was set-stocked, overstocked, and combined with the drought, appeared to have killed the native perennial pasture base. The property had an average annual rainfall of 625 mm and the soils were mainly basalt clay loams. At the breaking of the drought the property changed hands. The new operators applied fertiliser and subterranean clover, and introduced improved grazing management. This consisted of a non-rigid rotational grazing system with rest periods to allow seedlings to establish, young and adult plants to build root reserves, and opportunities for plants to set seed.

With 2 reasonable summers, and improved management, native perennial gasses have largely recolonised the property. This is an example of how forgiving land can recover with reasonable management, and how quickly native species can reappear as a major and valuable part of grazing systems.

In southern NSW, especially on the Slopes and Plains, it can take much longer for native perennials to reinvade exotic pastures or paddocks coming out of cropping. However, in February I visited a property west of Cowra and noted a good reinvasion of native perennials into a thinned out lucerne stand that was still dominated by subterranean clover. Grazing management and good seasonal conditions again appeared to be important.

Weed resistance to herbicides

It is well documented that 'cropping-only' properties are facing increasing problems from weeds developing resistance to herbicides. Weeds such as wild radish, ryegrass, and black oats have already developed resistance to group A, B, C, D, F, L, and M herbicides. Costs escalate, and yield and crop quality become increasingly affected as resistance increases.

As a general rule, having pastures in the crop rotation greatly reduces the rate of development of weed resistance to herbicides. If carefully managed, pastures can help ensure that weed resistance to herbicides never becomes a problem.

This is not to suggest that pastures offer a "magic bullet" solution, but they do increase the control options. Pastures offer a number of options to help delay the onset of herbicide resistance, or to avoid it developing. These include the following:

- Healthy perennial based pastures can be very competitive against many crop weeds. A 3-year or longer pasture phase can decrease weed numbers considerably.
- Dilution of resistant weed populations in a pasture phase. This happens quite quickly where herbicide resistant weeds are associated with less plant vigour, as is the case with some group M resistant weeds (e.g. glyphosate).
- More herbicide options are available in pastures. Weeds can be reduced and/or eliminated by greater choice of herbicide groups that do not yet have resistance problems. Pastures are often eliminated in spring prior to a winter crop, and therefore add an opportunity to totally prevent weed seed set for a season, something almost impossible in a "crop-only" system, especially in non-summer crop areas. Spray-topping is a useful option to reduce annual weed seed set while not harming the pasture base.
- Pastures offer non-chemical weed control options of cutting for hay or silage, slashing, or crash grazing prior to weed seed set. Sometimes a non-selective herbicide treatment which is non-damaging to perennial pasture, needs to be applied after cutting or crash grazing to prevent weeds from re-shooting and setting seed.

Perennial pastures can assist with crop rooting depth

Research undertaken in southern NSW and Victoria by CSIRO, NSW Agriculture and Victorian Department of Primary Industries (Peoples 2004) has shown that crops following lucerne can root far deeper in paddocks with hostile subsoils (e.g. high pH, sodicity and boron toxicity) than crops following annual pastures. Crop roots follow the channels left by decaying lucerne roots.

Research has shown that lucerne is a good "primer" plant to root down into such hostile subsoils. Follow-on crops are therefore better able to access moisture and nutrients at a greater depth than would be the case in a "crop-only" farming system.

Soil fertility and pastures

Correcting soil deficiencies can also have some undesirable consequences on pastures if management is not altered to take into account a changed pasture growth pattern.

Appropriate fertiliser applied to pastures can dramatically improve winter-spring legume and annual grass growth. This can use most of the available soil water and smother native summer grasses when they are starting to get away. Grazing management needs to be modified to nullify the smothering effect of the "spring flush". Management that ensures herbage mass is kept within reason (e.g. <2500 kg DM/ha) will generally preserve the native grass base.

In the Coonabarabran district (and in many others) hundreds of farmers are showing that it is possible to improve pastures with fertiliser and at the same time retain native species (Watson *et al.* 2000). Some farmers have been improving native pastures for over 50 years with fertiliser and annual legumes, and have very productive pastures, as well as a healthy native species base.

Before European settlement the carrying capacities of most Australian grazing lands were low, and both the native plants and animals evolved to cope with such conditions. Europeans greatly increased stock numbers, watering points, and as a result native animal numbers also increased. Overgrazing was the end result.

The only solution was to raise pasture productivity and to improve management, or to revert to a near unproductive grazing system. Research has shown that the only way to increase productivity is to improve soil fertility and management.

We know soils can become more acid as a result of pasture improvement, but we also know how to deal with this situation. Provided issues like soil acidity and rising water tables are addressed, pastures where soil deficiencies are corrected will nearly always be more healthy (e.g. more organic matter, higher biological activity) as well as more productive.

Research going back to the 1950s and continuing through to the 1980s at Armidale (CSIRO) showed that long term pasture fertiliser use could build a soil bank of nutrients like P and S. When the bank was high, one could go several years and measure no response to fertiliser. But when soil fertility once again dropped to critical levels, production declined. The message is to monitor soil fertility levels regularly and address deficiency issues before production is adversely affected. Some of the advocates of non fertiliser use are now in this position.

Increasing soil acidity has also been a consequence of improved annual legume based pastures in areas such as the Central and Southern Tablelands and Slopes. Key factors contributing to the problem, from the start of European settlement, have been soils that were acidic in nature, greatly increased soil N availability as a result of productive legumes, leaching of N from predominately annual legume based pastures, increased soil organic matter, and removal of soil nutrients such as calcium from the paddock *via* sale of farm produce.

Unless soil acidity is addressed pasture and crop production declines. Proven remedial actions have been based on applying lime to counter soil acidity, ensuring pastures are perennial based (to prevent/ reduce N leaching), and by judicious use of acid tolerant species.

Sodic and other difficult soils

In their natural state, many NSW soils are low in organic matter and are sodic in nature (high level of exchangeable sodium as a percentage of exchangeable soil cations). Low soil organic matter combined with sodicity is a recipe for hard setting soils that cause enormous crop and pasture germination problems, low infiltration of water and air, and generally perform poorly.

Applying gypsum (and in acid soils a combination of lime and gypsum, or in some cases lime only) corrects surface soil sodicity, and if combined with pasture improvement can also greatly improve soil organic matter.

In "crop-only" rotations, regular and high rates of gypsum need to be applied to contain redevelopment of sodic conditions. Where improved pastures are used, soil organic matter improvement can result in a greatly reduced need for regular gypsum application.

Conclusion

Pastures, as part of an agricultural system, offer many very important advantages that "crop-only" systems will increasingly struggle with. These include overall sustainability, spread of profit risk, role in reducing cropping costs (especially fertiliser N replacement and/or supplementation), improved soil water use (less leakage), higher soil organic matter, improved soil biological activity, less soil erosion risk, greater opportunities to maintain and/or increase biodiversity, more options to avoid weeds developing resistance to herbicides, provide an improved ability for crop roots to penetrate difficult and often hostile subsoils, and an easier and cheaper way to address sodic soil problems.

In my view, there is a real need to challenge the merits of "crop-only" farming systems. One may initially enter these for profit motives only. As the realisation gradually develops that pastures can be just as profitable, and sometimes more profitable, and that pastures can also far more easily address a host of issues discussed above, I believe that the trend to continuous cropping will decline. It is also important to understand that "crop-only" systems are hard to reverse once they have been practiced for a number of years.

For pastures to be effective, for example to be profitable and able to restore soil organic matter, they must be managed professionally. Issues like soil nutrition, pasture establishment, species selection, and grazing management need to be planned and implemented effectively based on the best scientifically proven technology.

Successful cropping depends on long term rotations and management. Effective pastures, the enterprises that depend on them, and their effective role on their own or as part of a rotation, also need to be managed in a long term context.

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