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MANAGING PASTURES FOR BETTER SOILS:

MIXING FARMING AND PASTURES

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Abstract: *Good pastures are crucial to profitable and sustainable land use. The right balance between the cropping "withdrawal" phase and the pasture "deposit" phase will result in a farm which is both economically and ecologically viable. A legume-based pasture phase ('ley') benefits livestock production and soil structure. Further advantages are improved performance of future crops through increased availability of soil nitrogen, and improved infiltration of rainfall thus reducing erosion hazard and making efficient use of moisture. The pasture phase can be an effective break for crop diseases and weeds, and contributes significantly to sustainable farming.*

INTRODUCTION

The rangelands of native, naturalised and sown pastures are of paramount importance for profitable and continuous land use on large and small farms alike. The central requirement for sustainable long-term farming is that we use and work the land within its limitations. In most situations this demands the incorporation of a pasture rotation into the farming system.

A medium- to long-term pasture phase containing legumes and grasses (both perennials and annuals) is the best means available to heal the soil structural wounds of repetitive cultivation and annual cropping. Perennial-based pastures are a major part of the broadacre farmer's "**Permaculture**", with many of the benefits and advantages of this perennial based philosophy. Well-managed pasture will rejuvenate soil structure, stabilise the soil surface, increase rainfall effectiveness, reduce run-off., and improve soil fertility.

Natural pastures of the slopes and plains were relatively stable prior to cropping and the introduction of sheep, cattle and feral animals such as rabbits. Continuous cropping and the grazing demands of domestic and feral animals tended to eliminate palatable species which leads to an increase in the number and contribution of the less desirable species, and an increase in soil degradation.

Sustainable pasture management involves re-establishment of desirable pasture species and adoption of appropriate, environmentally sensitive grazing practices for both new pasture species and existing native pastures.

Long-term exploitative cultivation damages soil, reduces crop yields and eliminates pasture seed reserves from the system. After cropping and cultivation cease, the weed species which volunteer often have shortcomings in terms of grazing requirements and the environment.

Options available to minimise the effects of cropping activities on the soil environment include: (1) returning crop land to a permanent volunteer pasture; (2) establishing a long-term legume-based pasture phase; and (3) developing a "ley" rotation system incorporating crops and pastures. Traditional cropping land exhausted by long-term farming can be sown with a permanent productive improved pasture to run cattle or sheep which will benefit soil structure, reduce soil loss and in many cases improve profits.

BENEFITS OF QUALITY PASTURE

Livestock production

The obvious problems of mono-culture annual cropping include: reduction in yields, increase in pests, escalation in growing costs, variability in markets for grain, and an increase in soil degradation. Economically attractive alternative crops are limited, but grain legumes and oilseeds can provide alternative income, as well as benefit soil parameters and crop rotations.

Livestock production offers an alternative to cropping, especially if suitable pastures, water, fencing, handling facilities and shade *etc.*, are available. A combination of cropping with livestock brings obvious advantages, *eg.* home-grown grain for supplementary feeding, beef feedlots and piggeries, grazing fallows for weed control, income diversification, spreading of the labour requirements and more efficient utilisation of the bio-mass produced (*ie.* grazing off "failed" grain crops and crop residues).

High quality pastures containing a balance of perennial and annual legumes and grasses can significantly improve animal performance. If grazing management is effective, the benefits include:

1. Increase in carrying capacity, *eg.* four or more times that of natural pastures, depending on species and grazing system;
2. Increase in liveweight gain leading to quicker fattening and turn-off;
3. Improved conception and marking percentage;

4. Higher wool yield per head and per ha;
5. Reduced dependency on annual forage crops for periods of feed shortage or fattening;
6. Increased opportunity in favourable seasons to conserve surplus forage as hay or silage; and,
7. Improved drought tolerance.

Increased carrying capacity of improved pastures

With the exception of lucerne, research results are not available to indicate the increased carrying capacity of improved pastures. It is apparent though from farmer experience that dense, well-managed perennial grass and legume based pasture increases carrying capacity from 50 to 400% over volunteer pasture (following cropping).

In the case of lucerne, research at Trangie shows that carrying capacities of 10-12.5 DSE's/ha (dry sheep equivalents) are possible given intensive subdivision and rotational grazing management. Even with less intensive subdivision and management, a doubling of stocking capacity is possible in North West NSW. In more favoured zones such as Tamworth, typical mixed pastures containing lucerne phalaris and sub clover readily support 10 DSE/ha. Even higher capacity is possible on the best soil types.

Rate of liveweight gain

Rate of liveweight gain (LWG) is a major factor in profitable beef and lamb production. LWG on low quality pasture without much legume component is low, averaging around 250 gm/day for steers and 50 gm/day for lambs. However, on high quality lucerne or clover based pasture LWG often exceeds 1000 gm/day and 200 gm/day, respectively. Fast weight gain means rapid movement of young stock off the farm, and this quicker turnaround improves dollar returns due to the greater number of animals sold.

Average conception and marking percentages

Average conception and marking percentages of sheep and cattle leave significant room for improvement. The potential Merino conception rate is around 130%, but only about 120% is achieved in practice, and the average lamb marking is only around 75%. Similarly, the potential crossbred conception rate is around 180%, but average conception rate is around 150% and average lamb marking is around 120%. A convenient rule-of-thumb is that you can expect 2% extra lambs for every one kg of ewe liveweight above the critical liveweight at joining. The beef cattle potential conception is around 100%, but the average is about 85% and marking is around 80%.

Genetics and animal husbandry play a part in these figures. However, the quality and quantity of feed on offer is a major contributing factor over which managers can also exert control.

Simple checks such as manual fat scoring of ewes and beef cows pre-joining will allow separation of mobs for specific placement into pastures which can provide the correct level of nutrition well before joining.Critical liveweights for sheep at joining are: Merinos should weigh 40 kg plus; and cross bred ewes 45 kg plus. Ewes and beef cows should be 3 condition score plus, to ensure maximum conception rate. Check cows brisket, behind shoulder, loin, ribs and tail head areas for cover to determine condition score. Check ewes over the short loin and long ribs to determine fat score. See NSW Agriculture Agfacts A3.4.10; A3.3.35; and A2.3.26 for details on condition scoring sheep and cattle.

Table 1: Benchmarks for Pasture Mass and Length (Bell;Johnston)

Livestock Class	Minimum green herbage mass (t DM/ha)		Approx. pasture length of dense pasture (cm; 2.54 cm = 1")	
	Sheep	Cattle	Sheep	Cattle[A]
Dry	0.5	1.0 - 2.0	1.25	2.5
Mid Pregnancy	0.6	1.0 - 2.4	1.50	3.0
Late pregnancy	1.1	1.2 - 2.6	2.75	3.5
Lactation	1.5	1.0 - 3.0	4.50	9.0
Rapid growth	1.6	3.2	5.00	10.0

[A]Cattle consume much more than double the intake of sheep on per head basis so that the above table refers to feed on offer at a point in time and not to rate of consumption which is determined mainly by stocking rate.

Higher livestock production

Wool cut per head is extremely responsive to feed intake and quality, however the picture is not that simple. Wool sheep can survive and still grow some wool on a poor feed supply. This may give a micron benefit, but can also produce a tender fibre and destroy a valuable pasture asset through abusive grazing.

In contrast, beef and lamb production systems usually inflict less damage on the pasture resource because the need to maintain weight gain provides an automatic safety valve. This means that in practice, meat-producing livestock must be removed from defoliated pasture and onto fresh feed promptly to maintain the rate of weight gain which effectively protects pasture from overgrazing.

The foregoing items (1, 2, 3 & 4) are dependant on minimum levels of feed quality and availability. This has been quantified in experiments and guidelines determined as benchmarks or minimum requirements of "green herbage mass" for various classes of livestock. Table 1 gives these benchmarks for livestock.

Reduced dependency on forage crops

Annual forage crops are often important in the early stages of property development and for specific fattening purposes. However, in economic considerations and from a practice viewpoint, they are generally inferior to quality perennial-based pastures.

Fodder conservation

The fodder conservation option can be a significant advantage, especially on farms of limited size where maximum output is essential for viability. Practical limitations such as cost of machinery, labour shortage and suitability of the terrain tend to curtail opportunities for forage conservation on some properties.

Drought tolerance

The drought tolerance of a pasture is determined by factors such as depth of the root zone, tolerance to adverse soil conditions (*eg*. low P, acidity, and the physiological attributes of a species or cultivar (*ie*. "drought hardiness"), However, grazing management can also affect the performance of a species during drought. Highly improved pastures naturally tend to be grazed at high stocking rate and kept relatively short and leafy so that when pasture growth is curtailed by drought, available feed quickly diminishes unless stocking pressure is reduced.

Unimproved pastures usually with a body of tall dead residue and fairly modest stocking rate may appear to endure drought better than improved pastures. However, this is usually an illusion which can be dispelled if relative productivity is compared to over time.

Soils

Soil structure improvement

The positive effect of well-managed, productive pastures on soil structure is well documented. Good soil structure is basic to good plant growth as it improves rainfall penetration, moisture retention, soil gaseous exchange, root development and nutrient uptake.

The rate of soil organic matter and nitrogen rundown with continuous cereal growing is high. Cultivation and fallow accelerate these processes. Loss of organic matter weakens soil structure, increases susceptibility to compaction and reduces the ability of soils to withstand erosion and hold nutrients within the top soil.

Research at North Star has shown that soil structure, as measured by the size and number of water stable aggregates, is improved by pasture (see Murphy & Harte, Figure 1, this proceedings). Land cropped for 7 years and then returned to grass pasture for 3 years had three times more soil aggregates larger that 2 mm in size than land without pasture.

This is attributed to: (1) the ability of pasture, especially grass roots, to bind soil; (2) the cessation of aggressive cultivation, and (3) the trend for soil organic matter to increase when the land is returned to grass pasture. Microorganism and earth worm activity increase as organic matter levels rise, and assist soil structure by organically binding soil particles during the undisturbed pasture phase.

Research at Tamworth indicates that a lucerne pasture phase in the rotation depresses atrazine herbicide carry-over by increasing soil organic matter and nitrogen, and by lowering pH. This has obvious benefits for sorghum plus atrazine systems which are part of common crop rotations in N-W NSW.

Cultivation with disc implements progressively pulverises the soil into smaller fractions which increases the rate of organic matter decay and nutrient release. It gradually creates a soil more susceptible to surface crusting which hampers moisture penetration and emergence of seedling, particularly small seedlings of pasture species.

Implement weight, vibration transmitted through the soil, and clay smearing by tines and discs cause direct soil compaction. Under continuous cultivation and cropping, a plough pan can quickly develop in most soils.

Compaction is measured by changes in bulk density. High bulk density (>1.4 g/cm^3) retards root penetration and development (depending on soil moisture and texture), and impedes the movement of water in the soil (Murphy & Harte, Figures 5 & 6, this proceedings). Several years of vigorous grass and or medic pasture can lower bulk density (Murphy & Harte, Figures 5, this proceedings).

Fibrous root systems of grasses are recognised as being particularly beneficial to soil organic matter, although the tap root systems of legumes (particularly the deep system of lucerne) are also beneficial to soil structure. It is common knowledge among farmers that old grazing lucerne stands ca be ploughed in a higher gear than successively cropped paddocks.

Moisture is often the factor most limiting crop and pasture production. Improved soil structure due to a pasture phase and undisturbed root channels left by decaying pasture plants , dramatically increases water infiltration (Murphy & Harte, Figure 6, this proceedings). Any management strategy which improves rainfall retention in the root zone will generally improve production of crops and pastures, especially in drier seasons. However, once the soil profile is full of moisture, it should be used by an expediently sown crop or by perennial pasture to maximise productivity and avoid unnecessary run-off from further rainfall. This also has implications in the prevalence of rising water tables and the salinisation problem.

Nitrogen build-up

Pasture legumes nodulated with the correct rhizobia add significant amounts of nitrogen to the soil. This nitrogen promotes growth of companion grasses, and is most important for the following cereal crops.

Lucerne, clovers, annual medics and serradella *etc*., contribute to accumulation of soil nitrogen. Research at Tamworth showed that lucerne will raise total soil nitrogen in the top 15 cm of the profile by about 150 kg/ha/yr on well-structured black earths and by about 110 kg/ha/yr on less productive red soils. Three to four years of good lucerne pasture will "fix" enough nitrogen for about 5 wheat crops or 3 sorghum crops.

Large amounts of nitrogen only accumulate under well-grown, well-managed lucerne stands. If lucerne is overgrazed and never allowed to make bulky growth, the rate of accumulation is significantly reduced, irrespective of soil type.

In experiments in southern Queensland, the estimated nitrogen contribution by annual medics to crop or companion pasture grasses was equivalent to 70 - 100 kg/ha/yr. Experiments in southern farming areas indicate that mixed grass and legume pastures annually contribute an average of 61 kg/ha additional nitrogen. Where the pasture legume is grown without grass the average increase is likely to be doubled.

Nitrogen accumulated under pasture such as lucerne will be rapidly used up by nitrophilious weeds which will increase as the lucerne thins out over time. Therefore, if accumulated soil nitrogen is to be available to following crops, it is important to rotate out of lucerne into the cereal crop phase whilst the lucerne is still fairly free of weeds . In other words, you have got to plough out your lucerne while it is still too good to plough out.

To be sure of enough stored soil moisture for the forth-

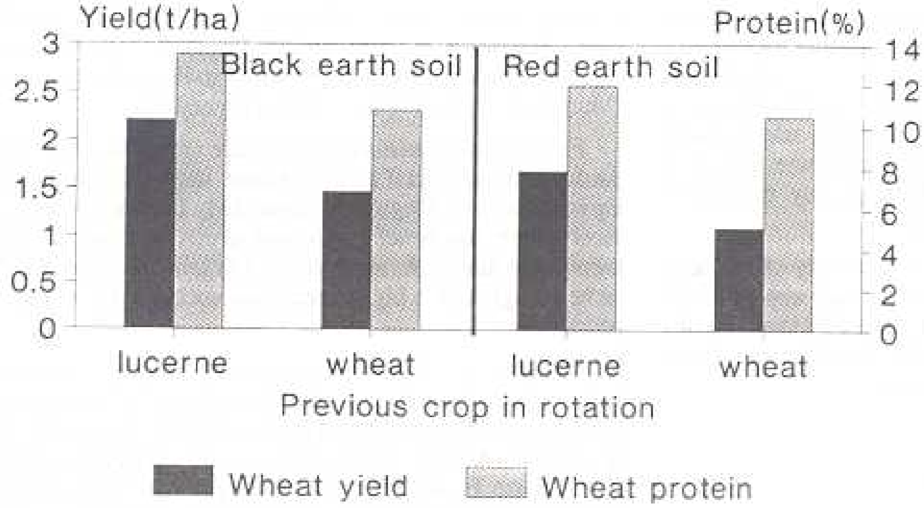

Figure 1: Wheat yield and protein improvement following a lucerne pasture phase on two soil types at Tamworth (I.C.R.Holford, unpublished).

grass control contribute significantly to sustainable production and profitability.

In most years, diseases cause a significant reduction in cereal grain yield. Integrated crop and pasture systems incorporating different crops and a pasture phase contribute to effective disease control and higher grain yields. Crop rotation is necessary because some diseases carry over on residues from crop to crop in a continuous cropping system. In addition, some diseases are carried by more than one type of cereal, and some grasses such as barley grass, annual phalaris and ryegrass also act as alternative disease hosts.

coming winter crop, lucerne should be ploughed out early. This is due to lucerne's great ability to extract soil moisture and dry out the soil profile to well over one metre. Winter crops should be sown on at least 60 cm depth of moist soil to ensure economic yields.

Cereal grain yield

The beneficial effects of the additional nitrogen were demonstrated at Tamworth on black earth where, compared to continuous wheat, the lucerne rotation produced an annual average grain yield increase of 600 kg/ha for no less than 7 consecutive crops (Figure 1).

In addition to the beneficial effects on soil nitrogen and structure, quality legume-based pastures are of special importance in cereal production for their role in breaking some disease cycles.

Grain protein

Grain protein content is central to wheat quality. Across the wheat belt during the last decade, there has been a steady decline in protein levels which has caused great concern within the industry. The problem is directly related to reductions in soil nitrogen levels. Legume-based pastures are one highly efficient and economical means of retrieving the situation.

Research at Tamworth (Figure 1) showed that wheat grain protein content was on average 3% and 1.5% higher on black earth and red clay soil types, respectively, after an initial lucerne phase when compared with grain protein from the continuous wheat system. The difference narrowed after several crops of wheat. Even where nitrogen fertiliser was applied to the continuous wheat at 45 kg N/ha, grain protein levels were inferior to those of the crops following lucerne. A similar picture has emerged from research in Victoria and Queensland, on the effects of a medic pasture ley on subsequent grain protein.

Crop disease break

Integrated crop and pasture rotations that incorporate other break crops and include appropriate, timely pasture

Root and foliar diseases of cereals are minimised by rotation with legume pastures, but volunteer host grasses in the pasture can reduce the disease break impact. Fusarium crown rot, take-all and common root rot infect wheat, barley, triticale and pasture grasses. The severity of these diseases is best reduced by rotation with a less susceptible crop after the pasture phase such as canola or grazing oats, or by reduction of the grass component in the pasture prior to cropping. Grass can be reduced by heavy grazing, silage or hay-making, or with application of herbicide in the year prior to commencement of the crop phase. Note that Yellow Spot is not carried over on grass hosts and is carried over on wheat and barley residues (K.J.Moore, *pers comm.*).

Fusarium crown rot is difficult to control because it persists in the stubble on crowns of previously infected hosts for at least one year. However, a pure legume pasture, such as lucerne, can reduce disease carryover to a level which allows wheat to grow successfully, provided grass hosts of the fungus are kept out of the pasture.

Weed control

A medium- to long-term pasture phase provides efficient control of many broadleaf and grass weeds. Prevention of seeding by grazing, spray-graze and/or pasture topping, and also hay or silage making over several seasons can eliminate most annual weeds and significantly check perennial weeds.

Vigorous, high quality pastures check weed growth by strongly competing for moisture, nutrients and light. However, the weed seed bank is not always sufficiently reduced by a single pasture phase. Some viable seed may remain where it was buried by earlier cultivation and germinate when conditions become favourable.

Wild oats is effectively controlled by four years of grazing lucerne. Table 2 illustrates the high degree of control by lucerne rotations at Norwin. This is strongly supported by trials at Tamworth as shown in Figure 2.

The fertiliser program used during the cropping phase often leaves residual nutrients such as phosphorus and sulphur which promote future pasture performance.

PASTURE-CROP MANAGEMENT

To assist overall farm planning and management, it is convenient to use land capability criteria to classify a farm into discrete or separate classes. The SCS farm planning service can help in this or it can be a good DIY project. Land slope, soil depth and soil fertility are the main criteria used for classification.

Using a five Class system, Class I land is easily identified as the best arable which is regularly used for cash cropping and even double cropping using appropriate sequences of winter and summer cereals, winter and summer oilseeds and most importantly winter and summer grain legume crops. It is seldom more profitable to sow to perennial pastures, although when crop returns are low, short rotation pastures for livestock fattening can be lucrative. At the other end of the scale, Class V includes hilly, rugged, heavily timbered, rocky areas which have no significant agricultural use.

The land Classes II, III, and IV are where pasture improvement really fit. Class II areas are arable and suited to a 40:60 pasture: crop rotation where pasture mixtures such as lucerne, Sirosa phalaris, Seaton Park and Clare sub clovers fit very well. Haifa white clover can complement such a pasture mixture, particularly for sheep, but is a major bloat risk for cattle. Four or more years of this pasture, followed by six years of crop works well. Many of the better red clay soils in the Slopes region fit into this category. Pasture establishment is usually achieved by undersowing the host crop, a technique which is highly successful when used within its limits. An example of a rotation for red clay soil is given in Table 3.

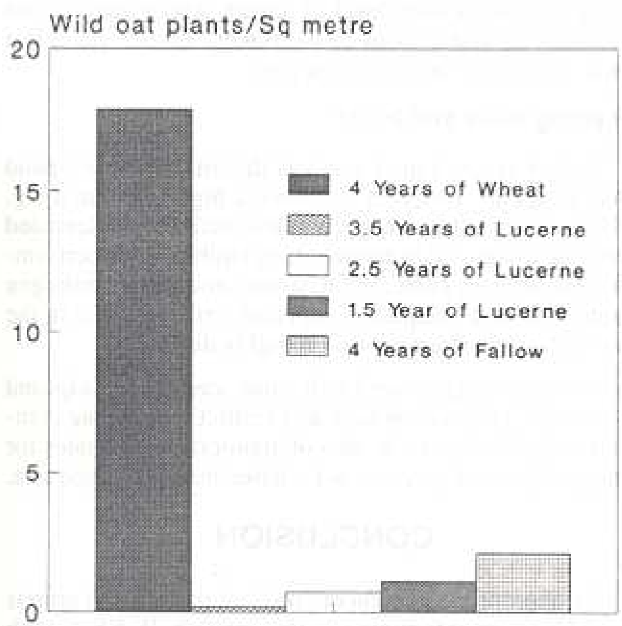

Figure 2: Wild oat density in the second wheat crop after lucerne pasture, fallow or wheat (McNamara *et al.*, 1975)).

Table 3: An example of a rotation for red clay soil.

Year	1	2	3	4	5	6	7	8	9	10	11	12
Crop	Barley & Pasture	Pasture				Graze Oats	Wheat		Barley	Faba Bean	Barley & Pasture	Pasture.....

Table 2: Four year lucerne rotation dramatically reduces wild oat seed at Norwin (30km west of Toowoomba) (Lloyd, Unpub, 1972).

Wild oat seeds/m^2			
Initial Population	Continuous Wheat	Wheat-sorghum rotation	After four years lucerne
1968	1972	1972	1972
225	2200	13	0

Class III land is of greater slope and/or a lighter, shallower soil type which responds well to a similar pasture mixture used on Class II, but only reverts to annual crop once or twice every eight to ten years. A variety of methods are used to establish pasture including: (1) undersowing a host crop; (2) preparing a seedbed for sowing pasture only (no host crop); and (3) using direct-drill techniques with herbicides. Direct-drill technique generally has a moderate success rate and many other practical advantages.

Class IV land is the non-arable hill country suited only to pasture and grazing use. Pasture improvement is restricted to relatively cheap techniques such as spreading fertiliser and clover seed by air. More intensive development which may be applicable to the better soils and higher rainfall parts of this land Class. Such development may include aerial herbicide application and seeding a complete pasture mix with phalaris, lucerne and clovers.

It is significant that about 70% of the northern NSW Slopes are native pasture often dominated by wiregrass (*Aristida ramosa*). The grazing strategy developed for these areas is capable of converting wall-to-wall wiregrass country at less than 2 DSE/ha to 5 DSE/ha wallaby grass pasture in 3 years with minimal fencing, the odd dam and a few Merino wethers. The strategy relies on encouraging wallaby grass (a valuable winter green native perennial grass) to take over from wiregrass by adopting heavy summer grazing and light winter grazing management. See NSW Agriculture Agfact P2.5.28 for more details.

GRAZING STUBBLES

Crop residues and volunteer weeds can be a highly valuable feed sources, particularly sorghum residues which often contain a significant amount of green leaf after harvest. As in most farm operations, managing stubble grazing involves a level of compromise. The feed value must be weighed against the disadvantages of soil compaction (especially after rain when the ground is soft and susceptible to hoof damage) and the soil moisture lost to weed growth.

Compaction

Compaction by livestock trampling and pugging when soil is soft can be devastating. The hoof pressure exerted by a stationary 50 kg sheep is around 1 kg/cm^2 or 10 t/m^2. The pressure exerted by a 500 kg cow is around 1.5 kg/cm^2 per square centimetre or 15 t/m^2. These pressures increases during walking. An average human pressure is around 12 t/m^2. To prevent permanent damage, it is essential to remove animals from crop residues and fallows whenever the soil is soft which means that relief paddocks need to be available.

A clay soil compacted by aggressive cultivation or trampling may have a bulk density of about 1.6 gm/cm^3 or greater whereas non-compacted soil under permanent pasture may be as low as 1.3 gm/cm^3 (Figure 2). A typical house brick has a bulk density of 1.8 gm/cm^3 which is almost one ounce/cubic inch.

SOIL MOISTURE

Moisture is often the most limiting crop growth factor and moisture accumulation in the root zone during fallow has a major impact on crop performance. A large part of potential wheat grain yield is determined by the stored soil moisture content at sowing. Rainfall during crop growth results in icing on the cake in good seasons and sometimes can salvage potential crop failures. Sowing a crop on less than 60 cm depth of moist soil is usually a risky practice.

Moisture depletion from fallows by weeds can jeopardise future crop prospects especially in below average seasons. However, when livestock returns are good, feed from such grazing may be a more profitable use of soil moisture than a low value crop. The manager's task is to weigh the pros and cons each season and hopefully arrive at the most profitable use of the soil moisture asset.

PASTURE/CROP ESTABLISHMENT

Pasture establishment with a cereal grain cover crop is one of the successful strategies used on the northern Slopes provided several limitations are recognised and good management practices are adopted. These included:

1. Reduce seeding rate of the crop to 20 kg/ha or half the normal rate, whichever is the lower. This reduces the competitive effect on pasture species which are much weaker than cereal seedlings, particularly in a dry spring.
2. Use separate seed delivery mechanism for cereal and pasture seed to place the cereal at 5 cm depth and pasture at 1 cm depth. A band seeder is the best machine to do this.
3. Use a roller to firm soil around pasture seed which is usually placed in the dusty surface. This will give more rapid, even emergence at least on equal terms with weeds. A cambridge roller is the ultimate machine and well worth the dollars. Note that rolling some hard-setting clay soils may not be advisable if surface crusting is likely.
4. Heavily cropped soils are often very low in available nitrogen (part of the reason to rotate into legume pastures) and must receive at least starter amounts of nitrogen fertiliser when sowing pastures. This is particularly important when establishing grass species such as Sirosa phalaris. Often such soils are deficient in phosphorus and sulphur and these must be added to obtain vigorous growth of both legumes and grasses. Compound fertilisers such as "Starter 15" or "13:15" are strongly recommended to be sown with pasture seed in these situations.
5. Sowing time on the Northern Slopes is an even more significant factor when sowing pasture with a cover crop. Sowing should be completed by the middle of June to allow sufficient root and top development before heat and moisture stress in spring. Risk of failure skyrockets with later pasture sowings. The added burden of the cereal crop easily tips the moisture balance in a dry spring, therefore sow pasture alone if forced to sow in July and abandon sowing pasture with crop if forced into August.

BLOAT RISK

Bloat deaths from white clover, lucerne and native medics cause serious financial loss and are unpredictable. However, there are a range of preventative and stock management measures which reduce bloat risk to an acceptable level and still give confidence in growing highly productive, but bloaty legume species.

Some of the recognised measures include regular 5-in-1 vaccination, blocks, licks and automatic plutonic administration in water troughs or capsules and various grazing techniques. Another measure is to use nitrogen fertiliser to increase the grass component and change grass:clover ratio. This works well in pastures with a fair population of grass but where soil are nitrogen deficiency.

New Zealand research indicates that docks (*Rumex* spp.) in the pasture can assist livestock to control bloat. Dock contains a high level of tannin which reduces the formation of stable foam in the rumen. Cattle will select dock specifically in bloaty pastures.

Seeding rates and bloat

A high proportion of grass in the mixture helps avoid bloat problems. However, to obtain a high proportion (*eg.* 60%) quickly after sowing is often difficult on degraded soils due to low soil nitrogen which inhibits grass performance but not the legume which has root nodules and nitrogen fixation. Use of adequate compound fertiliser sown in the row with or near pasture seed is highly desirable.

The ratio of grass seed to legume seed can be adjusted to raise the grass component and restrict the legume component. Table 4 gives an idea of appropriate seed rates for a range of pasture species , and is based mainly on seed size.

CONCLUSION

An appropriate rotation or "mix" of pasture and crop is available for most farming systems across N-W NSW, with a more generous choice of alternatives in easterly locations. The benefits and advantages of crop-pasture associations to economic and environmental well-being of the farm are blindingly apparent and there for our taking.

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Table 4: Comparative seeding rates for legumes and grasses with special reference to pastures suitable for cattle

Species	Seed no./kg	Seeding rate (kg/ha)
Legumes:		
Lotus	2.2 million	[A]0.4
White clover	1.6 million	0.5
Lucerne	440,000	2.0
Subclover	120,000	7.0
Vetch	30,000	28.0
Grasses		
Currie cocksfoot	1.8 million	[B]0.7
Sirosa phalaris	800,000	1.5
Perennial ryegrass	530,000	2.5
Demeter fescue	420,000	3.0
Wheat (for comparison)	30,000	4.2

Cattle pastures	Seeding rate (kg/ha)	Establishment (Plant/m^2)
Sirosa phalaris	1.5	25
Demeter fescue	3.0	25
Aurora lucerne	1.0	12
Seaton Park subclover	3.5	12
TOTAL	9.0	74

[A] Seeding rate required to give approximately 25 plants/m^2, assuming 30% establishment; [B] Seeding rate required to give approximately 25 plants/m2 assuming 20% establishment

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