THE POTENTIAL ROLE OF LEGUMES IN MAIZE GRAIN AND FORAGE CROPPING SYSTEMS

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ABSTRACT

Forage cropping systems for dairy or beef production frequently use maize as a warm-season crop followed by small grain cereals or annual ryegrasses in the cool season. Forage produced in such a system is generally low in protein and continuous cereal/cereal rotations are costly in terms of nitrogen inputs and allow some insect pests to remain a problem. The use of legume rotations may help overcome these problems.

Two forms of rotation seem possible: namely, one in which a perennial such as lucerne or the semi-perennial red clover alternates with maize and oats in a 2 to 4 year sequence on the same land; the other, where a cool-season annual legume (**Trifolium, Medicago, Ornithopus, Lupinus** or **Vicia** spp.), or summer dormant perennial (**Lotus, Coronilla** or **Astragalus** spp.) grows during the cool season in a double cropping system with maize. The advantages and disadvantages of these systems are discussed, together with preliminary data on the potential of some cool-season annual legumes.

The possible role of a self-regenerating cool season annual legume in improving land utilization and soil fertility under maize grain production is also raised.

INTRODUCTION

Overseas Practices

Legumes are well known for their ability to improve soil fertility by the fixation of atmospheric nitrogen, and to produce forage of high protein content. These features have led to the development in world agriculture of several ley farming systems where legume crops alternate with other crop types.

In mild climates with adequate rainfall, a complete legume-nonlegume rotation can be achieved within a twelve month period. In southern USA, for example, crimson clover (**Trifolium incarnatum**) seeded into crops of cotton or corn at the time of the last inter-row cultivation, later serves as a winter cover and soil improvement crop. A volunteer stand of clover can be maintained if a reseeding, hardseeded variety is used (Hughes et al., 1969). Other annual legumes such as vetches and shaftal clover (**T. resupinatum**) have been used in the same way. Recently, the use of the cool season active, partially summer dormant, perennial **Coronilla varia** (crown vetch) in the same role has been suggested (Hartwig, 1974). A warm-season maize, cool-season subterranean clover (**T. subterranean**) system has also been described for the Lockyer Valley of south-eastern Queensland (Schroder, 1959). Subterranean clover regenerated naturally and the two-crop system produced a yield of forage comparable to that of permanent white clover pastures in the area while requiring only 40 cm of supplementary irrigation compared to 90 cm for the pasture.

In many temperate agricultural areas, only one crop can be successfully grown each year because of water or temperature limitations, but here also important ley farming systems have developed. The evolution of a legume pasture-cereal crop rotation has revolutionised agricultural production in the cereal belt of South Australia since the late 1930's (Webber 1975). In this Mediterranean-type climate a legume pasture of naturally regenerating medics alternates with a cereal grain crop on neutral to alkaline soils, while on acidic soils subclover pastures are maintained for two to three years before being converted to a period of cereal production. These integrated systems produce grain and also quality forage for livestock and have improved soil fertility, soil structure, crop yields and overall farming stability in the area.

The growing of cereal crops following red clover or field beans has also been a traditional rotation in Britain (Bland, 1971), although other land use requirements and higher artificial fertilizer inputs have recently decreased these practices.

Possible New Zealand Systems

In New Zealand, maize for grain is an important crop on some of our best Waikato, South Auckland and Gisborne soils. These environments should also be capable of producing substantial growth from some cool-season forages, provided these forages can be established when the maize crop canopy begins to open up in early April, and provided the establishing plants are not excessively damaged during the later grain harvest. A naturally regenerating cool-season annual legume or summer-dormant perennial legume may suit these requirements. These legumes would add nitrogen to the soil and probably reduce the winter carryover of some insect pests of maize; for example, Argentine stem weevil and soldier fly (Esson, pers. comm.). More importantly, beef animals could be finished on this legume forage and maize stover during late winter-early spring and sent to the freezing works "off season" at some cash incentive.

Maize-based forage cropping systems for dairy or beef production in New Zealand could also benefit from the use of some form of legume ley system. In double cropping systems currently in use, maize silage crops are frequently followed by small grain cereals or annual ryegrasses. Conserved forage produced in such a system is low in protein, and fertilizer N inputs are high. Low protein crops need protein supplementation when used as feed for lactating dairy cows. Use of a legume rotation could partially or completely overcome these problems.

Two basic types of legume rotation are possible in a maize-based forage cropping system:

1. A predominantly warm-season active perennial crop such as lucerne or semi-perennial red clover could alternate with maize in a 2 to 4 year cycle.
2. A cool-season active annual (**Trifolium, Medicago, Ornithopus, Vicia, Lupinus** etc.) or winter active, summer dormant perennial (**Coronilla, Lotus, Astragalus** etc.) could be grown during the cool season in a double cropping system with a warm season maize crop.

These systems are discussed below. Good paddock scale yields have been assumed as a reasonable basis for comparing the systems (Elliott, 1967; Anderson, 1973; Dyson and Douglas, 1975; Eagles and Taylor, 1975).

SYSTEM 1 (a)

Lucerne grown for 4 years, followed by maize and oats in a two crop rotation for 4 years, then back into lucerne. Another equivalent area of the farm would be maintained in the same sequence, but 4 years out of phase with the above.

Yields

Maize 20,000 kg/ha
Oats 12,000 kg/ha
both at 8% CP*
Lucerne 14,000 kg/ha/a at 18% CP*
= 23,000 kg/ha/ annum (11% CP in total forage).

Advantages

- legume can be summer grazed for dairying;
- technology is reasonably well established;
- system provides an adequate forage crude protein content.

Disadvantages

- some soil types are not suited to lucerne;
- long legume rotation may be less efficient in N fixation;
- possible fungal and insect problems exist with lucerne, particularly on dairying country.

SYSTEM 1 (b)

Red clover grown for 2 years, followed by maize and oats in a two crop rotation for 2 years, then back into red clover. Other areas of the farm would be maintained in the same sequence, but 2 years out of phase with the above.

Yields

Maize 20,000 kg/ha
Oats 12,000 kg/ha
both at 8% CP
Red Clover 12,000 kg/ha/a at 18% CP
= 22,000 kg/ha/annum (10.5% CP).

*CP = crude protein.

Advantages

- legume can be summer grazed for dairying;
- established technology;
- reasonable rotation time of 2 years;
- red clover can be grown on most cropping soils.

Disadvantages

- probably lowest yielding system of the alternatives discussed.

SYSTEM 2 (a)

A naturally regenerating cool season legume alternating with maize. The legume could be a free seeding annual or a perennial that was semi-dormant over summer.

Yields

Maize 20,000 kg/ha at 8% CP
Legume 5,000 kg/ha at 14% CP
= 25,000 kg DM/ha/annum (9.2% CP)

Advantages

- potentially the lowest cost system with the best chance of using reduced cultivation;
- best system in a maize grain situation;
- ideal rotation time for efficient soil N utilization.

Disadvantages

- legume must be conserved in spring in a dairying situation;
- legume forage quality (CP content) may be partially sacrificed to allow reseeding;
- no technology has been established.

SYSTEM 2 (b)

A double cropping system involving maize followed by a late maturing cool season legume. The legume would be resown each autumn at high seeding rates and harvested while flowering in the spring.

Yields

Maize 20,000 kg/ha at 8% CP
Legume 6,000 kg/ha at 18% CP
= 26,000 kg DM/ha/annum (10.3% CP)

Advantages

- this system gives the highest yield per hectare and a reasonable protein content in the conserved forage;
- short rotation time should allow good N utilization;
- could possibly be used in a maize grain situation by sowing the legume during final inter-row cultivation of the maize.

Disadvantages

- legume must be conserved in spring;
- no technology has been developed;
- weed control in both crops may be a problem.

No attempt has been made to assess the relative costs/kg DM of the various legume ley systems because many uncertainties remain as to their actual operation. However, systems with reduced cultivation or increased grazing are likely to be lower in cost providing yields can be maintained.

New Zealand Experience **with Potential Forage Ley Legumes**

High nitrogen levels built up under good ryegrass-white clover pastures have been used to grow cereal crops in New Zealand for many years, but shorter term pure legume leys have been used much less frequently. Some information is available on the management and productivity of lucerne (Elliott, 1967) and red clover (Anderson, 1973; Smetham, 1973) in the North Island. Detailed information comparing red clover and lucerne in New Zealand is not available, but red clover should produce acceptably on a somewhat wider range of soils (Fergus and Hollowell, 1960), while on soil types suited to both crops, lucerne is likely to be the most productive. Little is known of the potential of cool season active annual legumes in a forage cropping role. Some annuals of this type are already naturalized in the North Island; for example, **T. subterranean** has proved a valuable and productive species on dry East Coast hill country (Levy, 1970), several **Medicago** spp. are naturalized on coastal sands and dry hill country (Levy, 1970), while **Ornithopus pinnatus** persists in many Northland pastures (Halliwell, 1960). In pure sward evaluations, **Ornithopus sativus** has outyielded **T. subterranean** on coastal sands in the Manawatu (Williams et al., 1975).

During the winter of 1975, small exploratory trials were conducted in Northland, where a number of cool-season active annuals were planted in mid-April and harvested once, twice or three times up until late October. Maximum yield of all species was obtained when only a single final cut was made, and were in the order:

Ornithopus sativus > **Medicago littoralis** cv. Harbinger > **Trifolium cherleri** cv. Yamina > **Medicago tornata** cv. Tornafield > **Vicia dasycarpa** cv. Namoi > **Trifolium vesiculosum** cv. Yuchi > **Trifolium hirtum** cv. Sirint and cv. Hykon.

Highest forage protein contents during mid-spring were maintained by **Ornithopus** and **Vicia,** which was similar to Australian experience (Gladstones and Loneragan, 1975). The yield potential of later flowering adapted types in Northland in a one or two-cut system planted in mid-April and finally harvested in mid-October is approximately 6,000 kg DM/ha. More detailed trials with a wider range of species are under way this season.

DISCUSSION

Ensiled or greenfeed maize has been utilized ineffectively on many New Zealand dairy farms, with little appreciation of its nutritive limitations when used to supplement droughted, low-protein summer pasture. Another problem has been the poor integration of supplementary feeding and effective pasture utilization on dairy farms. When supplements are fed cows do not forage well, so limited supplementation will spare pasture but may not increase animal production (Matthews, 1975). The ability to largely replace grass with conserved forage at some times of the year will be necessary to achieve both animal production and pasture management flexibility.

Maize-legume forage systems could be used to partially or totally replace pasture because of their more nutritionally balanced protein and mineral content. Blended conserved feed from the "cool season" legume systems may still require some concentrate additions when fed to lactating animals, but the ratio of cereal to legume forage and hence of protein in that forage, could be varied to suit animal requirements in the "warm season" lucerne and red clover systems.

Little is known about the quantitative N fixing ability of the annual legumes, but they do nodulate and grow well in Northland. Nitrogen fixation by white clover falls as the N status of a soil increases (Sears et al., 1965), so it may be that longer term perennial legume leys would not be as efficient overall in N fixation as shorter leys. Loss of nitrogen by leaching from the warm and cool-season legume systems could also differ. More research on these issues is required.

Insufficient information is currently available to finally recommend any one system over another, but preliminary data do permit one generalisation; in cooler zones of the North Island, "warm season" legume systems may prove more practical because of poor late autumn and winter growth of the "cool season" annuals. The "cool season" annuals seem capable of adequate production in warmer climatic zones. More information on the legume phase of these forage systems will be required before better decisions can be made on their relative merits; particularly information on yield, forage quality, weed control, N fixation and reduced cultivation establishment of maize in legume stubbles. When this data is available, comparisons between legume ley and totally cereal-based forage systems (maize/oats), which require higher N inputs and may require protein and mineral supplementation, will also be possible.

Less contentious are the potential benefits of a naturally regenerating cool-season legume in a maize grain system, because here forage and N are produced by the legume when the ground would otherwise be fallow. Seed survival of the annual legume during summer (Hagon, 1974), weed control, pugging of wet soils by stock and techniques for rapid maize establishment will likely be problems requiring research attention.

Maize-legume systems are already used to some degree in New Zealand. A good example is Borthwick's beef wintering "feed lot" at Feilding (Marshall, 1975) which has been developed to supply beef to specialized quality markets or to even the flow of carcases through the freezing works. The development of "farm scale" conserved feeding systems of this type will play an important role in achieving better market flexibility for our primary products, improved economy within our killing and transport industries and greater overall primary production.

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