# CONSERVATION BASED FORAGE CROP SYSTEMS FOR MAJOR OR COMPLETE REPLACEMENT OF PASTURE

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## ABSTRACT

Forage crop cultivars capable of forming high yielding, conservation based, forage production systems are available for the North Island of New Zealand. Three basic systems are discussed, along with some modifications that could be made to these for specific purposes.

A system comprising a warm season maize crop followed by a cool season oat crop, with both conserved as silage, should produce 31,000 kg DM ha$^{-1}$ annum$^{-1}$ on good sites at high inputs of fertilizer nitrogen. Silages produced are suited to growing and/or finishing cattle greater than six months of age, or as a supplement to pasture in a dairying system.

Integration of a red clover ley with the maize/oats system reduces yield to around 24,000 kg DM ha$^{-1}$ annum$^{-1}$, but provides a better balanced ration for dairying at much reduced nitrogen fertilizer inputs.

A warm season maize, cool season annual legume (*Ornithopus sativus*, serradella or *Medicago polymorpha*, burr medic) system is also possible in areas with mild winters. This should produce around 27,000 kg DM ha$^{-1}$ annum$^{-1}$ of conserved feed, provided wilting and acid additives can be used to produce well preserved legume silage. A combination of maize and legume silages would be reasonably suitable for dairying, or the system could be used to supplement pasture with the legume being grazed.

The main advantage of these systems is their high forage yield, provided good agronomy and sites with effective drainage are used. Conservation on a large scale also allows animal production systems to be disconnected from the seasonal constraints of pasture growth. Extensive use of these systems would require increased internal production of quality protein concentrates (for dairying), possibly from the fish industry, and local production of fertilizer nitrogen would also be advantageous.

Levels of animal production, fertilizer use and conservation costs inherent in these systems can only be accurately quantified when they are fully tested on a farm or farmlet scale.

## INTRODUCTION

Conservation based forage crop systems and grazed pasture have been compared by Mitchell (1970, 1974). Forage crop systems usually produce more forage but often at greater cost than grazed pasture. At the present international prices and level of demand for our primary products, conservation based forage cropping systems are likely to find most use in a pasture supplementary role in dairying (Linton, 1978). However, some use has already been made of such systems for the "out of season" production of beef (Brown, 1976) and an increase in this type of use could be justified in both the meat and dairy industries as the capital cost of greater processing capacity and the difficulty of retaining skilled labour in meat processing both increase. Future improved international demand and prices for our agricultural products may also warrant substantially increased New Zealand production, provided this remained cost competitive.

Further theoretical argument on the pros and cons of conserved forage crops compared to grazed pasture will not resolve the issue. What must be done now is to test the best forage crop options that have been developed in both small plot trials on a wide range of sites and, more importantly, on a research farmlet and practical farm scale so all inputs and outputs can be quantified.

This paper describes three basic forage cropping systems which can completely or in part replace pasture; also how to operate them and what to use them for. Some of the agronomy inputs given, particularly fertilizer, can only be treated as broad recommendations and will vary from site to site.

## SYSTEM 1: MAIZE AND OATS

This involves a double crop rotation with maize grown in the warm season and oats in the cool season. Oats would be planted in early April and harvested in late October; maize would be planted in early November and harvested late March.

**Varieties:**

A maize hybrid of 110 to 120 day RM (relative maturity) would be used in warm climatic zones and of 90 to 100 day RM in cooler areas. Either of the crown rust resistant Florida oat lines Ab113 or F501 (Eagles and Taylor, 1976) could be used.

**Agronomy:**

Site should be flat to lightly rolling with good drainage and at least reasonable summer moisture. Soil pH could vary widely from 4.5 to over 7.0, but around pH 6 would be preferred.

**Planting** of the system would commence by ploughing out of pasture in autumn. Control any perennial weeds by using dicamba for docks and glyphosate for kikuyu, paspalum or couch before ploughing. Sow oats at 80 kg ha$^{-1}$ with a drill, or broadcast and disc in. Generally, no fertilizer, herbicide or pesticide should be required for this first oat crop. In spring sow maize at 70-100 x 10$^3$ plants ha$^{-1}$ with starter fertilizer drilled at around 24:24:24 kg ha$^{-1}$ of N:P:K and a further 25 kg N ha$^{-1}$ supplied post emergence. Establish maize using moderate cultivation (plough/disc/harrows), reduced cultivation (tines or discs) or by direct drilling; although direct drilling can entail greater risk on some sites. Use herbicides suited to the district and soil, but replace half to all of any atrazine with an equivalent amount (a.i.) of cyanazine to avoid subsequent damage to oats by atrazine residues. When using direct drilling, additional chemical control of Argentine stem weevil or slugs may be required. After removal of maize, direct drill oats into the maize stubble after first grazing any tall weed growth.

Fertilizer inputs will increase in succeeding years if cropping on the same site; maintain maize starter at the initial rate and increase total application to an annual level of 230:60:120 kg $ha^{-1}$ of N:P:K by the fourth year and thereafter retain at this level. Apply one third of the annual total to the oats. If animal manure is returned to the land, fertilizer inputs can be decreased. Some lime may also be required, particularly when using direct drill maize establishment (Blevins *et al.*, 1978).

**Harvesting** of both crops would involve fine-chopping and storage in trench type silos. Harvest maize at the dent stage of maturity (approximately 35% DM) and ensile directly. With oats, cut at the milk stage of grain maturity then condition and wilt from 25 to 35% DM over an 8 to 16 hr period, before fine-chopping and ensiling.

**Yields:**

| | |
|---|---|
| Maize | 18,000 kg DM $ha^{-1}$ (as cut) |
| Oats | 13,000 kg DM $ha^{-1}$ (as cut) |
| | = 31,000 kg DM $ha^{-1}$ $annum^{-1}$ |

These yields are considered to be those attainable by good farmers on good sites in the Waikato and are below those recorded in research trials (Taylor *et al.*, 1976; Thom, 1977). Maize yields will be decreased most by weeds and pests, summer drought, lack of fertilizer or cool summers; while oat yields by poor winter drainage, late planting, lack of fertilizer or cold winters.

**Nutritive quality:**

The nutrient compositions of typical maize and oat silages are shown in Table 1, along with the feed compositions required for some animal production systems. It is clear that maize silage is low in protein and several minerals, while oat silage is low in energy and protein. The nutritive quality of oat forage could be improved by earlier harvesting (Taylor *et al.*, 1976), but this would decrease yield and increase the required wilting.

**Animal systems:**

*Beef.* Heifers, steers or bulls over six months of age could be fattened at a LWG of close to 1 kg $day^{-1}$ using *ad lib.* maize silage + 1.3% urea + 0.5% meat and bone meal (both on DW basis) plus access to salt (sodium chloride) blocks. *Ad lib.* oat silage + 0.5% urea should achieve LWG's of around 0.5 kg $day^{-1}$; but addition of grain would increase energy content and hence rate of weight gain. Younger animals fed on either of these silages would require additions of natural protein and greater mineral supplementation.

*Dairy.* Extensive protein supplementation would be required to achieve reasonable lactation on either

TABLE 1: Animal nutrient requirements and the nutrient content of forage crops and supplements. (All data are on a dry weight basis.

| | | Energy | Protein | | Mineral Nutrients | | |
|---|---|---|---|---|---|---|---|
| | | ME K cal $kg^{-1}$ | Nx6.25 % | Digestible % | Ca % | P % | Na % |
| **Animal requirements** | | | | | | | |
| Lactating cow (20-30 kg milk/day) | * | 2300 | 15.0 | 11.4 | 0.47 | 0.35 | 0.18 |
| Dry cow (maintenance) | * | 1900 | 8.5 | 5.1 | 0.34 | 0.26 | 0.1 |
| Growing steers of 200 kg (at 0.75 kg LWG/day) | * | 2500 | 11.1 | 7.1 | 0.36 | 0.28 | 0.1 |
| **Forages** | | | | | | | |
| Maize silage | | 2530* | 7.0 | 4.0 | 0.35 | 0.18 | 0.04 |
| Oat silage | | 2133* | 9.0 | 5.0 | 0.37* | 0.30* | 0.17* |
| Red clover (fresh, early bloom) | * | 2314 | 18.7 | 12.0 | 1.76 | 0.29 | 0.20 |
| Red clover (sun-cured hay) | * | 2133 | 14.9 | 8.9 | 1.61 | 0.22 | 0.15 |
| Serradella (taken as cut) | | 2170* | 18.7 | 12.0 | 1.22 | 0.31 | 0.60 |
| **Supplements** | | | | | | | |
| Meat and bone meal (50% protein) | * | 2604 | 53.8 | 49.0 | 11.25 | 5.39 | 0.78 |
| Fish meal | * | 2676 | 68.7 | 63.9 | 8.55 | 3.92 | 0.19 |

* Data from Anon, 1970 and 1971.

of these silages. During droughts, town supply cows have been milked for up to two months on maize silage plus 1.5% urea, 2.0% meat and bone meal (50% protein) and 0.4% salt; but this cannot be recommended as a continuous ration. Additional fibre as 10% red clover or lucerne hay, and natural protected protein as 5% fish meal, fed with the urea and mineral additions as above would provide a better ration, though some reports (Hemken and Vandersall, 1967) indicate that maize silage can form the sole roughage in dairying diets. Oat silage with limited protein additions could be used towards the end of lactation or as a dry cow ration. Prolonged exclusive use of either of these ensiled forages would also require addition of vitamins.

**Specific features:**

The maize/oats system produces very high yields of conserved forage and would be ideal to supplement seasonal deficits in pasture production. It would require substantial supplements of natural protein if used as a complete system for dairying. Quality protected protein could be produced as a byproduct from an enlarged New Zealand fishing industry, or vegetable protein from oilseed rape, soyabeans or lupins.

The system requires high fertilizer inputs, especially of nitrogen, but these could be reduced by field return of animal dung and urine. Both crops lend themselves to establishment by "reduced cultivation" techniques which conserve time and energy.

The wheat cultivars Arawa (late maturing) and Karamu (early maturing) could be substituted for Florida oats, but could lodge and would reduce yield (Taylor *et al.*, 1976). Planting of a vetch (*Vicia* sps) with the oats would improve the protein content and general nutritive value of a combined silage.

If used on around 20% of an otherwise pastoral dairy farm, significantly earlier calving could be achieved by using maize silage to supplement early lactation and by feeding oat silage to dry stock to permit greater saving of autumn pasture. This would allow some spreading of seasonal milk supply patterns to a factory.

## SYSTEM 2: MAIZE AND OATS WITH RED CLOVER

A maize and oats rotation (system 1) would be grown on half the farm and a pure stand of red clover on the other half. These two areas would be rotated every two years. An early maturing wheat would be substituted for the Florida oats in the final year of the cropping phase to allow establishment of the red clover in early October.

**Varieties:**

Maize and oat varieties as in system 1. The red clover cultivar Turoa for a 2 year ley or cv. Pawera for a 3 to 4 year ley. The early maturing wheat cv Karamu would be used when changing phases.

**Agronomy:**

The site would need to be similar to that in system 1, but good summer soil moisture for red clover growth would be important. Maize and oats would be grown as previously, but with all atrazine herbicide replaced by cyanazine. Fertilizer inputs would be changed to a basal dressing of 600 kg $ha^{-1}$ of 30% potassic superphosphate per annum over the whole area, assuming that return of animal dung occurred by grazing of red clover etc. Maize in the first year out of red clover would receive starter fertilizer containing around 24 kg N $ha^{-1}$, but an additional 100 kg N $ha^{-1}$ would be supplied to the cropping phase in the second year out of red clover.

Both maize and oats (and wheat) would be conserved as fine chop silage at around 35% DM. Red clover would be grazed, although it could be cut and carried with surpluses conserved as hay or wilted (40-45% DM) silage. Cutting or grazing of red clover would be at the early flower stage where possible.

**Yields:**

| | | |
|---|---|---|
| Maize | 18,000 kg DM $ha^{-1}$ | |
| Oats | 13,000 kg DM $ha^{-1}$ | |
| Wheat | 9,000 kg DM $ha^{-1}$ | |
| Red clover | 12,000 kg DM $ha^{-1}$ | warm $season^{-1}$ |

Over a four year period, each piece of land would have x2 maize crops, x2 oat crops, x1 wheat crop and x2 warm season periods of red clover; giving an average total yield of 23,750 kg DM $ha^{-1}$ $annum^{-1}$.

**Nutritive quality:**

The nutrient composition of wheat silage would be similar to that of oat silage. Earlier cutting of cereals would improve protein and energy content but substantially reduce yield. Fresh cut red clover should have good protein and mineral composition with reasonable energy content for dairying; but red clover hay or silage would be lower in energy and digestible protein.

**Animal systems:**

This system is best suited to dairying and not beef. Cows would be given a ration of 2:1 maize silage to red clover (DW basis) for two-thirds to three-quarters of their lactation, then 2:1 oat silage to red clover for the remainder. Dry cows would be fed mainly oat or wheat silage with some red clover hay. The lactation ration would be supplemented with 1.0% meat and bone meal, 1.5% urea and 0.4% sodium phosphate (monobasic), all on a DW basis.

**Specific features:**

Red clover added to a maize/oats system sharply reduces nitrogen fertilizer inputs and provides a more balanced ration for dairying. Forage yield is reduced, though this still remains at almost twice that of conventional pasture (Campbell *et al.*, 1977).

Calving date would need to be substantially later than normal to allow sufficient red clover growth in spring before lactation commenced. This would create a significant change in the seasonal supply of milk and could be used to spread the seasonal intake of a factory.

A more permanent (5 to 6 year) lucerne or pastoral ley could be substituted for red clover in this general type of system. A pasture composed of prairie grass cv. Matua, white clover cv. Pitau and red clover cv. Pawera may be suited to a cut and carry system although no research information is available. A conventional calving date would be used, more fertilizer nitrogen required and yield would be approximately the same as the red clover system, although this yield would be less sensitive to summer moisture deficits.

## SYSTEM 3: MAIZE AND COOL SEASON LEGUME

This involves a double crop rotation with maize grown in the warm season and a winter active annual Mediterranean type legume in the cool season. Only sites with reasonably mild winters are suitable. The legume would be planted in early-mid April and harvested mid-late October, with maize planted promptly after removal of the legume.

**Varieties:**
The legume sown could be either *Ornithopus sativus* (serradella at 15 kg $ha^{-1}$) or *Medicago polymorpha* (burr medic at 20 kg $ha^{-1}$), although several other types are being screened (Taylor *et al.*, 1978a). Legume seed would be sown in early April and the crop harvested in mid-late October. A maize hybrid would be chosen of suitable maturity to fit the 5 to 6 month warm season period that remained.

**Agronomy:**
The site should be within the warm climatic zone (Gerlach, 1974), although these legumes have grown reasonably well on sheltered, well drained sites in the Manawatu. Good winter drainage is essential for effective legume growth. Serradella suits light sands and silts and even well drained peats. It will grow at low soil pH (range pH 4.0-6.5), but will not tolerate flooding. Burr medic also prefers lighter soils, but will tolerate finer, heavier soils and prefers higher pH's (range 5.0-7.5). Most soils do not contain effective rhizobia for either of these legumes and good nodulation is essential for their establishment and subsequent growth. Use lime coated* (*Rhizobium* NZP 4018) burr medic seed and rock phosphate coated* (*Rhizobium* PDD 3154) serradella seed in the first year and sow into a moist seedbed. Coating of seed and seedbed moisture should be less important in succeeding years. Legume seed must be sown into a reasonably fine, firm, weed free seedbed, although cultivation could be shallow. Selective weed control by herbicides is extremely difficult, so legume seeding rates should be kept moderately high and they should not be sown on sites known to have substantial populations of winter growing weeds.

Both legumes will respond to phosphate (de Ruiter and Taylor, 1977), so fertilize with 500 kg $ha^{-1}$ of 15% potassic superphosphate prior to planting. Burr medic will probably respond to lime at soil pH's below 6.0 (Robson and Loneragan, 1970). A good stand of these legumes should fix substantial quantities of nitrogen, so fertilizer nitrogen inputs to the succeeding maize crop can be reduced. When establishing maize use a starter at around 24:24:24 kg $ha^{-1}$ (N:P:K) and a further incorporated dressing of around 26 kg N $ha^{-1}$ and 41 kg K $ha^{-1}$. This will provide a total annual dressing of 50:64:100 kg $ha^{-1}$ of N:P:K. These levels could be reduced if dung and urine returns are made or on sites recently out of good pasture. Maize could be direct drilled into the legume stubble if the legume has effectively suppressed weeds, but slug control may be required. Replace atrazine with cyanazine for weed control in the maize.

Techniques for conserving the legume during late October are the biggest uncertainty in this system. Legume forages do not ensile well because of low sugar and high protein content, so they would need to be wilted. Wilting of a heavy bulk of soft, low dry matter forage would not be easy in spring, so attempting to make hay would be even less practical. A combination of acid treatment (formic acid etc., Barry *et al.*, 1977) and some wilting prior to ensiling would probably be the best approach.

**Yields:**

| | |
|---|---|
| Maize | 18,000 kg DM $ha^{-1}$ |
| Legume | 9,000 kg DM $ha^{-1}$ |
| | = 27,000 kg DM $ha^{-1}$ $annum^{-1}$ |

These legume yields are for areas with mild winter climates. Colder winter conditions would reduce yields to approximately 6,000 kg DM $ha^{-1}$ (Palmerston North; Taylor *et al.*, 1978a).

**Nutritive quality:**
The nutrient content of serradella forage taken as a single bulk cut in late October (Taylor *et al.*, 1977) is shown in Table 1. Effective conservation as partially wilted, acid treated silage should retain most of the digestible protein and metabolizeable energy of the fresh forage.

**Animal systems:**
With beef animals, a composite ration of maize and legume silages should be capable of producing a live weight gain of 0.7 to 0.8 kg $day^{-1}$ on 250 to 350 kg steers or heifers with only small additions of urea.

Used for lactating dairy cows, a composite maize/legume ration may be only marginally low in some minerals (e.g. phosphorus), but would still require substantial protein supplementation.

**Special features:**
This maize/legume system should give good yields on suitable sites and permit substantial reductions in fertilizer nitrogen inputs into continuously cropped maize. It should also produce a better balanced animal ration than maize silage alone.

If used to provide additional feed on a pasture based, factory supply dairy farm, maize silage would be used for winter conditioning of dry cows and early spring supplementation, while legume silage would provide an ideal supplement to dwindling pasture supplies in late summer. Another alternative with less risk would be to break feed the legume to lactating cows during October and thus allow a surplus of pasture to build up. This surplus pasture would be easier to conserve as quality silage than the legume and would form an adequate summer supplement.

These legumes make most growth in the spring and do not tolerate frequent and close cutting (Taylor *et al.*, 1978b). This makes them unsuited to cut and carry systems extending through the winter period. A mixture of a cereal greenfeed (40 kg $ha^{-1}$) and Tama ryegrass (15 kg $ha^{-1}$) grown in alternation with maize would provide a more suitable system for multiple

* Available from Coated Seeds, Christchurch.

cutting through the winter-spring period.

## FARM TESTING OF A CUT AND CARRY SYSTEM

A major uncertainty in the forage crop systems discussed is not so much the amount of dry matter produced, but the animal production attainable from this forage. Bob Kirkham, a farmer at Te Awamutu, is operating a cut and carry forage crop based system for dairy production on part of an otherwise pasture based conventional dairy farm. Bob was interested to learn if per cow and per hectare production could be improved by better feeding and by housing of stock to decrease maintenance feed requirements. This operation has given some useful information on animal production.

Half of a 9.7 ha area was sown to maize (hybrid PX610) for silage and Tama ryegrass direct drilled into the maize stubble in autumn. The other half of this area was maintained in conventional ryegrass/clover pasture. Around fifty dairy cows housed in a barn were fed a combination of the forages produced from this area. A separate and larger herd was grazed on 80 ha of pasture remaining on the property. Tama and pasture were cut and generally wilted, then carted to the housed stock. A small amount of maize grain was fed in early lactation to both herds. The housed herd had a conventional calving date and was fed combinations of Tama plus maize silage followed by pasture plus maize silage during lactation, then mainly maize silage when dry.

Production by the housed herd was substantially above that of the grazed herd during 1977/78, namely:

| | Forage cut/carry system | Grazed pasture kg fat | Ruakura No. 2 (average) |
|---|---|---|---|
| Production per cow | 173 | 163 | 157 |
| Production per hectare | 856 | 461 | 543 |

No replacements were carried with the housed herd, but it contained an abnormally high proportion of heifers and bought in stock. Neither pasture nor forage crop yields were measured, but the following are considered to be reasonable estimates of feed as provided to the cows.

| | | |
|---|---|---|
| Pasture | 13,000 kg DM $ha^{-1}$ | (total annual) |
| Maize silage | 17,000 kg DM $ha^{-1}$ | (warm season) |
| Tama ryegrass | 6,000 kg DM $ha^{-1}$ | (cool season) |

With these assumptions, each of the housed cows should have received around 3,400 kg DM $annum^{-1}$ which is close to that necessary for the production achieved. Milk produced in the cut and carry system was therefore consistent with that expected from the forage system used and was substantially higher than that of grazed pasture on the same farm or on the highest producing pasture research farmlet at Ruakura (Campbell *et al.*, 1977).

This is an encouraging result using an untuned system operated without mineral or protein supplements and using a pasture well suited to grazing, but possibly not to cut and carry.

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