



2002 SCHOLARSHIP REPORT
(Completed: July 2005)

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Topic: Growing Cattle Feed Hydroponically

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Executive Summary

Hydroponic Fodder is essentially the germination of a seed (such as malt barley or oats) and sprouted into a high quality, highly nutritious, disease free animal food. This process takes place in a very versatile and intensive hydroponic growing unit where only water and nutrients are used to produce a grass and root combination that is very lush and high in nutrients. This green fodder is extremely high in protein and metabolisable energy, which is highly digestible by most animals.

This method of producing green fodder has many advantages for the farmer, the economy and the environment. These advantages include –

Reduced Water Usage

Marginal Land Use

Constant Food Supply

Reduced Growth Time

Reduced Labour Requirement

Cost effective

High Nutritional Value

Completely Natural

Unfortunately there are also disadvantages in growing fodder in such a controlled, humid, moist environment. Some of the problems that effect the yield production are MOULD, BACTERIA and FUNGI. However this problem can be combated through –

- Sterilising the grains surface to eliminate any mould spores on the grain
- Sterilising all surfaces in the growing area with chlorine or iodine
- Excellent shed ventilation
- The use of sufficient and the correct ratio balance of nutrients in the watering system.
- Through the use of Sulphur, a natural substance, found in an organic matter known as – Superior (a crushed rock product) – has mould-inhibiting properties.

To improve this method of growing cattle fodder, CO₂ can be injected into fodder sheds. Research under taken in Canada with Jim Ennis of Lethbridge, demonstrated that CO₂ injection into the fodder shed cuts the growing time of Malt Barley from 7 days to 4 days therefore increasing the shed production output by 75%.

This is because the amount of carbon dioxide has increased from an ambient level of 300 PPM to a high level of 2000 PPM, the amount a plant can process if in full sunlight.

There are also many types of grains that can be grown hydroponically. Grains such as oats, barley, wheat, sorghum and corn have all been tried. However when choosing a seed the main characteristics that come into play are their nutritional value, speed of seed growth and protein levels. The seed that has all these qualities is - Malt Barley as it is highly nutritious with a very high protein level and under the right conditions can grow to a height of 30 centimetres.

Shed design plays an important part in the success in growing cattle fodder hydroponically. There are many types of shed designs on the market but the most important aspect to remember when purchasing or setting up a Hydroponic Fodder Shed is the LOCATION of where the shed is going to be constructed. It is of utter most importance to assemble a shed that is going to suit the climatic condition of the region. Remembering to focus on either the cooling or heating benefits of the unit to provide the best growing conditions possible for the fodder.

Overall this hydroponic fodder system has the potential to allow farmers to yield a fodder that has the ability to provide huge ecological and economical advantages. This is due to the reduction in the amount of land required for maximum livestock production proving to be an asset for both regions where agriculture is difficult and in densely populated areas that lack sufficient growing space. This use of lesser grazing area to feed stock could in turn provide more acreage for food crop production thus improving the economy and sustainability of the land.

Prologue

I, Joe Mooney, along with my wife Lisa, are Beef Producers living in Glastonbury, 14 kilometres west of Gympie in Queensland. I have been involved in beef production all of my life. I spent the early part of my childhood growing up on a beef property in Mount Perry before moving with my parents to a dairy farm in Glastonbury. The dairy farm operated for ten years before closing and becoming primarily beef and cropping.

After school and the farm, I began a heavy diesel apprenticeship but unfortunately I did not complete the apprenticeship as my heart lead me back to the land where I spent the next five years working on properties between Mt Isa and Gympie. While working on the land I continued to pursue my passion of rodeo and this lead to an opportunity to head south to the Gold Coast where I began work at Movie World. Here I worked as a Stunt Man in the Western Action Show and in over two hundred movies, TV series and commercials. This work involved fights scenes, stunt work using horses and animals and also often included the training of these animals. I am still involved in this type of work when jobs arise.

In 1997 I purchased my first property at the 'Tweed', Kilkivan and in 2000 purchased my second property at Glastonbury. In total I own 3000 acres of free hold land and 500 acres of adjusted land also at Glastonbury. This country is currently running one hundred head of Stud Droughtmasters breeders and replacement heifers, 400 commercial breeders and replacement heifers, contract rodeo bulls and a small fattening operation.

Our beef operation is based on producing weaners ready for feedlots. We use predominantly Droughtmaster and Brahman cows (for tick resistance) and Euro bulls as terminal sires. Droughtmaster bulls are used for the breeding of replacement heifers.

Currently we fatten all cull cows for turn off direct to meat works or cattle markets wherever the best money might be. Our Euro cross cattle are aimed straight to feed lots or to backgrounders for feedlot entry at a later date. With seasons permitting we try to fatten a percentage of these weaners using crop and pasture.

Being such a small operation, we have had to look at ways of maximising our annual returns due to our current climatic condition. Over the last decade we have experienced only one good season that has reached the average rainfall for this area. During these years we have experienced three seasons in a row, which provided us with less than half of our average annual rainfall. Thus making irrigation a very costly and almost a non-productive exercise due to lack of water in creeks and bores.

These climatic conditions have also made breeding cattle extremely expensive due to the increased cost of grain and hay needed to feed cattle in order to maintain their health and quality.

One of the ways we looked at maximising our returns was through the introduction of a 'Droughtmaster Stud Cattle'. This enabled us to produce higher returns per beast area as we are now growing saleable bulls for breeding purposes.

The heifer portion produced is broken up two ways –

- The best confirmation heifers are retained in the stud
- The remainder returned to the commercial herd providing us with improved genetics for carcass quality.

Another avenue we examined was pasture improvements and fertilisation. This involved replacing native grasses with 'bissett blue grass', 'green panic' and various legumes to increase the carrying capacity of our land and its fattening ability. We settled on using a natural crushed rock fertiliser known as 'Nutura-min'. This fertiliser provides the land with trace elements and minerals and increases microbial activity in the soil making our overall cattle operation more sustainable. Through both of these processes we have now reached a stage where we harvest our own seed for further land development and produce a small income from seed sales.

A reduction in our overall cost of production was the next aspect we investigated. This involved the use of mineral licks, which contain iodised salt, sulphur, copra, molasses and superior (a mineral supplement). The benefits of this combination include –

- The improved digestion of available grasses
- Improvement in general health
- Virtual elimination of chemical dipping and spraying costs for ticks

To further reduce animal maintenance costs we have begun the processes of installing buffalo fly traps to further eliminate the use of chemical sprays.

In my quest to improve our annual returns, cost reductions and general quality of life I still needed new ideas. Then five years ago I was introduced to the idea of growing fodder hydroponically in sheds for cattle. In short, this process would allow us to increase our fattening capabilities on farm, with out the cost of buying more land but only the cost of the shed set up.

This process also eliminated any additional pressure on an already over worked irrigation system and provided a high protein fodder that could be totally organically grown. Thus giving us the option to market our saleable beef through new markets.

The process of growing fodder hydroponically in sheds allows the control of climatic conditions for optimal growth with a guaranteed fodder out put per day. Therefore allowing us to have sufficient feed for fattening purposes on a year round basis.

This method of growing fodder looked extremely good on paper, however some problems did exist in practice. These problems included –

- Moulds – due to the moist climatic conditions
- Shed designs
- Available material for shed construction
- Best seeds to use
- Plant nutrition

Believing this idea had merit, I have endeavoured to source any and all information available to help provide a better understanding of how the system works and any ways to combat the above problems. In my search it was suggested that I apply for a Nuffield Scholarship to help further my study in growing hydroponic fodder in countries abroad.

Aims \ Objectives \ Study Goals

As stated above my wife and I only run a small cattle operation and due to our current climatic conditions we have had to look at ways of maximising our annual returns, reduce our cost of production and improve our quality of life. During this quest we were introduced to the concept of growing cattle fodder 'hydroponically'. The idea looked awesome but with some further research into the system we learnt there were some problems currently existing within such a warm, moist, enclosed growing environment.

However, believing this system had the potential, I endeavoured to source any and all information available to help provide a better understanding of how the system worked and any ways to combat the associated problems. In my search I applied for and was successful in being accepted as a Nuffield Scholar, which has helped to further my studies for any new ideas in countries abroad and to combat current problems.

My Nuffield study consisted of research for information associated with

- The advantages of growing cattle fodder hydroponically
- How to combat mould in fodder sheds
- The best grasses to use
- CO₂ Injection
- The best type of shed design to use for maximum production

Hydroponic Fodder

1. What is Hydroponic Fodder?

Hydroponic Fodder is essentially the germination of a seed (such as malt barley or oats) and sprouted into a high quality, highly nutritious, disease free animal food. This process takes place in a very versatile and intensive hydroponic growing unit where only water and nutrients are used to produce a grass and root combination that is very lush and high in nutrients. This green fodder is extremely high in protein and metabolisable energy, which is highly digestible by most animals (Bill Cader, 2002 & Pavel Rotar).

It is important to remember - that to get maximum benefit from hydroponic fodder, it needs to be used in conjunction with dry matter. Usually hay or pasture grass, even in a dry state is sufficient, as the green fodder is a paddock supplement only and may cause scouring.

Picture 1 - Mature Hydroponic Malt Barley



2. The History

The growing of fodder using soil-less growing systems is by no means a new concept to Australia or the world. These systems have been in use for over 50 years to supply a wide range of live stock types for many different purposes in varying living environments (Agrotek Greenhouse fodder systems, 2002). During the war, the Australian Army used a similar system to produce feed for their horses (as shown in Picture 2). South Africa, South and North America were also using similar types of systems during this era and beyond (Chris Gatti in the Daily News, 2002).

As early as the 1930's 'crop-a-day' culture, as it was known then, was being practised through out Great Britain. The fodder was considered then as a sprouted forage, which would provide a variety of livestock and birds with a highly nutritive food with important mineral and vitamin contents (Harris, Republic of South Africa).

Picture 2 – *Feeding horse hydroponic fodder*



The Study Tour

My study involved research in the following areas -

- *The advantages of growing cattle fodder hydroponically*
- *How to combat mould in fodder sheds*
- *The best grasses to use*
- *CO₂ Injection*
- *The best type of shed design to use for maximum production*

1. *The Advantages of Growing Cattle Fodder Hydroponically*

Any environmental, ethnic and political tragedies of the past have resulted from what would now be called 'ineffective agriculture'. Such disasters include the deforestation of Greece, the desertification of Northern Africa, and the environmental destruction of Central Asia. The questions of how to rationally use land resources both ecologically and economically are becoming more crucial for many countries with each passing year.

Australia, for all its agricultural bounty, is a land all too frequently ravaged by drought, fire, flood and extreme seasonal conditions. The continued lack of good seasonal rain, the hot summer weathers which burn off natural field feed and grasses, the winter frosts that slow the growth and burn off valuable livestock food continue to devastate the lives of many farmers year in and year out.

Hydroponics - the science of growing plants in nutrient-rich solutions instead of soil - has proven itself to be efficient both financially and environmentally. Hydroponic methods have been used for a long time to grow plants, primarily vegetables, but hydroponics is now being used across many countries to take pressure off the land and grow green feed for livestock, birds and carp raised for agriculture. This method of producing green fodder has many advantages for the farmer, the economy and the environment. These advantages include:

a. *Water usage*

The hydroponic system requires a fraction of the water usage of conventional farming while still supplying high quality stock feed. It takes between 1 to 2 litres of water to produce one kilo of fodder as compared with 80 – 90 litres of water to grow a kilo of green grass (Calder, 2002). Therefore it uses minimal water for maximum fodder production. This water, which is not used by the growing fodder, is not wasted, as it can be recycled. The left over water still contains many nutrients and therefore can be reused to water small areas of pasture or collected and used on gardens, lawns or vegetable patches (Gatti, 2002). Because this water contains no chemicals (only natural supplements), it can be recycled or filtered for use within the shed without harming the environment.

b. Marginal Land Use

This type of fodder production provides huge ecological and economical advantages, as the production of this lush fodder requires minimal land usage as compared to field-grown grasses and feeds. For example research shows that fodder grown in a 9m x 6m shed can feed (supplement) daily, the same amount of cattle that graze on 1200 acres of pastured country in our area of Queensland. Therefore hydroponic fodder does not require acres and acres of land to produce the feed required fatten or maintain livestock thus allowing the farmer to enhance the value of marginal land.

Others studies completed in South Africa by Harris demonstrated that land usage by animals could also be decreased. For example information emerged demonstrating that using the pen system for sheep, where by the sheep were feed hydroponically grown green fodder, 250 animals could be raised in an area of some 520m² where as by conventional South African standards 1sheep per 2.5 ha is normal.

Pavel Rotar, Russia, states that 'The reduction in the amount of land required for maximum fodder production is an asset for both regions where agriculture is difficult and in densely populated regions that lack sufficient growing space'.

This is a crucial factor for Asia and other third world countries, as the lesser grazing area required to feed stock would provide more acreage for food crop production.

Picture 3 – *Large amounts of land and water being used to grow livestock fodder*



c. Constant Food Supply

Hydroponic technology has removed the need for long-term storage of feeds. Unfortunately, Hay, silage and other feeds lose some of their nutritional value during storage. This technology according to a veteran Kiwi, Tom Hayes has also provided farmers with the opportunity to take control over something they have at present little control over - grass growth. Farmers using this type of fodder production are guaranteed a consistent supply of quality fodder 365 days of the year irrespective of rain, hail, sunshine or snow. Therefore the farmer knows exactly what feed they have available every day of the year regardless of the seasonal conditions as it takes just six to eight days for the fodder to grow from a seed into a mature plant of 25cms. This knowledge then allows the farmer to send stock to the markets at peak or near peak condition. Having this constant food supply also allows farmers to retain their stock, selling them when the prices are suitable with out having to accept poor market prices because of lesser quality livestock.

Hydroponic techniques have also proven very successful in other countries where extreme environments exist. Pavel Rotar commented on a hydroponic system that was set up in eastern Kazakhstan, three kilometres from one of the largest titanium/magnesium plants in the world. In this area, where winters can last 250 days, the death rate of newborn cattle was extremely high. The contaminated environment and unfavourable weather conditions made healthy fodder difficult to come by. With the introduction of hydroponically grown feed, the death rate fell sharply and the surviving animals were stronger and healthier.

Similar results have been seen in the Voronezh region of Russia, near the Novovoronezh Atomic Energy Station. There hydroponically produced fodder has been used to feed swine, reducing death rates and improving the general health of the animals, while reducing feed expenses.

d. Growth Time

Case studies completed by Bill Calder has shown that the growing time of hydroponic plants takes as little as 7 days from seed germination to a fully grown plant as at a height of 25 – 30cm ready for harvest. All though Bill does suggest that for an even better result use an eight-day growing cycle.

During recent droughts, which turned many farms into dust bowls, deer and cattle farmer, Peter Ryan, had no troubles keeping his livestock alive and healthy as he started producing hydroponic fodder in eight days from seed to harvest. Peter stated that ‘for every 1kg of seed, 7 – 10kg of edible fodder is produced. However to grow the same amount of fodder in a paddock situation, if there was sufficient water for irrigation, would take up to 12 weeks from seed germination until ready to feed out to livestock’. Thus showing the great advantage this system has for farmers.

Picture 4 - Showing fodder at different stages of growth, notice the rich growth of the eatable root system in the final stage of growth.



Day 7

e. Reduced Labour Requirement

This process of growing cattle fodder requires minimal man-hours per day. Depending on the size of the shed in use, research has shown that as little as 1 hour per day is needed to maintain and produce hydroponic fodder. As compared to the many hours of intense labour required growing the same amount of feed as a pasture crop. More time will be required however depending on the distances being travelled to feed the hydroponic fodder to livestock.

Picture 5 - Delivering Hydroponic Bailey to livestock.



f. Cost effective

Studies have concluded that the production of hydroponic fodder is an extremely cost effective and financially viable. Warmblood breeders Chris and Liz Gatti have considered hydroponic fodder as 'cheap fresh green feed'. Their system can produce 350kg of green feed (wet) for a low cost of \$40 a tonne and little maintenance. Deer and cattle farmer Peter Ryan also proclaims that his system can yield up to 960 kg of nutritious fodder (wet) per day for a cost of approximately \$40. Remembering that whatever animal you are feeding still lives in its normal environment thus obtaining some dry matter requirements from that environment.

These costs do not even compare to the costs of paddock grown fodder. It has been estimated that the costs of insecticides, fertilisers, machinery and their running costs for cultivation and harvesting and labour of field grown feeds are 10 times greater than that of hydroponically grown feed (Prof. C.A. Arano, 1981). Evidence is also given by Prof. C.A. Arano (in Resh, 1981) that hydroponic grass units produce animal feed at about one-half the cost of the produce conventionally. This is based on the larger amounts of fuel needed in the production and transportation of traditional animal feeds.

Further research has uncovered that the cost to fatten a beast on hydroponic fodder would cost around \$40 – \$80 over a 90-day to 120 day period. However to fatten the same beast on grain in the same time period, to achieve the same results would incur a cost of approximately \$350 depending on grain prices during this period.

Another benefit associated with this method relates to annual beef production. For example, a farmer using hydroponic fodder could sell 200 head of cattle up to 3 times a year, as compared to a farmer who using a normal paddock situation, could only sell 200 head once a year. This makes hydroponic fodder a very cost effective, profitable way to live on the land.

Between 60 to 75 percent of the diseases that afflict livestock results from their feed thus increasing the importance of quality assurance in the food and fodder chain, especially since the outbreak of Foot and Mouth and Mad Cow's disease in the U.K and Europe. Tom Hayes, New Zealand, states that 'this hydroponic grass provides an ongoing, safe, disease free fodder supply' thus helping to keep our agricultural industry disease free.

g. Nutritional value

Hydroponic fodder is a highly effective, particularly nutritious feed, which produces maximum protein and is very rich in vitamins such as B-carotene, trace elements and enzymes. This fodder is 90 - 95 digestible unlike unsprouted grains, which are at the best 30% digestible. Hydroponically grown green feed also contains a very high moisture content thus helping to reduce the problem of colic amongst livestock (R&D Aquaponics, 2004).

Studies conducted by Prof. C.A. Arano of Buenos Aires (in Ryan, 2002) into the nutritional status of hydroponically grown feed, found that every kilogram of fodder was equivalent nutritionally to 3kgs of lucerne. Chris Gatti also discovered that the protein value of oats jumped from 8% as a seed to 11.5% as green fodder after eight days of watering. Further investigation by Nick Williams (2000) uncovered that during germination period of malt barley seed, enzymes are activated which change the starch, protein and lipids found in the grain into simpler forms. For example starch into soluble sugars, which are generally better utilised in the rumen. Some of these are subsequently converted into structural carbohydrates as evidenced by a 9% fibre level after four days versus 4.8% fibre in the grain. Such an increase in digestible fibre also improves the utilisation of the fodder, as does the higher overall crude protein content that increases from 12.96% in the grain to 14% as green fodder.

With the increase in green fodder digestibility comes the increase in a beast's daily weight gain due to the increase in the conversion of fodder to meat for beef. Research has demonstrated that this conversion has improved by as much as 20% per beast. Evidence shows that farmers using hydroponic fodder are seeing a weight gain of up to 3kgs per day per beast, compared to 0.51kg per day per beast in a paddock situation.

Walter Pout, Locksley (2002) states that his steers require 6 - 8 kg of green fodder (wet) per day to see a weight gain of 1.3kg per day.(remembering that you need less than 1kg of grain to produce this) Cattle feed on grain also show improved weight gains as compared to those only paddock fed. These cattle than require much larger quantities of grain to achieve such weight gains, as much of the grain is not utilised and passes through the beast.

Hydroponic fodder can also help improve the quality of milk production and quality. A test completed on milk production with a diet of fodder versus one of normal feeds such as grain, hay or silage showed a vast improvement in milk production and butterfat content. A group of 60 cows on a fodder diet increased their milk production by 10.07% over the control group. In addition the fodder fed group also produced a butterfat content of 14.26% higher as compared to those fed on a regular diet (Ryan, 2003). While a Canadian dairy farmer reported a stimulated appetite of his cow as a result of the daily feeding of fresh green fodder. Thus showing an increase in the milk production per cow of 3.6 kg per day over lactation period. Further more a farmer from South Africa reported that one of his top milking cows dropped 3.6 litres of milk per milking after leaving off the green fodder, which was fed at the rate of 6.8kg per day.

Picture 6 – Feeding Dairy Cattle Hydroponic Malt Barley Fodder



Other research has uncovered that feeding livestock hydroponically produced fodder may increase considerably the fertility rates of males and females, and in poultry farms, egg laying has been known to increase by 40% and cannibalism among chickens has been eliminated.

The most recent information gathered, on feed values has come from Greenfeeds Solutions. This company had tests done in 2003 by Feed test in Hamilton. Sprouted wheat grass had the following results.

Dry matter	31.6%
Crude protein	17.4%
Digestibility	90.4%
Metabolisable energy	13.4 MJ/kg dm

When compared to wheat as cereal grain

Dry matter	90.0%
Crude protein	11.1%
Digestibility	80.0%
Metabolisable energy	12.0 MJ/kg dm

Comparison of these results shows that the sprouted grain has produced 3.1 times as much metabolically energy , and 4.4 times as much protein. In addition the sprouted grain is more digestible. Remembering this sprouted feed is then feed out into the paddock situation not like grain being feed in the feedlot .

h. Use of Green Feed for Finishing Cattle

Using a hydroponic shed that grows 1.5 tonnes of green feed (wet) per day. This amounts to 110 kgs of dry matter .The feed produced contains approximately 25% protein and at least 9 MJ/kg of energy.

Cattle growing at 1.0 kg /day have a dry matter intake of 10 kg per day with a protein content of 12%. Pasture that has matured will have a protein content of approximately 10.5% protein. This quality of pasture will not finish cattle and will severely reduce their weight gain. Cattle can utilise pasture of lower quality provided there is adequate protein in their diet. So to utilise this pasture this fodder can be used to gain a finished article.

For an example: Using 420 kg live weight cattle, required to grow at 1.0 kg/day.

Feed intake = 10 kg dm/day

Protein requirement = 12%

Energy = 100 MJ/day

The diet should comprise 90% pasture and 10% green feed. This will give a diet containing 12% protein and have an energy content of 107 MJ/day. A growth rate of 1.0 kgs per day will return around \$2.00 on current market prices. 110kgs of green feed dry matter/day will feed 110 cattle per day resulting in a return of \$220 per day (Bruce Farquharson, Green Feed Solutions).

i. Completely Natural

An important factor about growing this type of feed is that it is a completely natural product. The fodder is produced without the use of any hormones, synthetic growth stimulant or chemical fertilisers, as any fertilisers that are used are totally organic. Therefore there are no pesticides or fungicides used that could alternately contaminate the meat or milk that are being produced. Fodder grown hydroponically is also free of dust and any other agriculturally related contaminants and toxins.

Studies completed by the Agricultural College of Ayr in West Scotland discovered that the use of a completely natural sprouted fodder in beef production produced a beef that is 'particularly pleasing, of exceptionally fine quality and produces an exceptional carcass for MSA grading'.

2. How to Combat Mould in Fodder Sheds

Unfortunately growing fodder in a controlled, humid, moist environment does come with some minor problems that effect the yield production with the main problems being MOULD, BACTERIA and FUNGI.

The common type of mould, which affects the yield, is a mould known as 'Rhizopus' and it attacks the grain. Rhizopus is a common bread mould, which is present on all cereal grains and in the soil to varying degrees worldwide. Fortunately the very fine climatic control in fodder sheds often limits the amount of mould spores that can germinate.

However if this mould is allowed to progress rapidly early in the growing stage it becomes a food source for more dangerous pathogens such as bacteria and aspergillus which will cause problems, even death in cattle. The aspergillus mould has been found to be the cause of poisoning cases in South Africa, Israel, France, England and China.

Picture 7 - *A mould known as 'Rhizopus', which attacks the grain*



Andrew Olley, HACCP Practitioner, affirms that sterilisation of the seed is an important place to start. Andrew has found that if the grain's surface is sterilised eliminating any mould spores on the grain, on entry to the growing system, that the only infections then come from other parts of the system either inside or outside.

Studies show that the most effective sanitiser for the grain is 'Sodium Hypochlorite'. Andrew Olley recommends that the Sodium Hypochlorite is used at a high rate with a short contact time to surface sterilise the grain. He recommends that to ensure a good kill of pathogens that the chlorine is in contact with the grain for 5 – 10 minutes before rinsing in clean water.

It is also highly important to sterilise all surfaces in the growing area with chlorine. This should be undertaken everyday and it is of upmost important that the growing trays are heavily sterilised between crops.

New trials at Melbourne University are showing very promising results using iodine to sterilise the working area. However the results with iodine to combat moulds and fungus (and promote plant growth) so far, seem to show that iodine will take over from Sodium Hypochlorite as a sanitiser for the fodder shed.

Further investigations into the development of moulds, fungal and bacterial nasties, have uncovered inadequate shed ventilation to be another cause. Therefore to combat this problem it is vitally important that the fodder shed uses intake and out-take ventilation fans. This is to insure that the shed is sufficiently ventilated allowing a constant flow of air throughout the shed. The use of intake and out-take fans also helps to prevent large amounts of mould spores from settling on the plants and reproducing. Locating these fans either end of a high peaked roof also allows the hot air to escape and thus reduces the amount of moisture droplets developing in the air.

Continued research has uncovered that insufficient nutrients in the watering system produces a weaker, slower and smaller plant that are very susceptible to the attack of moulds, fungi and bacteria. Consequently it is of extreme importance that the correct nutrients and their ratios are used in the production of a quality hydroponic fodder yield.

Further study has discovered Sulphur, a natural substance, found in an organic matter known as – Superior (a crushed rock product) – has mould-inhibiting properties. The use of this product not only inhibits mould growth but also provides the plant with 104 macro, trace and ultra trace mineral elements essential for the health of livestock.

Trials performed by Dr Lewis Kahn, University of New England, have quantified and confirmed many of the benefits associated with using 'superior'. Testimonials relating to the use of 'superior' have suggested benefits such as -

- The utilisation of low quality feeds
- Improved conception rates
- Improved animal health
- Prevention of acidosis
- Reduced grazing pressure

Another solution that has been investigated to help combat the mould problem, (the same type of mould that forms in moist Lucerne hay), is through the use of an '**Ultrasonic Fog Generator**'. This machine was designed and built in Israel but Jim Ennis of Lethbridge in Canada introduced the idea of using this concept in fodder sheds. These generators produce – 'Dry Water' – as the water droplets are less than 5 microns; very 'dry' when compared to atmospheric fog which is anywhere from 12 to 15 micron droplets.

The fog or fluid in a gaseous state is capable of deep penetration of minute spaces. This eliminates the "free water" which contributes to contamination, disease and pollution of solutions using traditional methods in agricultural applications. By adding easily soluble substances to the water such as 'Superior', nutrient treatments can be provided to the plant, which in turn will help to produce an improved yield.

Research into this ultrasonic fog generator found that it provided an easy and efficient way to grow fodder as the plants thrived in the clean, almost sterile environment that the system provides.

The ultrasonic fog machine is also very effective for foliar feeding in an enclosed area. Unlike hand sprayers the fog is able to infiltrate all areas of the plant. All the pores in the top and underside of the leaf as well as the stem absorb foliar nutrients. A water fogger machine works like a multi function humidifier. The mist created is so fine it gets into very minute areas; however, the surface remains dry eliminating the threat of mould and mildew.

Another application for the ultrasonic fog generator is the cleaning and sterilization of the growing environment and equipment. The fog produced by the unit has all the properties of a gas and as such is an ideal vehicle for the transportation and deposition of a sanitization agent. As an added bonus, the fogger is also a water purifier! Pathogens and bacteria cannot survive the ultrasonic vibration of the piezoelectric crystal.

Further tests have shown that plants treated with fog laced with natural nutrients require a fraction of the recommended dose. The ultrasonic fogger produces fog through vibration that is faster than the speed of sound. To fog a 3' X 4' X 8' area requires approximately ½ litre of liquid eg; nutrient solution, per hour. The generators can be either wall mounted or set on a mobile trolley depending on the suitability.

Picture 8 – *Ultrasonic fogging generator*



3. **Carbon Dioxide (CO₂) Injection**

People laughed when it was claimed the **playing music to plants** made them grow better. It really did because the sound vibrations actually strengthen the stem fibres, shorten the internode length, and cause stress growth reactions from the plant. Then people continued to laugh when it was claimed that **singing to plants** made them grow better. However, it is true. The CO₂ from human breath actually makes plants grow faster (Reinders, 1996).

All plant dry matter is 90% carbon, hydrogen and oxygen. All the carbon has to come from the Carbon Dioxide (CO₂) in the air. Studies have shown that plants do not need CO₂ in the dark period, only during the light times and the more light that is available the more CO₂ it requires for photosynthesis. Experiments have revealed that during photosynthesis, it takes about 10 photons to make enough electrons to create sufficient energy to split one CO₂ molecule into carbon and oxygen atoms to form sugar. There are trillions of photons striking the plant leaves, but if there is not enough CO₂ provided, the photons will just bounce off the leaves with out doing much at all (Reinders, 1996).

Research completed in Canada with Jim Ennis of Lethbridge, demonstrated that CO₂ injection into the fodder shed cuts the growing time of Malt Barley from 7 days to 4 days therefore increasing the shed production output by 75%. This is because the amount of carbon dioxide has increased from an ambient level of 300 PPM to a high level of 2000 PPM, the amount a plant can process if in full sunlight.

This increase in fodder production comes at an expense of 1 gas cylinder of CO₂ per month and the initial set up cost of the Carbon dioxide emitters. This means that a shed, which was producing 100 trays or approximately 1 tonne of feed per day, can now produce 175 trays or approximately 1.75 tonne of feed per day.

EXAMPLE: A shed producing 100 trays per day could feed 120 feeder steers (400kg average weight per beast) eating a maximum of 8 kg of fodder (wet) per day in paddock situation. With CO₂ injection the shed could now feed over 200 feeder steers (400kg average weight per beast) eating max 8 kg of fodder per day in paddock situation and thus maximise use of the same size shed for little or no extra cost.

Further information gathered during the study indicated that a shed with CO₂ injection producing approximately 175 trays per day requires about 2000 litres of water per day to grow feed for 200 head (without CO₂ injection the water requirement will be less). In comparison to our irrigation where 60 000 litres per hour, running 24 hours per day, 7 days per week would not be able to feed any where near the same amount of cattle.

4. The Best Grasses To Use

There are many types of grains that can be grown hydroponically. Grains such as oats, barley, wheat, sorghum and corn have all been tried. However when choosing a seed the main characteristics that come into play are their nutritional value, speed of seed growth and protein levels. The seed that has all these qualities is - Malt Barley as it is highly nutritious with a very high protein level and under the right conditions can grow to a height of 30 centimetres.

Further inquires into the best type of seed to use exposed information stating ' when all of the necessary items are put into the equation such as – size of the seeds, germination, price, availability, protein increase, nutritional value etc, then malt barely comes out on top' (Calder, 2003).

Running second to Malt Barley are Oats as they are considered to be the next best seed to sprout. Nevertheless trials completed by Peter Ryan, revealed that oats were considered quite nutritious but lacked the roughage required by his livestock.

An analysis of malt barley was completed by AGROTEK and the results of this analysis are documented below (Olley, 2002).

CERTIFICATE OF ANALYSIS
Presented To Agrotek, Nambour,
By Casco Australia Pty Ltd, Toowoomba

TEST IDENTIFICATION	RESULTS	UNITS	METHOD
Moisture	80.0	%	RFV001
Protein	23.3	%	RFV001
Acid Detergent Fibre	16.9	%	RFV001
Neutral Detergent Fibre	35.2	%	
Digestible Protein	16.3	%	RFV001
Digestible Dry Matter	77.4	%	RFV001
Total Digestible Nutrient	76.0	%	RFV001
DM Intake % of Body Weight	3.4		RFV001
Net Energy Lactation	7.3	Mj/kg	RFV001
Net Energy Gain	5.0	Mj/kg	RFV001
Net Energy Maintenance	8.0	Mj/kg	RFV001
Relative Feed Value	200		RFV001
Metabolizable Energy	11.4	Mj/kg	RFV001
Boron	22	Mg/kg	MIN0001
Calcium	0.15	%	MIN0001
Copper	11	Mg/kg	MIN0001
Iron	160	Mg/kg	MIN0001
Potassium	0.70	%	MIN0001
Magnesium	0.24	%	MIN0001
Manganese	37	Mg/kg	MIN0001
Sodium	0.10	%	MIN0001
Phosphorus	0.46	%	MIN0001
Sulphur	0.28	%	MIN0001
Zinc	40	Mg/kg	MIN0001
Nitrogen	3.7	%	MIN0001

However, the previous table is just an analysis of malt barley, when overlaid with seed at the two day and four day stage of growth the dry matter levels lift dramatically as shown in the table below (Greenfeeds Solutions).

<i>Analysis Performed</i>	<i>Method</i>	<i>Unit</i>	<i>Result</i>
Moisture	Wet	%	55.1
Dry matter	Wet	%	44.9
Crude Protein (N x 6.25)	Wet	% of dry matter	10.8
Acid Detergent Fibre	Wet	% of dry matter	
Neutral Detergent Fibre	Wet	% of dry matter	
Digestibility	Wet	% digestible DM	90.6
Metabolisable Energy	Calculated	Mj/kg DM	13.7
Digestible Energy - Horses	Calculated	Mj/kg DM	

So even in severe drought conditions you are now able to produce fodder for animals with a dry matter level good enough to promote weight gain without even shifting stock to better pastures or out on agistment.

5. The Best Type Of Shed Design To Use For Maximum Production

There are many types of shed designs on the market but the most important aspect to remember when purchasing or setting up a Hydroponic Fodder Shed is the **LOCATION** of where the shed is going to be constructed. It is of uttermost importance to assemble a shed that is going to suit the climatic conditions of the region, remembering to focus on either the cooling or heating benefits of the unit to provide the best growing conditions possible for the fodder.

Research has uncovered that the design of the shed was a very important factor that contributed to minimising these heating or cooling costs and studies in Canada show that the use of solar run fans and pumps contribute to lowering the costs of sheds and is considered a very cost efficient way to run a shed.

It is extremely important to use a shed design that uses considerable airflow with fan intakes that comes in from a high point like through the roof. Maximising airflow helps to minimise and eliminate mould problems. The use of carbon dioxide injectors and fogging machines also allow for maximum growing and fodder production.

Further recommendations suggest that the shed runs length ways – North to South – so that the sun hits the sides of the shed – East to West – to allow for maximum use of the sunlight. Using a hail proof, clear plastic material also allows for maximum use of the sunlight thus allowing for maximum photosynthesis – more light, less heating costs.

Further studies revealed that the use of a smaller nutrient tank permits optimum growing conditions. This tank must be stirred vigorously or aerated with a compressor to allow even and constant nutrient supply thus preventing nutrient settling on the bottom of the tank.

Picture 9 - *Inside a Fodder shed in Canada*



Picture 10 - *Outside the fodder shed*



Conclusion

This research will hopefully encourage many other Australian farmers to look at their own farming practices and help them to make the necessary changes needed, to provide a sustainable, efficient method to increase their on farm profit with minimal outlay and very low continual running costs.

This hydroponic fodder system has the potential to allow farmers to yield a fodder that has the ability to provide huge ecological and economical advantages. This is due to the reduction in the amount of land required for maximum livestock production proving to be an asset for both regions where agriculture is difficult and in densely populated areas that lack sufficient growing space. This use of lesser grazing area to feed stock could in turn provide more acreage for food crop production thus improving the economy of the land.

Such a system allows the farmer to have control over the feed production 365 days of the year – rain, hail, shine or snow thus allowing the turn over of quality and quantity livestock. The farmer is now able to send stock to the markets at near peak condition, selling when the prices are suitable instead of having to accept poor market prices because of poor conditioned cattle.

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Acknowledgements

A wide range of people and organisations have given their support during the undertaking of this study and report, to each and everyone I am very grateful.

Thank you to –

- The Australian Meat and Livestock Association and The Nuffield Farming Scholarships Trust for the opportunity to undertake this study.
- The farmers and farming families across the world who gave time, information, hospitality and generously allowed an insight into their lives.
- The Nuffield scholars with whom I first travelled with during our 6-week induction travel. Thank you for all your support, inspiration, enjoyment and the offering of valuable information.
- Jim Ennis of Lethbridge, for his hospitality and wealth of knowledge.
- Nathan Green for contacts at the Taxis A & M who in turn provided contacts for various Stud Beef Properties.
- Trevor Zerner for contacts in Canada.
- The hydroponic fodder growers for your time, knowledge, inspirations and hospitality.
- Graham Ramsay for being a great travelling partner
- All of the Australian public who have contacted me for information and guidance into Hydroponic fodder systems.
- The School of the Air and ABC Radio for your support and publicity

I am so ever grateful for the support and encouragement provided by my ever-loving wife, Lisa, and from my family and close friends throughout this research expedition.