

DAIRY SHELTER ON THE CANTERBURY PLAINS

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Introduction

Extensive conversion of farm land on Canterbury plains to dairy farming, usually with the conversion to centre pivot spray irrigation has resulted in ‘clearing’ of large tracts of the landscape. The removal of trees has been essential to the development of cost-effective irrigation systems but at what cost? The perceptions of non-agricultural stakeholders about tree removal appear to add to negative views of the sustainability of dairying in Canterbury. However perennial pastures grown under irrigation have changed the landscape and the role of shade and shelter trees is less clear.

This discussion paper reviews current literature (from an SFF and DairyNZ funded project) and explores how shelter and shade influences production in a dairy farming system on the Canterbury plains and considers: what value is there to replanting shelter trees on Canterbury dairy farms? The review encompassed both international and local research, but the findings reported were chosen to be applicable to Canterbury dairy systems where possible and highlighted if conditions differ to the Canterbury norm. Any gaps in the literature that required further evidence or research were discussed.

Canterbury Climate

The shape and success of any farming system is highly influenced by the predominating climatic conditions that it experiences. NZ farming systems tend to be well adapted to existing climatic conditions and manage most of what “mother nature” throws at the system. Farmers to varying degrees utilise “tools” in their arsenal to lessen the extremes of adverse weather pressures.

Global warming and resulting climate change will result in new climatic impacts with new challenges required to build resilience and maintain or increase production in the current farming systems.

Climate change predictions suggest Canterbury will get warmer, windier and drier with an increased frequency of droughts and storms. As these changes occur, increased efficacy of water use and general farming practices will be necessary to maintain and/or increase production(Hennessy, et al. 2007)

The Canterbury plains have a temperate climate which is a seasonally dry and windy with cold snaps during winter. The dry and windy conditions of the plains have necessitated the introduction of irrigation to improve growing conditions for most productive farming systems.

There are still extensive areas of the Canterbury plains still farmed as dryland farms these are predominately dairy support, mixed cropping and sheep and beef enterprises.

Shelter and shade

History of shelter in Canterbury

When the first British settlers arrived in Christchurch in 1844 there were virtually no trees to be seen on the whole of the Canterbury plains. This was a totally foreign landscape to people who were accustomed to small paddocks bordered by hedgerows and deciduous trees. The early settlers of Canterbury had grand visions of transforming this flat landscape into a carbon copy English countryside vista. The English influence on our landscape is still very visible today. Trees were planted, not only for amenity purposes, they had a functional role, primarily as shelter but also to provide timber and for protection from the forceful winds of the Norwest.(Price, 1993)

Shelter is one way to mitigate the adverse effects of weather on plants, soils and animals; for many years there was government subsidies of >65% of total costs to plant windbreak shelter. By 1984 1.9 million hectares of land susceptible to wind erosion was protected by national wind erosion control schemes. (Basher and Painter, 1997) The recent conversion of large tracts of Canterbury plains to dairy farming with spray irrigation has sometimes led to 100% clearing of trees and shelter belts with an estimated 6.7 metres/hectare (0.5 million metres) of shelterbelts have been removed. (Tait and Cullen, 2006)

How a windbreak works

Agricultural production is affected by many factors, of which climate is a key factor. Managing for extreme climatic events and adapting to diverse regional climate characteristics within the farm system can help to mitigate detrimental effects of climate and weather on production. Wind is a dominant feature of the Canterbury landscape and one of the few weather elements over which a farmer can exert some control with the use of windbreaks.

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As already discussed Canterbury has a seasonally dry and windy climate with cold snaps during winter. Windbreaks can create small scale changes in climate across an area (dictated by the height, length, width, shape, and permeability of the shelter). This creates a microclimate close to ground level (important to pasture plants and grazing animals). Using shelter to create a microclimate can increase: crop yield, soil moisture, soil temperature, daytime air temperature, relative humidity, and decrease: wind speed, night air temperatures and evaporation (Figure 1). Most authors conclude the effects of windbreak on climatic factors are measured in terms of multiples of windbreak height (H).(Gregory, 1995 and Burke, 1998)

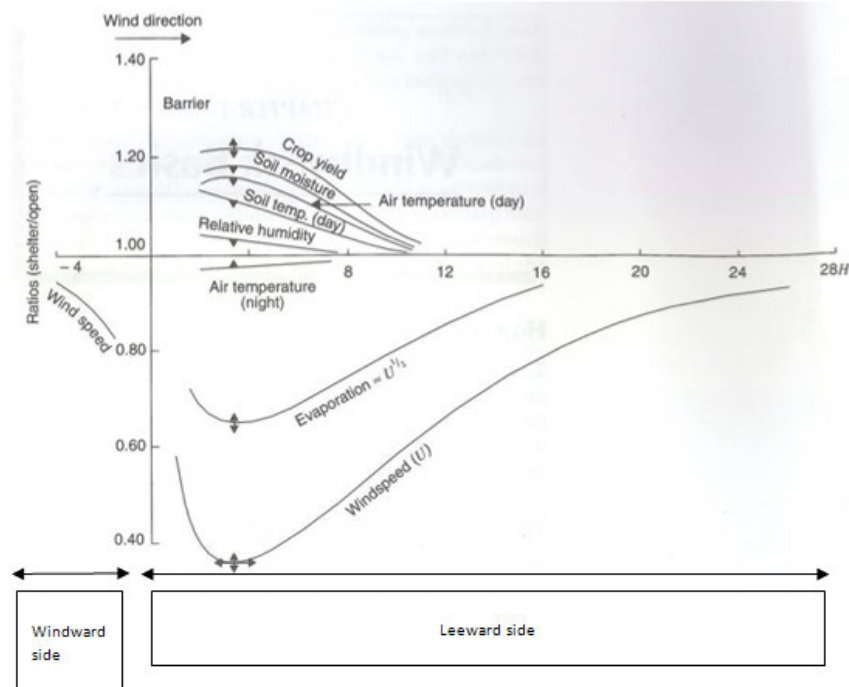


Figure 1. Microclimate variation near a wind break (H = height of windbreak)

The distance at which the wind is reduced in speed to at least 80% of open wind speeds is between 15-20 times the height of the windbreak (15-20H), although there have been reports of distances up to 30H. (Burke, 1998).

Effective shelter and shade

The effectiveness of windbreaks to reduce windspeed and provide shade to block solar radiation is determined by many factors and best practice shelter and shade construction techniques will amplify efficacy. This is discussed in full detail within the full literature review (Goulter, 2010).

Planting of natural vegetation on farms is a costly exercise; therefore good advice needs to be sought before undergoing extensive planting. There are several locally produced planting

guides that can be used to aid planning and planting, these include: Practical methods to minimize set-up costs to plant and maintain natural vegetation and develop farm plans to minimize reduction in grazing areas and maximise benefits from planting, information about plant spacing, plant selection and maintenance. See the following references (Southern Woods, 2010 and Meurk, 2005). Local landscape design firms are also providing advice to farmers, and see this as a key area of business expansion.

Pasture

As a general rule the use of shelter will help increase pasture production, but not in all cases.

Water use in plants

There is a common misconception that an increase in wind should *always* lead to an increase in water use in plants. But in normal cases the plant is able to adapt to a high wind environment, this is done by closing or partial closing of the stomata on the leaf surface. This will decrease the amount of water lost from the plant, by decreasing transpiration. However, stomatal closing also decreases other important plant growth factors, such as:

- the plants ability to photosynthesise,
- restricts movement of sugars, nutrients and growth regulators within the plant,
- reduces root uptake of minerals from the soil and
- reduces nitrogen metabolism.

Stomatal closing varies with species and cultivar. Although the stomata will regain its turgidity overnight, all of these factors will still effectively reduce plant vigour and production.(Sturrock, 1983)

Increased transpiration

However, increased transpiration can occur in plants with increased wind speeds if the plant leaf surface is physically damaged, e.g. when leaves collide with neighbouring leaves,

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bend over, frequently rotate and when leaves are injured from loess blown soil particles. Most damage occurs to the waxy cuticle of the plant's leaves. This cuticle helps to regulate gases and water vapour between the plant and the environment in conjunction with the leaf's stomata. Figure 2 shows an image of the leaves of a grass plant under zero and high wind conditions. You will note that there is a large amount of damage to the surface of the plant exposed to high wind speeds and would most certainly affect the plants ability to transpire, and retain water in a windy environment.

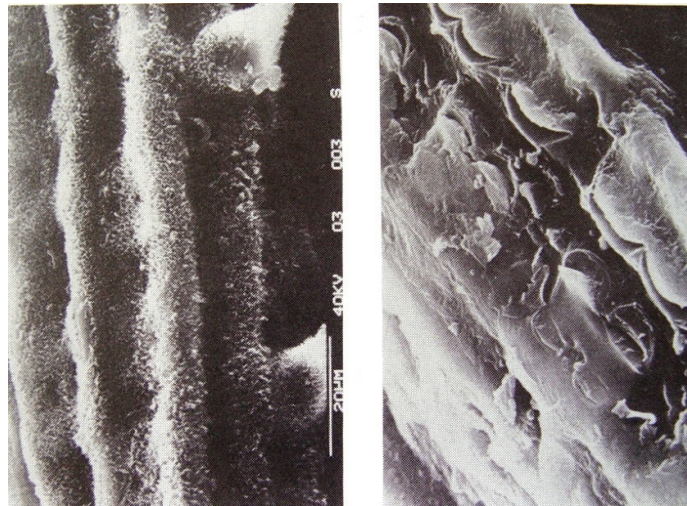


Figure 2. Scanning electron microscope images of the leaf surface of *Molinia caerulea* with zero wind (left image) and at high wind speeds (right image). (Pitcairn and Grace, 1985)

Leaves of white clover have also been researched in the field under windy conditions. It was observed that the contact between the leaves and the ground caused leaf damage and wax removal at a rate too fast for renewal. (Pitcairn and Grace, 1985) In general the upper threshold for physical damage to herbaceous plants is a windspeed of 6m/s. Other, more visible damage caused by high wind on pasture includes: leaf stem fractures, wilting, desiccation, and necrosis (wind scorch) of leaf tips. Some species are more wind tolerant than others, e.g. ryegrass is more tolerant than tall fescue. (Gregory, 1995)

Seasonal differences

Desiccation of young, fresh growth is common due to an underdeveloped wax layer on the leaves. This means that fresh spring and summer pasture growth with the addition of irrigation water is more vulnerable to leaf desiccation. Especially since the westerly wind run in Canterbury during these months is higher. (King and Sturrock, 1983) This implies that it is even more important to incorporate shelter in an irrigated environment. The potential for shelter to increase productivity of irrigated pastures requires further research.

The shorter growing season in winter due to reduced temperature from no shelter reduces cuticle development. Insufficient pre-winter hardening predisposes plants to winter desiccation too. Winter browning of herbage occurs when periods of high evaporation potential coincides with low temperatures or with frozen soil that inhibits uptake of water and nutrients from the soil. (King and Sturrock, 1983)

Shelter and shade effects on air and ground temperatures

During the daytime an increase in air temperature of 4°C has been shown within 10H of the sheltered zone (Figure 1). This should increase the rate of photosynthesis and respiration as well as stimulate plant development and cell division.(Bird, 1998)

At night a decrease of 1°C can occur which reduces respiration losses (Figure 1) which in turn increases pasture growth. However this decrease in temperature can raise the risk of frost damage if there is a reduction in air movement by dense shelter planting. This is particularly evident along the margin of the shelterbelt on the western side which is shaded from the rising sun. The night time decrease in temperature is due to reduced mixing of air within the quiet zone on the leeward side of shelter belts.(Bird, 1998)

Soil temperatures can be higher in sheltered areas during the day (between 2 and 10°C by varying reports) in surface and 10cm depth of soil. This (along with higher moisture levels) can provide benefits such as improved germination rates in new pastures (up to the 10H zone) which provides more growth at the start of the season.(Bird, 1998)

Shade effects on plants

The use of natural vegetation to provide shade is of most benefit to animal production and comfort. Typically, shade on pastures will reduce production by decreasing the amount of sunlight that falls on the leaves (light interception), thereby slightly reducing rate of photosynthesis and plant growth, a reduction in tillering of grasses and a decrease in root nodule formation in white clover. (Gregory, 1995) There are some species that are more tolerant to shade than others, e.g. Lucerne. (Bird, 1998) The shade effects are usually only evident 1-2H from the shelter/shade belt. (Gregory, 1995)

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Other effects on plants

Positive

- Sheltered plants have fuller root systems and are more able to access soil moisture and nutrients (Sturrock, 1983)
- Pollinating insects, e.g. bees, dislike windy environments, therefore increased pollination of clover plants will increase nitrogen fixation from clover and therefore free nitrogen available to pastures (Janett, 1988)

Negative

- Competition for nutrients and moisture between shallow rooted shelter trees, e.g. poplars, and pastures. This can be minimised by: deep ripping during planting to encourage vertical root development (Bird, 1998), a shallow ditch between treeline and pastures will isolate roots (Gregory, 1995).
- Valuable grazing land taken up by planting shade and shelter vegetation. The area and total cost can be minimised by getting best practice planting techniques, good advice and planning (Southern Woods, 2010), approximately 3% of total land area is required for effective livestock shelter on flat land (Gregory, 1995).
- Increased nutrient transfer, pugging and weeds invasion can occur around areas planted for shelter (although this is a sign of poor shelterbelt design). (Gregory, 1995)
- Increased facial eczema spores have been found in shaded areas of trees, although shaded areas can be used for animals affected by photosensitivity.(Gregory, 1995 and Verkerk, 2009)
- Rainshadowing has been found due to the sheltering effect of the treeline, however soil moisture levels were not affected to any great extent. (Radcliffe, 1985)
- Soil erosion during pasture renovation using conventional full cultivation methods still remains an issue during spring. Minimal tillage techniques, well timed cultivation and well chosen sheltered paddocks to perform full cultivation can help to minimise topsoil losses.

Animals

Animal welfare

Animal welfare is an increasingly important aspect of modern farming practice and the responsibility of the individual farmer. Exemplary animal welfare practice will position our dairy products over and above other types of international dairy production systems. Conversely, international market access and trade barriers may pose a problem for New Zealand dairy products if customers perceive issues with existing farming practices change around such

issues as: induction of calving, bobby calf, mastitis, lameness, and provision of shade and shelter. (Campbell, 2009)

Possible trade barriers

Currently the World Trade Organisation (WTO) regulations state that specific trade restrictions based on animal welfare standards are not permitted, as long as the country can demonstrate that they have science reviewed minimum standards or codes of animal welfare in place. However there are influential markets such as the European Union who are currently lobbying to include animal welfare compliance in their trading criteria. This may require detailed evidence of on-farm compliance and food labelling to include 'animal welfare approved'. Political and market pressures such as this may in the future impart strict auditable legislation on on-farm animal welfare practices.(Campbell, 2009) Non agricultural stakeholders in NZ have increasing influence on local, regional and central government decisions and their wider perception of current dairy farming practices will be important to farmers' freedom to farm.

Animal welfare legislation

In New Zealand animal welfare legislation is the responsibility of MAF Animal Welfare Group of Biosecurity New Zealand. The animal welfare legislation lies in the Animal Welfare Act (2009) and the detailed regulations are provided in various industry specific Codes of Welfare.

The most recent code of welfare pertaining to Dairy Cattle was issued 19th February 2010. Within this guide there is specific reference to provide shade and shelter for dairy cattle. There is a wealth of information in this current Dairy cattle code of welfare, much more than the last issue (1992). It is encouraged that all dairy farmers and the related industries are fully conversant with the code.

The minimum standards relating to shelter (this includes shade) from the Dairy Cattle Code of Welfare 2010, are:

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1. All classes of dairy cattle must be provided with the means to minimise the effects of adverse weather.
2. Newborn calves that have been removed from their mothers must be provided with shelter from conditions that are likely to affect their welfare adversely.
3. Sick animals and calves that are not suckling their mother must have access to shelter from adverse weather.
4. Where animals develop health problems associated with exposure to adverse weather conditions, priority must be given to remedial action that will minimize the consequences of such exposure.

The recommended best practice guidelines from the same code are:

5. Shelter (e.g. windbreaks or natural topography) should be provided to protect animals from adverse weather especially cows when they are close to calving.
6. Animals that are photosensitive should be protected from exposure to direct sunlight.
7. During hot weather conditions the heat loading on animals, especially during the afternoon, should be reduced by, for example:
 - a) provision of plentiful drinking water
 - b) use of paddocks close to the dairy
 - c) movement of animals at their own pace
 - d) provision of water sprinklers at the dairy and in the dairy yards
 - e) provision of shade
 - f) use of sun protection formulas, e.g. zinc creams
 - g) once a day milking in the morning.

(NAWAC, 2010)

Effects of shelter and shade on dairy cattle

Dairy cattle in New Zealand are grazed in a pastoral system, and are therefore exposed to the effects of weather: heat, cold, rain, snow, and wind. Provided the dairy animals are fed well and their nutritional demands are being met, mature dairy animals tolerate inclement weather reasonably well (young stock is excluded from this generalization as they are more vulnerable than adult stock). Although there are occasions that arise where weather extremes can pose a welfare risk to stock. (NAWAC, 2010) This becomes the responsibility of the person in charge to mitigate the effects of weather and have management plans in place to implement when needed.

The effects of shelter on grazed livestock can be attributed to either the alleviation of cold stress from reduced wind speed across a grazing area and/or shelter from rain, or reduced

heat stress through provision of shade during periods of high: solar radiation, relative humidity and air temperatures. Whether it is heat or cold, physiological stresses impact on productivity by the indirect effects of reduced grazing periods and therefore reduced feed intake and production.(Holmes and Sykes, 1983)

Animal stress from heat or cold is influenced by many internal and external factors which can have a bearing on an animal's heat balance (Table 1).

Table 1. Factors which influence animal's heat balance

Climatic Factors	Animal Factors
Wind speed	Rate of heat production (metabolic rate)
Solar Radiation	Body insulation (subcutaneous fat cover)
Long wave radiation (infrared radiation)	Capacity for evaporative heat loss
Rainfall	Physiological status, i.e. pregnant, lactating
Snow	Nutritional status
	Surface area versus body mass
	Animals age

The animal is able to regulate it's body temperature by shivering in cold conditions to increase heat production or increase evaporative heat losses by panting, standing to increase surface area or sweating in hot conditions. There is a "buffer zone" within the upper and lower temperature thresholds; this is called the "thermoneutral zone". The visible stresses of shivering and panting/sweating are not evident within the thermoneutral zone, but subclinical (non-visible) production losses will occur in animals within their thermoneutral zones.(Holmes and Sykes, 1983)

Signs and effects of cold

The signs of mild cold exposure in dairy cattle are:

- pilo-erection (hair follicles will stand up to trap a layer of warm air, much the same as 'Goosebumps' in humans)

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- increased feed intake (if available)
- increased hair growth (this is related to hormonal changes related to seasonal climate changes)
- increased levels of thyroid hormone production which alter metabolism (this makes iodine levels in diet very important)(Verkerk, 2009)

The early signs of significant cold exposure in dairy cattle are the following behavioural changes:

- seeking shelter
- facing away from the wind or rain with back hunched
- lying down to reduce exposed surface area
- refusal or reduced grazing
- shivering and huddling together.

More serious symptoms related to hypothermia are:

- core body temperature drops below normal range
- animals become depressed and listless (urgent remedial action is required if these symptoms present themselves)
- animals may die.(NAWAC, 2010)

Generally a well fed calf or cow is very resilient to cold conditions. Dairy cattle are more susceptible to cold conditions when fed maintenance, it is estimated that dairy animals are even more susceptible to adverse conditions when fed at sub-optimal (below maintenance) levels during these conditions, or if they are thin or suffering metabolic disorder or other disease.

Newborn, wet, sick, deprived of food, or transported calves are more vulnerable to adverse weather conditions. (NAWAC, 2010)

Calves fed maintenance levels, even under calm dry conditions, will frequently be exposed to air temperatures which are below their critical lower temperature. Calves are very susceptible to cold because they have a large surface area compared to body mass. Under wet and windy conditions all ages of cattle will frequently be exposed to temperatures below their lower critical temperature.(NAWAC, 2010)

Even if animals are not at a critical temperature, grazing and other behaviours are affected adversely. For example it has been observed that cows calving in large herds are less likely to stay with their calf under adverse weather conditions. This means the calf is less likely to receive colostrum in those critical first few hours. It also puts a strain on traceability of breeding when cows have abandoned their calves and several cows have calved in the same mob. It is therefore important to keep your “springer” cows that are close to calving in sheltered paddocks if unfavourable weather is forecast, paddocks should be selected for southerly shelter.

Dairy cattle will increase their feed intake in order to replenish the energy spent regulating their body temperature. This energy is supplied by feed energy or from burning stored body fat. For each 1 degree Celsius decline in temperature below their lower critical temperature, cattle require an additional 2% energy in the diet. This can be accomplished by an increase in feed intake, but if they are already at maximum intake, then the energy density of the diet must be increased.

Signs and effects of heat

An animal standing in the sun has two inputs/sources of heat:

- one is external: absorption of solar radiation, ambient temperature and relative humidity from the environment,
- the second is internal: metabolic heat production.

In a hot environment the animal can suffer from heat stress because their heat inputs are greater than their heat outputs. A severe case of heat stress can cause death in an animal. And chronic heat stress is highly undesirable in the long term as a heat stressed animal has a low voluntary food intake and consequent lower productivity.

The visible behavioural signs of heat loadings on dairy cattle are:

- Reduced feed intake
- Increased water intake
- Seeking shade
- Increased respiratory rate (above one breath per second)
- Standing to increase surface area and cooling effects
- Drop in milk production
- Irritability

More severe heat loadings and heat stress:

- Open mouth panting
- Sweating
- Crowding around water troughs and each other if shade not available
- Rumen acidosis

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- Hyperthermia
- Death

Solar radiation is a major contributor to heat loading, especially in dark coated animals. Relative humidity also plays an important role in heat transfer to animals; high relative humidity reduces the amount of heat able to be lost from the animals through sensible heat transfer.

High producing lactating dairy animals are less able to combat the effects of heat loading by thermoregulation due to internal heat production from increased feed intake and milk production, therefore the thermoneutral range for lactating dairy cows is thought to be lower than 26°C. (Chebel et al, 2004)

Another common term in science literature to describe heat loadings on animals is temperature humidity index (THI) which incorporates relative humidity and air temperature.

However, both of these terms do not account for solar radiation which is very important in New Zealand conditions due to our high levels. It is suggested that a measurement of solar radiation as well as air temperature and relative humidity is more valuable in evaluating heat loadings on animals in a high solar environment, i.e. $>500 \text{ W/m}^2$ this is called the Black Globe Humidity Index (BGHI). (Buffington, 1981)

Heat effects on fertility

Bulls

Exposure to hot temperatures has been shown overseas to adversely affect bull fertility by reducing sperm motility, increasing sperm abnormalities, decrease the ability for the sperm to fertilise ova and in some cases decrease bull libido. Although it is unlikely that New Zealand bulls would be exposed to these tropical conditions.

Cows

Recent studies has shown that non-lactating dairy cows have a better chance of becoming pregnant than high producing lactating animals. It is also shown that the greatest impact on reproductive failure was caused by heat stress. Dairy cows that were exposed to heat stress 20-50 days prior to AB were 31-33% less likely to conceive than those not exposed to heat stress. (Santos et al, 2004) This will increase artificial breeding costs and may increase the proportion of empty cows in a herd. Although peak temperatures in Canterbury fall outside the critical timing before AB (as stated in the literature), it is still relevant to dairy systems who use AB and calve all year round.

Heat effects on milk production

Dairy cows that have access to shade have been shown to have an increase in milk solid production of 3%. This study was carried out in Hamilton over one summer with an average air

temperature of 25°C which is relatively cool by Canterbury standards, although the humidity levels in Hamilton are much higher than Canterbury. The proportions of Milk components (fat:protein:casein:lactose ratios) were unaffected between shaded and unshaded cows, this also agrees with international studies in a sub-tropical environment with greater heat loadings than this study. (Fisher, 2008) A further study in New Zealand showed a 0.5kg of milk per day increase in milk production than cows without access to shade. (Kendall, 2006)

A recent study in Canterbury using milk production data from 13 dairy farms in the Selwyn district of Canterbury saw no relationship between a high THI >72 (which is stated to be the conditions at which heat stress is to occur in dairy cattle) and milk production data during the summer of 2008/09. This study showed that Canterbury experienced very few days with a THI of >72 and the effects on milk production during days which did reach a THI >72 were not significant. In fact, two of the thirteen farms showed a positive relationship to high THI and milk production.(Laird and Barrell, 2009)

Further research would be required to correlate paddock conditions with milk production in relation to provision of shade etc as it was not stated in this study whether the cows had access to shade or other cooling mechanisms whilst in the paddock or within the dairy shed. It could also be argued that for Canterbury conditions a BGHI would be more reliable as a measure of heat load, owing to Canterbury's high solar radiation levels and low humidity (there is an inverse relationship in Canterbury between a rise in air temperature and relative humidity) (Laird and Barrell, 2009).

It has been suggested that cows that use shade during the hottest parts of the day will limit their feed intake by reducing the amount of time grazing. However, it was observed in many New Zealand studies that the cows that did lie or stand in the shade will spend the same amount of time grazing as non-shaded cows. It was observed that the shaded dairy cows spent more time grazing between midnight and 3:30am, and therefore compensated for the amount of time not grazing under shade structures. (Fisher, 2008)

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Mitigation methods of heat loadings

Within the paddocks

Shade: Providing effective shade trees or structures which block the majority (50-99%) of solar radiation will help to alleviate heat loadings as they reach the critical levels, but should not reduce airflow. Some studies have shown that cows prefer to use shade created from natural vegetation as opposed to man-made or artificial structures using shade cloth or iron. This is believed to be because trees can be more efficient at blocking solar radiation and with the additive benefit of evaporation from the leaves which cools the surrounding air. However trees can have a shortened lifespan if grown without protection from a large dairy herd and therefore need to be protected from grazing, this can make artificial structures more practical.(Schutz, 2009)

The space required per cow is very important in providing effective shade to the grazing herd to prevent dominant cows from excluding subordinate cows in the herd from entering the shaded areas. An ideal area would be approximately 4-9 square meters per cow, although as a rule of thumb 1 square meter per 100kg liveweight should be sufficient to allow all herd access to shade when needed (this is the space allowed in most cow housing situations).(Verkerk, 2009)

Graze cows close to the shed: Use of paddocks close to the dairy shed during hot days are very important in afternoon milking, this reduces the distance the cows need to walk to the shed. Large farms in Canterbury have extremely long distance for cows to walk to the shed. This walk to the shed may negate the positive effects of paddock shade.

Use of less thermogenic feeds: Some feed sources create greater heat production (more thermogenic) when digested than others, this includes ryegrasses that contain the endophyte ergovaline (this is contained in some modern cultivars to provide insect protection, it is also present in older wild type ryegrass cultivars). Choose pasture cultivars carefully when renovating pastures. The use of other lower thermogenic feeds during warm weather will also mitigate heat loadings on cows, e.g. carbohydrate based feeds such as molasses.

Have ample water available. The most important practice is to provide cattle with sufficient quantities of cool clean drinking water. Water will keep an animal's body temperature within normal limits, as well as help to improve feed consumption. Animals in confined feeding systems require water at a rate of 1.1% of body weight per hour.

At the milking shed

Sprinklers: Cows should be wet to the point where water is running off them, otherwise localized humidity around the cow increases and cow comfort decreases.

OAD: Once a day (OAD) milking during the hottest months of summer will alleviate heat loadings on dairy cattle, especially if the milking occurs in the mornings. However there will be production losses associated with converting a herd to OAD.

Shelter and irrigation

In conditions of high evaporative demand, irrigation can only partially relieve moisture stress in plants, even if they are watered to soil capacity. This is especially evident in some shallow soils of Canterbury. Shelter alleviates water stress by reducing evaporative demand and the following factors:

- Radiation
- Vapour pressure deficit
- Wind

The main objective of irrigation should be in keeping the stomata open throughout the day to maximize photosynthesis, and hence plant growth. Surface, or flood irrigation, and sprinkler irrigation should have the same complementary aims.

Sprinkler irrigation has further benefits of using shelter in their systems. These include:

- Reduction in evaporation of falling droplets
- Reduced wind drift
- Improve uniformity of application, i.e. reduce under and overwatering areas which potentially reduce pasture production.

Shelter in a pivot irrigated farm

The construction of sprinkler irrigation, e.g. centre pivot, has necessitated the removal of tall shelter belts in Canterbury. This however does not mean that shelter cannot be provided in farms irrigated by centre pivot. The most limiting factor to planting natural shelter is the height restrictions imposed by the passing of the centre pivot irrigator over the land. Low growing shelter or more accurately termed, hedges, can be used in the areas underneath the centre pivot radiating out from the centre (Figure 3). Further planting could be carried out around the

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boundaries of the farm shown in Figure 3, these provide shelter and shade (depending on the orientation), provide a natural screen for dairy farming operations and further improve perceived visual amenity.

Further research is required to determine how effective low shelter is in controlling windspeed, evapotranspiration and animal comfort. The existing relationships between shelter height and impacts (Figure 1) suggest that low shelter will be less effective (less area protected) at controlling these factors than tall shelter.

Centre pivot-irrigated farms have areas which could be utilized for tall natural shelter which would provide significant visual amenity and provide shelter/shade for at-risk stock during acute weather events. These are at the corners of the paddock where the area remains un-irrigated by the pivot (these areas are usually comparatively less productive at growing pasture even if watered by other less effective manually moved methods, e.g. k-line or long lateral sprinklers). The ends of the pivot that are watered by the terminal gun can also be planted in tall shade and shelter trees.

An extensive table of native vegetation species useful for hedgerows and shelterbelts can be found in the following publication: *Establishing shelter in Canterbury with Nature Conservation in mind - A practical guide for the true Cantabrian!*. (Meurk, 2005)

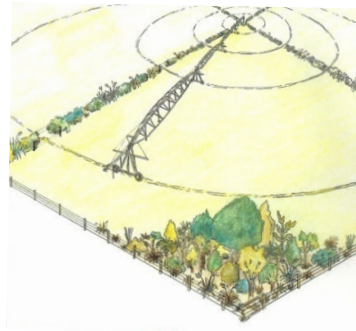


Figure 3. Centre pivot irrigation with radial patterning of hedging and bush filled paddock corners (Meurk, 2005)

Biodiversity and visual amenity

As already discussed the removal of vegetation on dairy farms to facilitate irrigation structures has been rapid in the last decade of Canterbury agricultural development. This has been very visible to the wider public and has developed into a prolonged and polarized discussion of the sustainability of current dairy farming practices in a dry Canterbury environment. This has mostly been centred on sustainable use of water resources; however there are other forums of discussion that have incorporated issues of animal welfare and biodiversity.

Public perception of current dairy practice

There are some current practices of dairy management that are deemed objectionable to the average urban dweller, whether they are impacting adversely on animal welfare or not, e.g. grazing dairy cattle on winter brassica crops in a muddy pugged paddock is usually done out of necessity to adequately feed the herd. The dairy farmer will usually have a run-off paddock that the herd can use once the break is finished, however the public driving past will only see cows standing in mud and not realize there are these well managed practices in place. Provision of attractive planting of shelter and amenity trees in and around paddocks, has the potential to substantially improve the visual amenity of dairy farms.

Research is required to determine the additional value of visual amenity from tree planting for dairy farmers ; what is the role of improving visual amenity on growing discontent among non-dairy farmers (both urban and rural) towards current dairy farming practices in Canterbury?

Biodiversity

So has the removal of shelter vegetation also reduced biodiversity? Although the shelter trees that have been removed have usually been a monoculture of exotic trees, these trees do provide a small part in providing environments for nesting birds and insect populations, and aiding on-farm biodiversity. The author predicts that re-introducing natural (preferably native) vegetation onto dairy farms will help facilitate the reintroduction of a greater range of species on-farm. Further research is required to quantify any benefits made to biodiversity with replanting of vegetation on Canterbury dairy farms.

Conclusion

Conversion of large areas of the Canterbury plains to dairy farming and spray irrigation has resulted in the clearance of many shelter belts from the plains. This review has explored the value of shelter to components of the farming systems and identified areas where further

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research is needed to address the question: do shelter belts add value to dairy farm systems on the Canterbury plains?

Developing farming systems which incorporate natural vegetation to provide shade and shelter on Canterbury dairy farms will require a range of beneficial drivers to motivate farmers and land owners.

Opportunities exist to show

- increased milk production (in some instances, further research is required using Canterbury conditions)
- increased cow fertility
- more efficient water usage within pastures
- more effective placement of irrigation water
- better animal welfare
- maintain access to international markets
- better public perceptions of current dairy farming practices
- less soil erosion

It is commonly agreed that dairy farming must be sustainable and resilient to change within the current global trading market. Sustainability and business resilience is also essential within the physical environment and climate change may produce further barriers to increased sustainable dairy production in Canterbury. Although a substantial commitment is required to replant shelter and shade in centre pivot irrigated dairy farms, there are resulting benefits (as listed above) that are realized with well planned and effective natural shelter and shade systems. However the scope of the benefits on a current dairy farming system in Canterbury are varied and the current literature contains some gaps in research findings that need to be addressed before definitive advice can be given to local dairy farmers as to whether or not to replant natural vegetation.

- The main areas that require further investigation through additional research are:
- Is there a drop in milk production when dairy cows are exposed to heat loadings in Canterbury (this research should include solar radiation (BGHI) as a measure of heat loads and not just a THI)?
- Is a combination of ‘amenity’ and shelter/shade plantings on centre pivot blocks of value to farming businesses?
- What is amenity value to farmers, local, regional and national non-agricultural stakeholders of such planting?
- What are the production benefits of planting low shade and shelter under a centre pivot?

- What the scale of competition for nutrients, moisture and light between trees and pastures using low shade and shelter under a pivot irrigator?

References

- Basher L R and D J Painter. 1997. Wind erosion in New Zealand. Proceedings of the International Symposium on Wind Erosion, Manhattan, Kansas.
- Bird P R. 1998. Tree windbreaks and shelter benefits to pasture in temperate grazing systems. *Agroforestry Systems*. 41:35-54.
- Buffington D E et al. 1981. Black globe-humidity index (BGHI) as comfort equation for dairy cows. *Transactions of the ASAE*. 24(3):711-714.
- Burke S. 1998. *Windbreaks*. Reed International Books Australia Pty Limited.
- Caborn J. 1965. *Shelterbelts and Windbreaks*. London: Faber and Faber. 288.
- Campbell D. 2009. Animal Welfare and Market Access: A Dairy Industry Perspective. in *Proceedings of the Society of Dairy Cattle Veterinarians of the NZVA*.
- Chebel R C et al. 2004. Factors affecting conception rate after artificial insemination and pregnancy loss in lactating dairy cows. *Animal Reproduction Science*. 84(3/4):39-255.
- Fisher A D et al. 2008. Effects of shade provision on the behaviour, body temperature and milk production of grazing dairy cows during a New Zealand summer. *New Zealand Journal of Agricultural Research*. 51(2):99-105.
- Goulter C L. 2010. Dairy Shelter on the Canterbury Plains. SFF Grant no L09/023.
- Gregory N G. 1995. The role of shelterbelts in protecting livestock: a review. *New Zealand Journal of Agricultural Research*. 38(4):423-450.
- Hennessy K et al. 2007. Australia and New Zealand, in *Climate Change: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Holmes C W and A R Sykes. 1983. *Shelter and Climatic Effects on Livestock*. Water & Soil Miscellaneous Publication. 59:19-35.
- Janett D S. 1988. *Shelter in the Rural Landscape*.

Notes:

- Kendall P et al. 2006. The effects of providing shade to lactating dairy cows in a temperate climate. *Livestock Science*. 103:148-157.
- King M and J W Sturrock. 1983. Shelter and the hill country environment. *Water & Soil Miscellaneous Publication*. 59:37-52.
- Laird F and G Barrell. 2009. Lack of effect of hot summer conditions in Canterbury on milk production of dairy cows. *Proceedings of the New Zealand Society of Animal Production*. 70:19-22.
- McLaren R G and K C Cameron. 1996. *Soil Science, Sustainable production and environmental protection*. 2nd edition ed. Oxford University Press. 304.
- Meurk C. 2005. Establishing shelter in Canterbury with Nature Conservation in mind - A practical guide for the true Cantabrian! Lincoln University and Landcare research.
- NAWAC. 2010. *Animal Welfare (Dairy Cattle) Code of Welfare 2010*, MAF Biosecurity New Zealand.
- M Parry et al Editors. 2007. Cambridge University Press: Cambridge, United Kingdom. 507-540.
- Pitcairn C and J Grace. 1985. Wind and surface damage. in *Effects of Shelter on the Physiology of Plants and Animals*, J. Grace Editor. Swets and Zeitlinger.
- Price L. 1993. Hedges and Shelterbelts on the Canterbury Plains New Zealand: Transformation of the Antipodean Landscape. *Annals of the Association of American Geographers*. 83(1):119-140.
- Radcliffe J E. 1985. Shelter belt increases dryland pasture growth in Canterbury. *Proceedings of the New Zealand Grassland Association*. 46:51-56.
- Santos J E P et al. 2004. The effect of embryonic death rates in cattle on the efficacy of estrus synchronization programs. *Animal Reproduction Science*. 82/83:513-535
- Schutz K E et al. 2009. Dairy cows prefer shade that offers greater protection against solar radiation in summer: Shade use, behaviour, and body temperature. *Applied Animal Behaviour Science*. 116:28-34.
- Southern Woods. 2010. *Dairy Farm Planting Guide*. Available from:
<http://www.southernwoods.co.nz/documents/DairyFarms2010pdf.pdf>
- Sturrock J W. 1983. The role of shelter in irrigation and water use. *Water and Soil Miscellaneous Publication*, National Water and Soil Conservation Authority, New Zealand. 59:79-86.
- Tait P and R Cullen. 2006. *Some External Costs of Dairy Farming in Canterbury*. Lincoln University [Publication for Malvern Hills Protection Society Inc]. Available from:
http://www.aares.info/files/2006_tait.pdf
- Verkerk G A. 2009. Personal communication.