Mulch mats - their potential in establishing forest and other tree crops

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FOREWORD

New forests in Ireland are mainly established on former pasture or tillage land. Cessation of such land uses results in rapid growth of weeds, more often than not necessitating the use of herbicide to get trees off to a good start. While herbicide application is a cost effective solution in these situations, alternative weed control systems need to be investigated, given that stricter EU regulations coupled with Forest certification schemes have resulted in some products being withdrawn for forestry use, and in the future others may follow suit.

COFORD funded the research outlined in this report with the straightforward objective of examining the technical feasibility of using a range of mulch mats, as an alternative to herbicide use, to establish forest and other tree crops on both afforestation and reforestation sites. Costs of the different options were also examined, as were the impacts on the mats on soil moisture and temperature.

What the research has shown is that mulch mats do control vegetation as well as the commonly used herbicides, on a range of sites, but overall their use is, at the moment, prohibitively expensive. However, technology may develop to the extent that mats can compete with herbicides and eventually partially or fully take their place. Work on other approaches, such a larger size plants and assured plant quality at establishment, allowing rapid early growth, are also worth considering. One way or another, investment in new approaches to vegetation control is needed, as forest establishment by planting is likely to predominate for the foreseeable future.

The three authors have done a useful piece of work and have produced a concise and readable summary of their results. Not only will the results be of interest to foresters but all those involved in growing Christmas trees and other perennial crops should find food for thought in the report.

Dr Eugene Hendrick
Director

Michael Lynn
Chairman

BROLLACH

Tá foraoisí nua in Éirinn bunaithe den chuid is mó ar iar-thalamh féaraigh nó curaíochta. Mar thoradh ar scor na talamhúsáidí dá leithéid bíonn fás gasta na bhfiailí, go ró mhinic ag déanamh riachtanas as úsáid luibhicíde chun tús maith a thabhairt do na crainn. Cé go bhfuil feidhmiú luibhicíde mar réiteach costas éifeachtach sna cásanna seo, caithfear imscrúdú a dhéanamh ar chórais rialú fiaile malartach, ag tógáil san áireamh go bhfuil roinnt táirgí áirithe tógtha ó húsáid foraoiseachta mar thoradh ar rialacháin níos dochta an AE i gcomhar le scéimeanna deimhnithe Foraoise, agus sa todhchaí d'fhéadfadh níos mó an bealach a leanúint.

Mhaoinigh COFORD an taighde imlínithe sa tuarascáil seo leis an cuspóir díreach d'imscrúdú a dhéanamh ar féidearthacht teicniúla de réimse mataí móta a úsáid, mar mhalairt ar úsáid luibhicíde, chun foraois agus barra crainn eile a bhunú ar láithreacha coillteoireachta agus athfhoraoiseachta araon. Rinneadh imscrúdú ar chostais na roghanna difriúla chomh maith, mar aon le tionchair ar na mataí ar thaiseacht agus teocht ithreach.

Is éard atá taispeánta ag an taighde seo ná go rialaíonn mataí móta fásra chomh maith leis na luibhicídí a úsáidtear go comónta, ar réimse láithreacha, ach ar bhonn foriomlán tá a n-úsáid, ag an bpointe seo, costasach go maith. Mar sin féin, d'fhéadfadh teicneolaíocht forbairt chomh mór sin go bhfhéadfadh mataí dul in iomaíocht le luibhicídí agus i ndeireadh na dála a n-áit a thógáil go páirteach nó go hiomlán. Is fiú machnamh a dhéanamh freisin ar chur chúigí eile, ar nós plandaí de mhéid níos mó agus caighdeán planda deimhnithe ag an mbunú, ag ceadú d'fhás luath gasta, . I slí amháin nó slí eile, tá infheistíocht gcur chuigí nua do rialú fásra riachtanach, d'fhonn gur dhóchúil bunú foraoise trí phlandáil ardcheannasach don todhchaí amach romhainn.

Tá an triúr údar tar éis píosa oibre úsáideach a dhéanamh agus tá siad tar éis achoimre soléite agus achomair de na torthaí a tháirgeadh. Ní hamháin go mbeidh suim ag coillteoirí sna torthaí ach ba chóir go díol spéise sa tuarascáil dóibh siúd uile atá bainteach i bhfás na gcrann Nollaig agus barra trébhliantúla eile.

An Dr Eugene Hendrick
Stiúrthóir

Michael Lynn
Cathaoirleach

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SUMMARY

An important part of establishing forests is the suppression of competing weeds: clearly the more vigorous the weed growth is, the more young crops experience competition for light, water and nutrients. Much research in forest vegetation management has been devoted to testing and developing herbicides. In recent years, however, environmental awareness and forest certification processes have led to a reappraisal of herbicide use. Given these developments it is important to examine potential alternatives to herbicides for use in Irish forestry.

The primary objective of the work reported here was to investigate the use of mulches in controlling weed vegetation in the forest. Mulching is a weed control technique used in agriculture and forestry throughout the world.

Eight different photodegradable plastic mulch mats were tested in four plantation types: a Nordmann fir (*Abies nordmanniana*) Christmas tree plantation, a eucalyptus (*Eucalyptus parvifolia*) foliage plantation, and a reforestation site planted with ash (*Fraxinus excelsior*) and Sitka spruce (*Picea sitchensis*), respectively. Results showed that mulch mats controlled vegetation around trees at least as well as conventional herbicides. However, the cost of using mats was up to seven times that of herbicides.

INTRODUCTION

Background

In forestry, control of competing vegetation is essential for rapid tree establishment. Weeds, particularly grasses, are fast-growing and compete aggressively with newly planted trees for moisture and nutrients. Generally, the more vigorous the growth of vegetation on a site, the more the competition with trees for the moisture and nutrients. It is widely acknowledged that a reduction in available moisture and nutrients due to weed competition on a site leads to reduced tree growth and survival (Davies 1987). In effect, weed competition reduces growth and vigour of young seedlings and often results in mortality. Thus, in order to establish a tree crop effectively, the rooting area of seedlings must be freed from competition until rooting is extensive and deep enough for the seedling to compete with weed vegetation. Maximum tree growth is obtained under weed-free conditions (Beaton and Hislop 2000), a contention supported by almost all the literature on the subject. However, maintaining weed-free conditions over the full site is prohibitively expensive. Furthermore, such an approach provides no cover for wildlife and the result is often unsightly.

In practice, weed control is carried out for the first two to three growing seasons after planting (Beaton and Hislop 2000, Lund-Høie 1984). Poorer sites and slower growing trees require a longer establishment time (Atchison and Ricke 1996) and hence competing vegetation may need to be controlled for a longer period. In Ireland, since the 1960s, the operation has been predominately carried out using herbicides. Recently, however, certification processes and increasing public and industry awareness of the importance of biodiversity conservation have led to some concerns over the continued use of herbicides. It is therefore important to examine potential alternatives for the Irish forestry situation.

Wagner and Zasada (1991) defined forest vegetation management as the management of non-crop vegetation to achieve silvicultural objectives, using a variety of methods that are environmentally sound, economical, and socially acceptable. Although the ability to control unwanted vegetation has been the principal criterion for selecting particular vegetation management treatments, these are only silviculturally effective if they enhance the survival and growth of treated stands (Wagner 1993). On purely economic grounds, vegetation management can only be justified if the value gained from a treatment is greater than its discounted cost (Row 1987, Brodie and Walstead 1987).

Optimising vegetation management in young forest plantations involves a number of factors, including finding the most effective time to reduce competing vegetation around the seedling (Wagner et al. 1996). This critical period is the time after planting when herbaceous vegetation must be controlled to avoid significant growth loss. Swanton and Weise (1991) identified this as an important component of integrated weed management for agriculture.

Wagner et al. (1996) also indicated that both timing and duration of herbaceous vegetation control are important to the growth of northern conifers. Weed infestation curves show that herbaceous vegetation can substantially decrease seedling diameter growth in the first year after growth. A study with Norway spruce (*Picea abies*) found that the greatest growth occurred when vegetation was controlled during site preparation, with substantial growth decreases occurring as the interval between planting and competition release increased (Lund-Høie 1984). Lauer et al. (1993) found that herbaceous vegetation control applied in the first and second year after planting nearly doubled wood volume gains in loblolly pine (*Pinus taeda*) at age nine, relative to trees that had received vegetation control in the first year only.

Developing technology to control unwanted vegetation has been the focus of most research in forest vegetation management, with nearly all the work being done on herbicides (Wagner 1993). Their attraction is that they generally kill both sprouting and non-sprouting plants and are therefore effective in controlling many plant communities. They also give the best vegetation control relative to cost (McDonald and Fiddler 1993). In suppressing the undesirable plants, soil moisture and nutrients are made available to the roots of new tree seedlings.

Most new woodlands require weed control to enable trees to establish successfully, and although research continues into alternatives, the use of herbicides is currently the only cost effective option in many situations (Willoughby and Claridge 2000).

In new plantations, treating competing vegetation when it is small, not yet fully established and still recovering from any damage incurred in site preparation, is fundamental to a successful vegetation control programme (McDonald and Fiddler 1996). When carried out early, weed control treatments are also more cost effective. However, one treatment per year is all most budgets can afford, and in these circumstances competing plants take advantage and may reduce seedling growth (McDonald and Fiddler 1996).

Over the past few decades, the use of herbicides to manage forest vegetation has generated considerable public debate across North America (Wagner 1994). Thomas et al. (2001) stated that in British Columbia there is a growing reluctance on the part of many land-owners and farmers to use herbicides because of the associated permits and training that are required before they can be applied. The recent certification initiative in Britain has confirmed this trend (Willoughby 1999).

Potential alternatives to herbicides – a brief review of the literature

Mowing

On sites where erosion is a problem, mowing may be an option between tree rows but it does little to reduce the competition for moisture and nutrients. According to Davies (1987), mowing of grass is positively detrimental to tree growth. He also found that in some un-mown grass swards the weeds often die back thereby creating a self-mulching effect in winter that gives the trees a good start the following season.

Mowing does reduce fuel build-up, cover for rodents and makes the plantation more accessible for other management activities (Atchison and Ricke 1996), but it is primarily cosmetic.

Weed plant species compete with each another as well as with newly-planted trees. Mowing can change the natural balance between weed species in favour of detrimental perennial grasses, which are resistant to cutting. However, Willoughby and McDonald (1999) found that maintaining a 1 m wide weed-free strip around trees, combined with mowing the inter-row to minimize weed seeding, was a cost-effective method of weed control. In their study on vegetation control for the establishment of ash (*Fraxinus excelsior*), Culleton et al. (1995) found that leaving an un-mown strip of grass between lines of ash was beneficial. They speculated that the trees, while profiting from the weed-free zone around them, were sheltered from the wind by the grass.

The conclusion is that mowing on its own is ineffective but combining it with another weed control method could have potential.

Cultivation

Cultivation is the tilling of the soil to provide a favourable environment for tree establishment and growth of plants or regeneration; and, where appropriate, to improve root anchorage for better wind-firmness. Methods include bedding, disking, moling, mounding, peat tunnelling, ploughing, ripping, scalping, scarifying and subsoiling (Paterson and Mason 1999). During the operation weeds are often cut below ground level, uprooted and left to desiccate, or they may be buried. Cultivation can be vital in ensuring successful and cost-effective establishment. Ploughing before planting is relatively cheap and as well as providing initial weed control, it also improves the ease and quality of planting (Davies 1987). Mounding, used extensively in Ireland, provides the same function.

Cultivation is quite effective in the control of annual weeds, especially at the seeding stage. However, this method may bring weed seeds to the surface where they can germinate so it is a better weed control method in countries with a Mediterranean climate where there is little or no summer rainfall. Seeds brought to the surface in summer will not germinate and uprooted weeds and rhizomes soon wither (Davies 1987). Otherwise, shallow cultivation is used to reduce the number of dormant seeds brought to the surface. During the growing season repeated tillage passes may be required as new weeds emerge. Shallow cultivation, not deeper than 7 or 8 cm, also avoids damaging small feeder roots near the surface.

Schuette et al. (1996) suggest that a combination of cultivation to remove the between-row vegetation and herbicide to maintain a weed-free band around the trees is a good way of controlling weeds. Cultivation as a means of controlling weeds is more effective on less fertile sites (Willoughby and Moffat 1996).

Mulching

Mulching (the spreading of material around desired trees to control competing vegetation) is used in agriculture and forestry throughout the world (Gupta 1991, McDonald and Helgerson 1990). It has been used in the western United States for the last thirty years. It provides a means to passively control vegetation and thereby reduce the need for mechanical or chemical weed control (Haywood 1999). Where labour for continual weeding is scarce, machines cannot operate, or the use of herbicides is restricted or not desirable, mulching may be an attractive alternative which can help to conserve soil moisture, improve water infiltration and reduce sedimentation (Walker and McLaughlin 1989, Gupta 1991).

In an agricultural context, mulching is one of the most environmentally benign strategies for weed control, reducing the need for tillage and herbicides, and avoiding associated problems (Feldman et al. 2000).

Although expensive in forestry applications, mulches have proven to be as biologically effective as other treatments (McDonald and Helgerson 1990). Willoughby (1999) estimated that in Britain plastic mulch installation would cost, on average, two and a half times as much per hectare than band spraying with herbicide.

Research has suggested that the use of mulch mats can reduce grass and herbaceous competition for water and improve the initial survival and growth of conifer seedlings. The mats are best applied in spring, soon after planting, before competing vegetation has had an opportunity to develop.

Waggoner et al. (1960) conducted an extensive study on the principles and benefits of using polyethylene films for vegetation control. Their results indicated that black films had the least modifying effect on soil energy budgets and had a high ability to conserve soil moisture. Black film, by reducing light transmission, also exerted good control over unwanted vegetation compared to translucent plastic.

Parfitt and Stott (1984) compared the effect of black polyethylene and straw mulch covers with herbicides (which maintained bare ground conditions) on the establishment, growth and nutrition of poplar and willow cuttings. The polyethylene mulch significantly increased the number of shoots per cutting and the length of the longest willow shoot, when compared with straw mulch and herbicide treatments. Temperature and moisture content under the mulches were higher than for the other treatments.

Bowersox and Ward (1970) also examined black polyethylene mulch as an alternative to mechanical cultivation in hybrid poplar establishment from dormant cuttings. They concluded that establishment success using black polyethylene mulch could equal or exceed that of mechanical cultivation. Similarly, Blain (1984) set up an experiment to study the response of *Salix* and *Populus* cuttings to mulching with black polyethylene. The mulch improved shoot extension growth and suppressed weed growth, although occasional weeds appeared where the polyethylene had become torn around the base of the cuttings.

In a study in Canada (VMAP 1994), results indicated that hardwood seedlings treated with Brush Blanket mulches grew as well as seedlings treated annually with Vision or Simazine herbicide sprays and better than seedlings that received no vegetation control.

Harper et al. (1998) established a trial to compare the effectiveness of the herbicides Glyphosate and Hexazinone with plastic mulch mat treatments in reducing grass competition and improving Douglas fir seedling performance. They found that pre-plant herbicide application was effective for at least three growing seasons for perennial grasses, and that Douglas fir seedling growth and survival improved. Post-planting spot application resulted in a high (65%) seedling mortality rate during the first year even when seedlings were protected. Mat sizes of 1.2 x 1.2 m were found to reduce competing vegetation ground cover for five years.

McDonald and Fiddler (1996) demonstrated that a vigorously sprouting shrub species could be killed with a sheet-type mulch. They tested large and small mulch mats and their efficacy in suppressing non-crop vegetation and enhancing conifer growth. Conclusions reached were that mulching showed promise for application in almost all plant communities, including those with plants that originate from sprouts and rhizomes, with larger mats being especially effective. A durable mulch that persists for several years has obvious benefits for seedling growth. In areas with a high density of widely spaced seedlings surrounded by dense, tall competition, having a visible mulch would be beneficial for evaluating seedling growth and survival. McDonald and Fiddler (1996) also

concluded that pore structure of the mulch is important, and ideally it should allow water to percolate downwards but restrict upward movement. This was borne out by Feldman et al. (2000) in their experiment in an agricultural situation where landscape fabric, which is permeable to water, was preferable to polyethylene film.

Although the microclimatic effects of various mulch materials on soil, air temperature and soil moisture have been investigated (McDonald and Helgerson 1990), there is a limited understanding of the relationship between mulch area and the growth and survival responses of trees. Larger diameter mulches appear to increase growth rates, however survival does not appear to depend on the diameter of the mulch mat. Thomas et al. (2001) found that 60 x 60 cm mats only increase tree growth during the first year, with no measurable effects in successive years. They concluded that the result was most likely due to the small mat size and postulated that perhaps a larger mat may have prolonged the growth response. Willoughby (1999) included 1 x 1 m mulch mats in his investigation into reducing herbicide inputs in British forestry and drew the same conclusions with respect to the mat size.

Many types of mulch are marketed but few may actually meet enough of the criteria outlined to be useful. According to McDonald and Helgerson (1990) the ideal silvicultural mulch mat should be opaque, dark, permit water infiltration, retard evaporative water loss, support favourable soil temperatures, sufficiently strong and durable to last until seedlings are established, low in cost and lightweight, non-toxic and of a colour that blends into the landscape. Other factors could include biodegradability and unattractiveness to animals. The authors also indicate that understanding site conditions, vegetation type, mulch material and combinations of these factors, are the important features of refining mulch technology. Technological advancements in mulch material that increase effectiveness, durability and size, while decreasing weight and application costs, will improve the attractiveness of this method.

Haywood and Youngquist (1991) investigated plant fibre and plant fibre-polyester mats placed round the root collar of newly planted loblolly pine seedlings and over a cover of grasses, forbs and blackberries. The small sample sizes precluded the detection of any positive response to the mats but it was concluded that the negative effects of the mats on the seedlings were minimal.

Haywood (1999) established two studies to determine the ability of a large selection of mulches to remain intact and in place under field conditions (durability), control weeds, and influence the growth of loblolly pine (*Pinus taeda*) seedlings. Among the mulches tested were jute, pine straw, cellulose, polypropylene and polyethylene. As weather can influence the durability of mulch, meteorological data were collected. Note was taken of installation difficulties for the various mats as these could be serious obstacles to their continued use. Pine seedling measurements and weed cover estimations were carried out and mulch durability estimated visually over three growing seasons. In most cases mulches eliminated the established cover and germinants and vegetation did not readily re-establish after the deterioration of the mulch. After three growing seasons, the loblolly pine seedlings grew better where mulches were used.

Adams et al. (1997) examined three alternative weed control strategies in blue oak (*Quercus douglasii*) seedling plantations in California. The effect of herbicides, porous plastic mats and impervious plastic mats were compared. No one strategy was superior, though all resulted in greater seedling survival compared with no weed control. The use of herbicides proved to be the most cost effective.

In a later paper Adams (2000) stated that the use of synthetic mulch mats may be competitive with cheaper chemical sprays for weed control where use of natural resources is intensive rather than extensive. Intensive use imparts greater value, and the protection and enhancement of this value often warrants investment that could not be justified under extensive management where value per unit area is low. In addition, environmental and social considerations have a higher priority in areas of intensive use and they may be more easily accommodated. It was also estimated that as the primary benefit of landscape fabric is its durability, thus producing less solid waste, the higher initial expense of fabric compared to black plastic may be offset. Initial labour costs for the fabric mulch were higher than for a bare ground control and organic mulch but this was reversed in the following two years of the trial.

Fertilisers are sometimes necessary to improve tree growth, mostly because of nitrogen deficiency. Various formulations are used such as nitram, urea or the slow release compound Osmocote. When mulch mats are used for weed control, such top dressings

may be difficult to apply. Appleton et al. (1990) stated that a feature of mulch mats is that they encourage rooting near the soil surface and that these surface roots, and therefore the trees, become damaged if soluble fertilisers are used beneath the mats. Armstrong and Moffat (1996) began an investigation into the benefits of slow release nitrogen fertiliser compared with conventional formulations on recently planted trees. They examined the effect of mulch mats on fertiliser response and the effect of weed control method on ammonia release from applied urea. They concluded that mulch mats presented few problems for fertiliser applied during the dormant season, but issues such as lifting and replacing the mats during application needed to be considered. No evidence was found that release of ammonia from urea applied at recommended rates reduced tree growth. In fact, mulch mats appeared to reduce the loss of nitrogen by volatilisation where urea was applied.

Organic mulches, especially those derived from waste products may, in economic, environmental and aesthetic terms, be a more favourable option than inorganic products. Froment et al. (2000) reported results of an experiment in which the effectiveness of four organic mulches (farmyard manure, compost, chopped straw and wood chips) applied at two depths was compared with a herbicide treated control. Results showed that all mulch treatments resulted in greater height and stem diameter increment compared with the herbicide treated control. Persistence of the mulches was assessed by comparing mulch depth at the start and end of the growing season. Farmyard manure was the least persistent, and compost was the most persistent. Straw and woodchip mulches gave the best weed control but height and stem diameter increments were less than for farmyard manure and household compost.

Smith et al. (2000) used a wood chip mulch (obtained from cleared right of ways) on pecan (*Carya illinoinensis*) seedlings. The chips were stockpiled for three months prior to being applied to a depth of 30 cm. Pecan harvesters sweep the ground so the mulch must deteriorate by the time the trees begin bearing nuts. The wood chip mulch treatments were applied in factorial combination with two rates of nitrogen, applied as either a single application at budbreak or again three weeks later. Foliar nitrogen concentration during the third year was positively related to mulch width as were stem diameter and tree height.

Lo et al. (2000) carried out a mulching trial in a hybrid poplar plantation using waste fibre from a paper mill. Analysis of the residue showed them to be mainly waste fibre and lime with few contaminants that could pose hazards to the environment. Weed biomass data showed that weed cover was in the range of 9-19%, which represented 80-90% weed suppression, compared with controls. The data also showed that the mulch was largely mineralised and lost its effectiveness as a weed suppressant after the fourth growing season.

Iles and Dosmann (1999) evaluated and compared the effects of five mineral (crushed red brick, pea-gravel, lava rock, carmel rock and river rock) and three organic mulches (finely screened pine bark, pine wood chips and shredded hardwood bark) on soil properties and on the growth of red maple (*Acer rubrum*). The authors concluded that the mineral mulches used in the trial did not create growth-limiting soil environments.

Pickering and Shepherd (2000) undertook a study to investigate nutrient content and nutrient release characteristics of six organic landscape mulches (cocoa shells, coarse conifer bark chips, wood chips, garden compost, horse manure and finely ground conifer bark). Comparisons were made with black polythene mulch and a bare ground control. The mulches were put in place and left for a twelve month period, after which they were removed and the plots sown with agricultural mustard (*Sinapsis alba*). Soil analysis was carried out at the beginning and end of the experiment, fresh and dry masses of the mustard crop were determined and their nutrient contents assessed. It was found that horse manure, garden compost and cocoa shell mulches with low C:N ratios and high potassium content resulted in significant increases in soil nutrients and supported the highest yields. After twelve months there was no evidence of nitrogen immobilisation or growth suppression under wood- or bark-based mulches.

Samyn and De Vos (2002) published results of a trial in Flanders, Belgium, where the use of mulch sheets made from 100% recycled waste[1] was investigated, along with a number of other treatments. Results showed that the sheet mulches increased the relative growth rate of all species planted in pasture.

[1] Ecopla sheets comprised of paper mill sludge 45%, compost (fruit, vegetable and garden waste) 45% and recycled paper or textile fibres 10%.

A number of experiments have shown that tree growth response often lags suppression of competing vegetation by one or more years. Lanini and Radosevich (1986) attributed the delayed response in conifers to the cyclic nature of their growth, where the current season's growth is partially dependent on carbohydrate produced the year before. It appears that the lag period between resource increase and concomitant increase in growth is species dependant. Flint and Childs (1986) also found that first year growth data did not show statistical differences among treatments and attributed them to a combination of nursery conditions and transplanting stresses on first year out-planted seedlings. This factor would have to be considered in any studies undertaken.

The literature shows that the interaction of factors involved in the response of trees to mulches is extremely complex. These considerations should be taken into account when choosing a mulch. However, the variety and choice of materials available means that growers can choose a mulch most suited to their circumstances while taking into account the material and maintenance cost.

Ground-cover plants

Establishment of ground-cover plants to prevent noxious weed invasion, while providing minimal competition with the tree crop, has been suggested as a potential method of controlling weeds in young plantations. During tree establishment perennial broadleaved ground-cover plants are possible alternatives to mulch, provided the cover can be maintained. Clover (*Trifolium s*pp.) and lucerne (*Medicago sativa*) are plants that may be used effectively under certain conditions (Beaton and Hislop 2000).

Experiments in the United Kingdom on converted agricultural land have shown the value of sowing ground-cover at planting (Williamson 1992, Williamson et al. 1992, Willoughby and McDonald 1999). The sown ground-cover out-competes and suppresses the growth of invasive weeds and thus confines herbicide use to maintaining a 1 m wide, weed-free band along the planting lines.

It is generally acknowledged that the control of weeds in forestry need not extend over the total site area for trees to survive and grow. Maintaining either a 1 m^2 spot around the base of each seedling or a 1 m wide strip along the row will often be adequate (Williamson 1992, Davies 1987, Willoughby and Dewar 1995). The spot can be maintained with a hand-held, ground-based applicator. Strip weeding allows mechanisation with the adaptation of agricultural spraying equipment. There is an open area of ground where weeds would proliferate if left unmanaged.

Williamson (1992) suggested two approaches to maintaining good weed control to promote rapid tree establishment and managing the ground flora in the inter-row:

- The vegetation round the planted trees is controlled and the vegetation naturally develops on the area between the weed-free areas. This then should be mowed regularly to prevent it seeding and becoming a problem.
- Weed control around the planted trees is imposed as before and a ground-cover crop is sown in the inter-row.

Williamson et al. (1992) reported the results of an experiment on the effect on tree growth of five inter-row management regimes on Corsican pine (*Pinus nigra*) and Norway maple (*Acer platanoides*). After two growing seasons the strip-weed-and-mow combination was the cheapest and most practical option for establishing trees. Willoughby and McDonald (1999) reported on the same experiment at the end of four growing seasons and found the same result. One treatment, sowing kale (*Brassica oleracea* var. *viridis*) in the inter-row, resulted in tree growth similar to strip-weed-and-mow, though tree growth was not as good as in the bare ground plots. The kale offered some competition but its main period of growth is in June, whereas the trees began their growth in May, before the kale plots had begun to grow. Once sown, kale requires very little management and provides food and cover for game birds for about three years. It forms a tall, dense canopy and effectively prevents most weeds from establishing.

Coates et al. (1993) studied the efficacy of various grass/legume mixtures in controlling competing vegetation and their effect on survival and growth of Sitka spruce (*Picea sitchensis*) seedlings on a coastal alluvial site in northwestern British Columbia. Legume or grass seeding reduced two out of four major competitors compared to the unseeded control, even though some grasses may provide more severe early competition than native species. It was felt, however, that the long-term competition effects of one of the native species were likely to be the greatest threat to Sitka spruce performance.

Seeding of clover (Trifolium repens) ground-cover was one of number of weed control methods employed by Ferm et al. (1994) to aid in the establishment of a birch plantation. However, vole damage and bark necrosis were associated with a high percentage of clover ground-cover. They found also that the clover did not reduce root competition as effectively as the best herbicides.

Hanninen (1998) compared seven clover species with cultivation and grass sod to determine their influence on birch growth in a nursery field. Contrary to the findings of Ferm et al. (1994), damage by voles and other pests was not a problem. It was concluded that annual clovers could have potential as ground-cover. They suppress weed growth during the summer without seeming to compete too much with the trees. During the winter they form a paper-like mat on the ground and delay weed germination in early summer. The one disadvantage was having to sow annually. However, herbicide use could be minimised.

Several criteria should be considered when choosing legumes such as clover for ground-cover in young plantations (Ponder 1994). Those that are used must grow well with minimal site preparation. Early benefits of leguminous ground-cover may decline later on because it will normally be shaded-out as the forest develops. However, enough seed may be stored in the soil to allow the legumes to re-establish themselves when the stand is thinned or harvested.

In Britain there has been some research on the practicality of establishing ground-cover through which the trees could be planted directly, without the need for weed-free strips to be maintained. Whereas Hanninen (1998) deemed clovers as non-competitive, Davies (1987) regarded them as highly competitive under UK conditions. Willoughby (1999) published the results of two experiments which investigated the use of nineteen alternative ground cover and silvicultural treatments for newly planted ash (*Fraxinus excelsior*) and Douglas fir (*Pseudotsuga menziesii*), established on fertile converted agricultural land. He found that most ground-cover was difficult to establish and was more competitive with the trees than naturally occurring vegetation. White clover did show some potential for suppressing weed competition without reducing tree growth.

Project objective

For a forest plantation to succeed, it needs access to water and nutrients. Weeds in the immediate vicinity of plants restrict this access. In the decades since the 1960s herbicides have been the means of controlling weed vegetation in Irish forests, due to their efficiency and relatively low cost. However, increased environmental awareness and forest certification processes, coupled with tighter controls, have reduced the range of herbicides and have raised the consideration of alternatives.

The objective of this project was to investigate the use of mulches in controlling weed vegetation in forest and related land-uses as an alternative to herbicides. Mulching is a means of passively controlling weed vegetation and reduces the need for mechanical and/or chemical intervention.

EXPERIMENTAL APPROACH

Trial site locations and crop types

Trials were carried out at three sites in the south/southeast of Ireland, in four crop types:

- Site 1: Clonroche Co Wexford. Christmas tree crop - Nordmann fir (*Abies nordmanniana*)
- Site 2: Chute Hall, Tralee, Co Kerry. Foliage crop - eucalyptus (*Eucalyptus parvifolia*)
- Site 3: Aclamon, New Ross, Co Wexford. Forest (reforestation) crops - ash (*Fraxinus excelsior*) and Sitka spruce (*Picea sitchensis*).

Mulch mats tested[2]

1. Woven Polypropylene Treespats (hereafter referred to as 'Acorn') 1 x 1 m (Acorn Planting Products Ltd, Little Money Rd, Loddon, Norwich, NR14 6JD UK).
2. Jute Treespats (hereafter referred to as 'Jute')1 x 1 m made from recycled jute coffee bags sewn to a polythene backing (Acorn Planting Products).
3. Vispore (hereafter referred to as 'Vispore') 1 x 1 m mulch mat made from polyethylene plastic (Treessentials Company, 2371 Waters Drive, Mendota Heights, MN55120, US).
4. Fabric Mulch Mats (hereafter referred to as 'Shaws') 1 x 1 m made from black woven polypropylene (Shaw Fabric Products LLC, P.O. Box 1288, Wellington, CO 80549-1288, Canada).
5. Brush Blanket (hereafter referred to as 'Brush') 1 x1 m photo selective polyethylene mats (Arbortec Industries Ltd, 12519 Pilgrim St, Mission B.C., Canada).
6. Cool Blanket (hereafter referred to as 'Cool') 1 x 1 m (Arbortec Industries Ltd).
7. Permatex Premium Tildenet (hereafter referred to as 'Tildenet') 2 x 50 m roll made from spun-bonded polypropylene (Cropwise, Saxelby Lodge, Saxelby Pastures, Melton Mowbray, Leicester LE14 3NA, UK).
8. Black Mulch Film (hereafter referred to as 'IP') 1.4 @ 30 x 1.4 m (I.P. Europe Ltd, IDA Industrial Estate, Courtown Rd, Gorey, Co Wexford).

The Permatex polypropylene roll was cut into metre-square mats and placed around the base of the trees. Products 8 and 9 were rolled out over a row of five trees and dug in at the sides and at each end. A hole was cut for each seedling. (Products 7-9 are designed to be laid down mechanically.)

All the mulches were photodegradable but not biodegradable. At the time the work was initiated there were only two or three fully biodegradable mulch mats at development stage. Since that time many biodegradable mulches have become available. It is recommended that some of these products be tested in the future.

Layout and experimental design

Treatments were laid out at sites 1 and 2 (at Clonroche and Chute Hall) in April/May 2002. Site 3 (Aclamon) was planted in early December 2002, with the mats placed on both species in mid December 2002.

Each trial was laid out as a completely randomised design with four replicates of each treatment. Each treatment consisted of 20 trees in a 4 x 5 matrix, with the central six trees being measured (Figure 2.1).

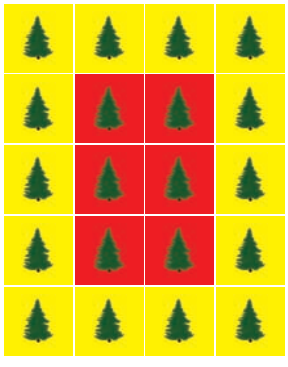

Figure 2.1: Layout of each 20-tree treatment plot, with the six central tree assessment plot shown in red. Vegetation was assessed in June and September/October of each year, with the most dominant and invasive species recorded.

[2] Reference to brands carries or implies no endorsement for the product or company by COFORD.

Part of the experiment treatment plots at establishment on Nordmann fir at Clonroche (April 2002).

The Clonroche site (October 2002). Note the monitoring equipment in the near background.

Jute mulch mats (treatment 2) placed around Nordmann fir at Clonroche (April 2002).

Jute mats five months after being installed (October 2002) showing vegetation growth, some of it on the surface of the mats.

Cool Blanket mulch mats placed around Nordmann fir (April 2002) Clonroche.

An IP Plastic treatment plot at Clonroche (October 2002).

Survival, growth and vegetation assessment

Survival and growth (root collar diameter (RCD) and stem height) were assessed at the end of each growing season.

Weather and soil condition measurement

In July 2002, a weather station was placed at the Clonroche site (Figure 2.2) to measure rainfall and air temperature. The rainfall sealing effect of the mulches and their effect on soil surface temperatures under each mulch mat treatment were quantified using temperature probes and tensiometers[3] linked to pressure transducers. Instrumentation was installed on a trial basis for the first year, and when found to be working satisfactorily was used over the following growing season across all treatment plots.

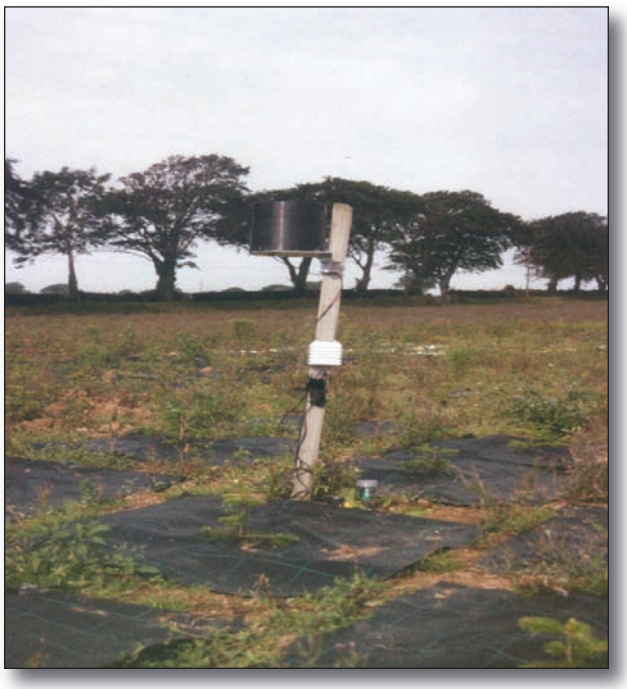

Figure 2.2: Soil condition and weather monitoring at Clonroche, Co Wexford.

Cost analysis

The cost of using mulch mats was estimated by recording the number of man hours taken to lay a certain number of mats, which then added to the material cost, to arrive at the total cost per hectare.

Assessment of the mulch trial in eucalyptus at Tralee.

[3] Tensiometers normally cover soil moisture tensions from 0-80 kPa (0 indicating saturated conditions, 80 kPa indicating dry conditions). Values from 10-20 kPa indicate field capacity (depending on soil type) - the amount of water held in the soil after gravitational water has drained away. Data stored were periodically uploaded to a computer.

EXPERIMENTS

Experiment 1: Nordmann fir[4] (*Abies nordmanniana*). Christmas tree crop. Clonroche, Co Wexford.

Site preparation and methods

Nordmann fir was selected at this site after a previous crop of noble fir failed due to Phytophthora root disease, to which Nordmann fir is not as susceptible. A summary of the work carried out at the site is presented in Table 3.1.

Table 3.1: Work carried out in the mulch mat trial in Nordmann fir at Clonroche.

Operation	Date
Nordmann fir planted	14-21 March 2002
Mulch mats installed	29 April 2002
Vegetation assessment	June 2002
Weather station and other instrumentation installed	23 July 2002
End of first growing season assessment	November 2002
End of second growing season assessment	December 2003
End of second growing season assessment	January 2005

Christmas tree (Nordmann fir) experimental site setup showing brush blankets in the foreground and Jute mats in the background in April 2002.

[4] Over the past decade and half the Christmas tree sector has experienced significant growth, with many specialised tree farms having been established. It is an important part of the Irish forest industry with annual sales in the region of €13m, including €7.5m in exports. The sector also makes an important contribution to rural development. The size of the European Christmas tree market is approximately 60 million trees a year. Noble fir is the most commonly sold Christmas tree in this country. While the Irish market is small the perception is that is becoming more discerning and demanding. Customers are prepared to pay higher prices for a better quality tree; it is becoming increasingly difficult to sell poor quality. Good returns to the investor can only be achieved through specialised knowledge, high standards of production, access to suitable markets and commitment from the producer. Ireland's domestic requirement is 400,000 trees per annum, while planting ranges from 300,000 to 500,000 trees. Production of noble fir for Christmas trees requires relatively fertile, slightly acidic soils, in areas that are not too exposed. Effective vegetation control is key to Christmas tree quality. However, with more stringent pesticide regulation, alternatives need to be investigated. Another consideration is the growing market for organic produce. Nordmann fir is the preferred Christmas tree species tree in Denmark and much of Europe, being favoured for its attractive foliage, with needles that are not sharp, and are not shed readily when the tree dries. It was introduced to Denmark in the 1850s as an ornamental and potential timber species.

Treatments

1. Acorn polypropylene mulch mat (Treatment 1, Chapter 2);
2. Jute mulch mat (Treatment 2, Chapter 2);
3. Visipore plastic (Treatment 3, Chapter 2);
4. Tildenet mulch mat (Treatment 7, Chapter 2);
5. Brush Blanket (Treatment 5, Chapter 2);
6. Cool Blanket (Treatment 6, Chapter 2);
7. IP Plastic (Treatment 8, Chapter 2);
8. Herbicide application - control.

The herbicide application (control) consisted of current vegetation control practice for Christmas tree crop: post planting spraying with terbuthylazine at 4 l/ha, then once per year in the spring, followed by spot treatment with glyphosate to control perennials. Vegetation control in this treatment was to a high standard.

Results

Mat integrity was very good on this site except for IP plastic which began to degrade with large holes appearing in it by the end of the trial. The Jute mats had some *Rumex* spp. growing on them (see Experiment 2).

Survival

There was no effect of mulch mat type on survival (Table 3.2).

Seedling growth

There were no significant effects of mulch mat type on root collar diameter (Figure 3.1a). There was, however, a statistically significant difference in mean height growth between treatments: trees in the Visipore treatment grew less than those in all other treatments, apart from the Acorn and Control treatments. The Brush treatment resulted in significantly higher height growth than the latter two treatments (Figure 3.1b).

Soil temperature and moisture availability

Mulch mats had no significant effect on soil temperature underneath them, compared with control (Figure 3.2). However, mulch mats did influence moisture availability (Figure 3.3). Plastic mats (IP Plastic, Brush Blanket and Cool Blanket) all caused soil moisture deficits from August 2003, through to mid December 2003. Heavy rainfall in

Table 3.2: Effect of mulch mat type on the survival of Nordmann fir at Clonroche, Co Wexford.

Mat Type	Survival after 3 years (%)
Acorn	100
Brush	100%
Control	99%
Cool	100%
IP	100%
Jute	100%
Tildenet	99%
Vispore	100%

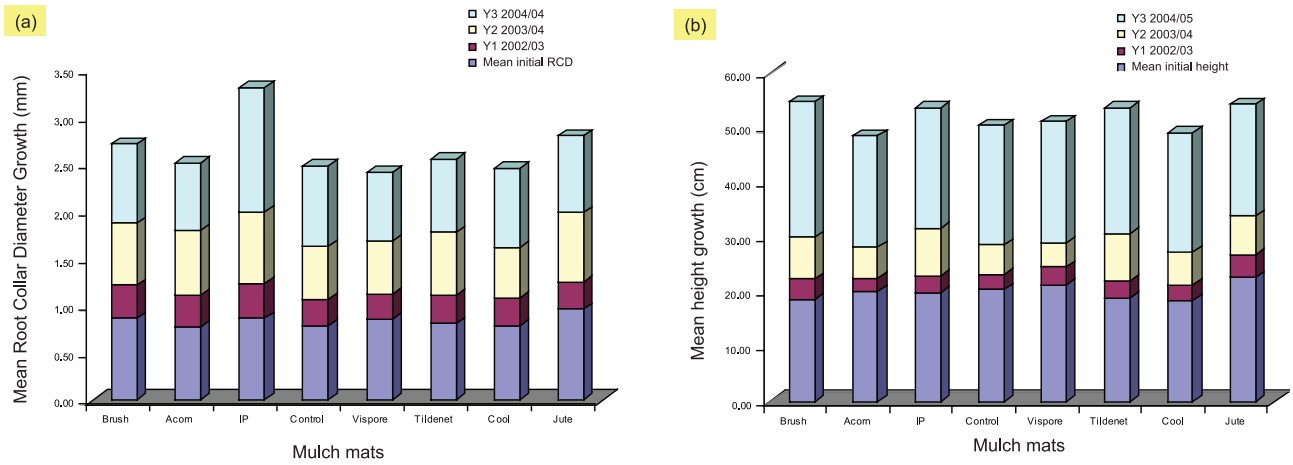

Figure 3.1: Effect of mulch mat type on (a) root collar diameter (RCD) and (b) height growth of Nordmann fir over three growing seasons - 2002/03 (Y1), 2003/04 (Y2), 2004/05 (Y3).

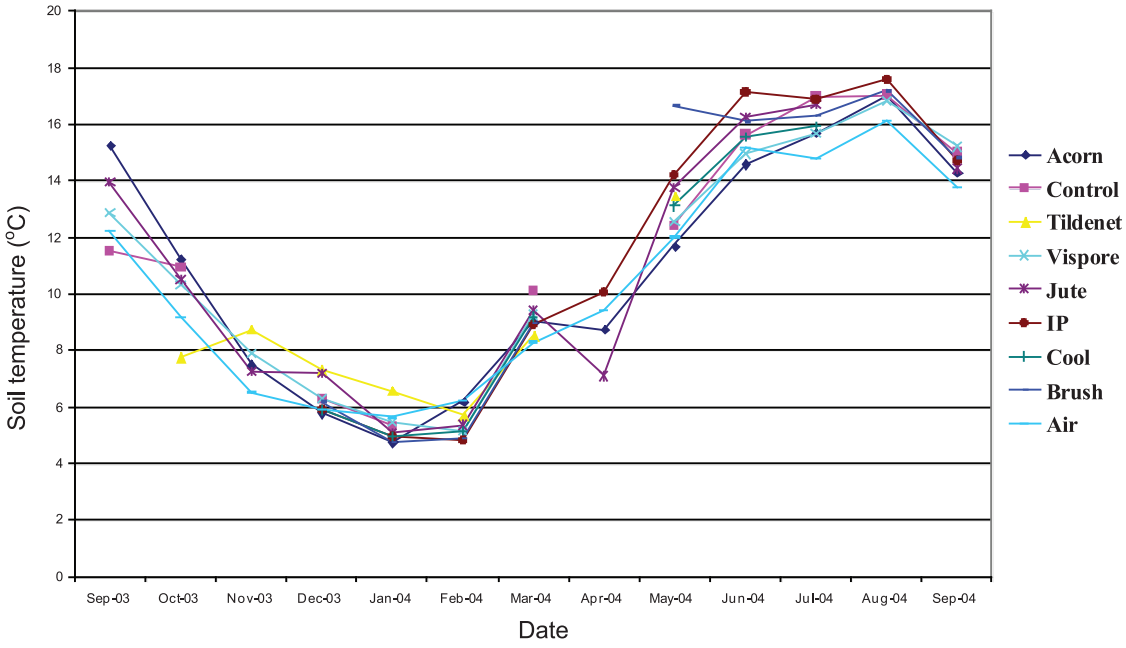

Figure 3.2: Soil temperature under the mulch mat treatment compared with the control [and air temperature] for the period September 2003 – September 2004.

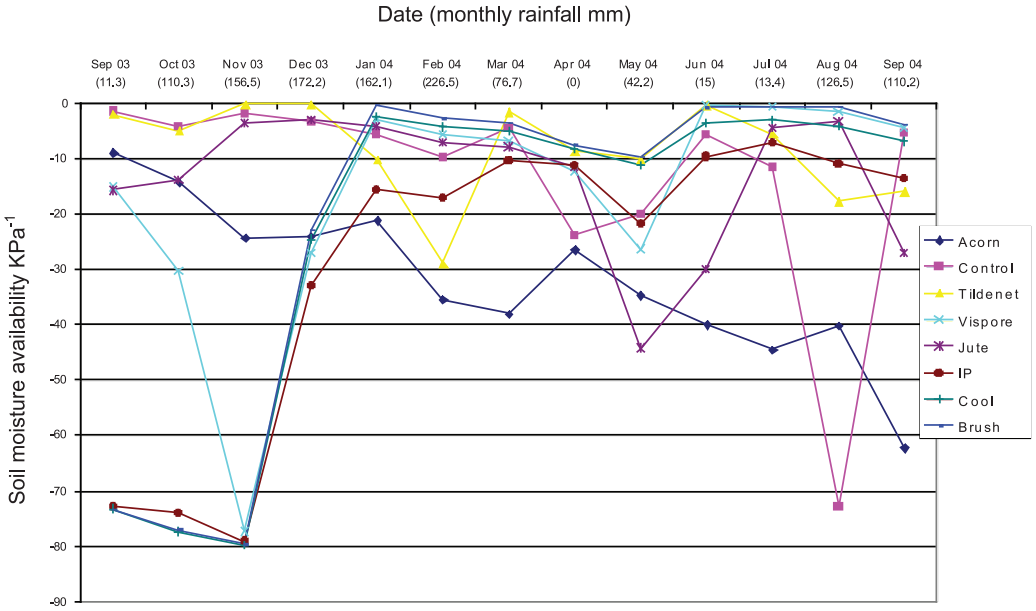

Figure 3.3: Soil moisture availability for each of the mulch mat treatments and control for the period September 2003–September 2004. The mean monthly rainfall for the site is shown in parentheses.

October, November and December 2003 subsequently led[5] to a decrease in soil moisture deficit, with levels under the plastic mats eventually reaching the same as those in the control.

Vegetation

The mats succeeded in controlling vegetation around the trees. Vegetation around the mats consisted mostly (60-65%) of tansy (*Chrysanthemum vulgare*). The remaining (25-30%) cover was mainly great willowherb (*Epilobium hirsutum*) or rosebay willowherb (*Chamaenerion angustifolium*). The remaining weeds posed no problems to the crop (these were creeping buttercup (*Ranunculus repens*), greater plantain (*Plantago major*), shepherds purse (*Capsella bursa-pastoris*), silver ragwort (*Senecio bicolour*), spear thistle (*Cirsium vulgare*) and wild pansy (*Viola tricolour*).

[5] Reductions in soil moisture deficit lagged behind rainfall.

Discussion

The mulch mats used at Clonroche controlled competing vegetation as effectively as conventional herbicide treatment. Height growth was slightly improved using the Brush blanket mats.

Only the plastic sheet type mats (IP Plastic, Brush and Cool Blankets) increased moisture deficits; those manufactured from woven polypropylene seemed to allow sufficient rainwater through. Woven mats also appeared to keep soil moisture at a more constant level around the tree, possibly by preventing excessive evaporation. Other studies have shown that temperatures can increase under plastic mulch to the extent that the soil dries out. This study, however, found no differences in soil temperature under the mats compared with control. This concurs with findings by Waggoner et al. (1960), which indicate that black films have the least modifying effect on soil energy budgets and conserve soil moisture well. Their work has also shown that black plastic, by reducing light transmission, better controls unwanted vegetation compared to translucent plastic.

Experiment 2: Eucalyptus[6] – small leaved gum (*Eucalyptus parvifolia*). Foliage production. Chute Hall, Tralee, Co Kerry.

Site preparation and methods

The site was former agricultural land, with a brown earth soil over limestone. It was prepared by first spraying off the weeds with Glyphosate and then single furrow ploughed at 1.5 m spacing. The trees were then planted onto the furrow at about 2 m spacing. Table 3.3 gives a summary of the operations carried out at.

Eucalyptus – small leaved gum (*Eucalyptus parvifolia*) after three growing seasons with some of the mulch mats still visible around the trees on the experimental site in Co. Kerry.

[6] Production of cut foliage in Ireland, for the home and export markets has grown rapidly in the last five years. Cut foliage is used in large quantities as decoration, either on its own or with flowers in bouquets. Evergreen plants with green, silver or variegated leaves are favoured, but species with berries are becoming increasingly popular. Data from The Netherlands indicate that 25-30% of bouquets now consist of foliage, compared to just 5% some 15 years ago. This trend is likely to increase because of the green, healthy image presented by such products and because of the predicted increase in consumption of floral products. Florists, the traditional users of foliage, continue to use large quantities but the most significant change in the market for foliage in recent years has been the rapid increase in supermarket sales. There are now over 150 ha of cultivated foliage crops in the Munster/Leinster region - the largest areas in Kerry and Wexford with smaller areas in Cork and Waterford. The main species is eucalyptus (with 60 ha recently planted using several new species/cultivars not previously grown in this country), with *Ozothamnus*, *Pittosporum* and *Viburnum* also widely grown. Forest-occurring species used include birch, noble fir, pine and rhododendron. One company exported over one million stems in 2006.

Table 3.3: Work carried out in the mulch mat experiment in eucalyptus at Chute Hall, Tralee, Co Kerry.

Operation	Date
Eucalyptus parvifolia planted	August 2001
Treatments put in place	13 May 2002
Pre treatment (initial) measurements	14 May 2002
Vegetation assessment	17 July 2002
End of growing season measurements - Year 1	November 2002
End of growing season measurements - Year 2	December 2003
End of growing season measurements – Year 3	December 2004

Treatments

(1) Acorn polypropylene mulch mat (Treatment 1, Chapter 2);

(2) Jute mulch mat (Treatment 2, Chapter 2);

(3) Visipore plastic (Treatment 3, Chapter 2);

(4) Tildenet mulch mat (Treatment 7, Chapter 2);

(5) Brush Blanket (Treatment 5, Chapter 2);

(6) Cool Blanket (Treatment 6, Chapter 2);

(7) Shaw fabric mulch (Treatment 4, Chapter 2);

(8) Herbicide application control.

The procedure followed was the same as that for Clonroche except that the IP Plastic was replaced by Shaw fabric mulch.

Mechanical site preparation consisted of a ploughed single furrow at a 1.5 m spacing so that the trees are planted on the mounds.

In the control treatment, Simazine (50%) was applied at 2 l/ha post planting and annually in spring thereafter. Glyphosate was periodically applied to perennials as a spot treatment.

Results

Mat integrity was the same as for the Clonroche site for the same treatments. Again, weed species were noted growing through the Jute. The species was mainly Rumex.

As the soil on the site was extremely well worked prior to planting some of the staples worked loose and caused the mats to flap. This could be a problem in large scale operations.

Small-leaved gum (Eucalyptus parvula (syn. E. parvifolia) with a brush blanket mulch installed (January 2005).

Survival

All treatments had almost full survival (Table 3.4).

Table 3.4: Survival of Eucalyptus parvifolia after three years in the mulch mat trial at Tralee, Co Kerry.

Mat Type	% Survival (3 years)
Acorn	99%
Brush	96%
Control	99%
Cool	99%
Jute	99%
Shaw	100%
Tildenet	100%
Vispore	99%

Seedling growth

Root collar diameter (RCD) alone was measured as eucalyptus is cut back annually to encourage shoot growth and proliferation. Trees in the Cool Blanket treatment had significantly lower mean root collar diameter than any other treatment, apart from the Shaw mat treatment (Figure 3.4). Trees in the Jute mat treatment had significantly higher mean root collar diameter than those in the Shaw and Cool Blanket treatments.

Vegetation

The vegetation around the mats consisted mainly of annual meadowgrass (*Poa annua*), bramble (*Rubus fructicosa*) and Rosebay willowherb (*Chamaenerion angustifolium*), as well as large numbers of Docks (*Rumex* spp.) which grew through the Jute mats[6].

Discussion

Only trees with the Cool Blanket mulch mat had significantly lower root collar diameter[7] than those in the control treatment. All the other mulch mat treatments resulted in the same or a significantly higher root collar diameter than the control. Most of the mulch mat treatments were therefore as effective in controlling weeds as herbicide application. In fact, once the eucalyptus had been cut back after the first year, and had become more bushy, they shaded out competing vegetation and there was no need for further weed control.

As almost all foliage plantations will be established on agricultural land it is possible to roll out and place mulch strips from a machine (as is the case with maize and some root crops). Trees can then either be planted through the strips, or pulled through a slit if they are planted beforehand. This makes the operation a lot cheaper and less labour intensive.

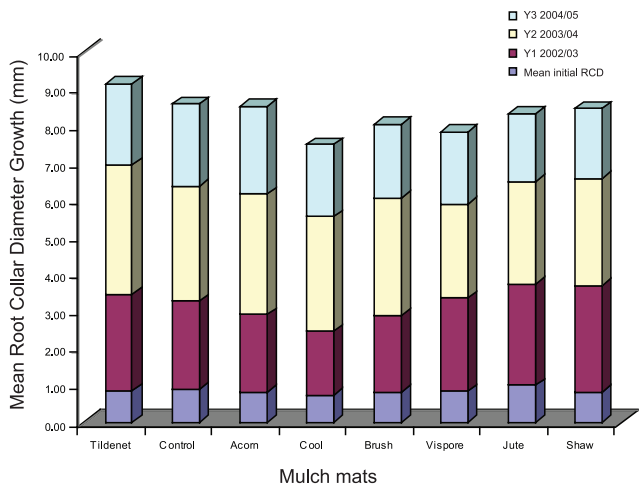

Figure 3.4: Effect of mulch mat type on root collar diameter (RCD) and height growth of *Eucalyptus parvifolia* over three growing seasons - 2002/03 (Y1), 2003/04 (Y2), 2004/05 (Y3). (Vegetation in the control plot was treated as described in the text).

Dock seed germinating on the Jute mulch mat and the roots then growing through it.

[6] Dock seed was collected and sown beneath and on top of a Jute mat in the laboratory at Waterford IT. The Jute mat comprised recycled coffee bean bags, sown onto a polythene backing. Dock seed germinated on the mat, and the roots penetrated the plastic backing and grew down into the soil.

[7] Root collar diameter is usually a better indicator of tree quality and vigour than height growth (Cleary et al. 1978, Chavasse 1980, Edgren 1980). Seedlings with large root collars also tend to have large root systems.

Experiment 3: Ash (*Fraxinus excelsior*). Crop on reforestation site. Aclamon, New Ross, Co Wexford.

Reforestation is the establishment of forest cover following its removal, usually by clearfelling. In Ireland logging residues are usually windrowed, with the intervening areas being planted.

Site preparation and methods

The previous crop at the site was a mixture of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) planted in 1966 and felled in 2002. Trees were established on mounds between windrows. Ash was planted at a sheltered part of the site, with the remainder being planted with Sitka spruce. Table 3.5 provides a summary of work done.

Treatments

(1) Acorn polypropylene mulch mat (Treatment 1, Chapter 2);

(2) Jute mulch mat (Treatment 2, Chapter 2);

(3) Visipore plastic (Treatment 3, Chapter 2);

(4) Tildenet mulch mat (Treatment 7, Chapter 2);

Table 3.5: Summary of work carried out at the ash experiment at Aclamon, Co Wexford.

Operation	Date
Ash planted	December 2002
Mulch mats installed	December 2002
Vegetation assessment	June 2003
Year 1 Measurements	December 2003
Year 2 Measurements	December 2004

(5) Brush Blanket (Treatment 5, Chapter 2);

(6) Cool Blanket (Treatment 6, Chapter 2);

(7) Shaw fabric mulch (Treatment 4, Chapter 2);

(8) Control.

The control plots were treated with Glyphosate for the first two years to control grasses and broadleaved weeds. Triclopyr was applied in 2004 to bramble (*Rubus fructicosa*) and furze (*Ulex* spp.) where necessary.

Results

Seedling growth

Overall there was no significant difference in mean height growth between the treatments (Figure 3.5).

Jute mulch mats placed around ash (*Fraxinus excelsior*) seedlings on a mounded reforestation site in Co. Wexford in 2002.

Mean root collar diameter in the control treatment was significantly lower than in almost all other treatments, apart from the Acorn and Brush treatments. It is important to note that there was very little variation in the RCD results in the control plots hence the differences.

Vegetation and survival

Competing vegetation consisted mainly of bramble (*Rubus* spp.), furze (*Ulex* spp.), rush (*Juncus* spp.) and Rosebay willowherb (*Chamaenerion angustifolium*). Rush tended to start growing just under the side of the mats, and unless they were well anchored down this tended to lift them, with wind causing further damage. Bramble did not cause problems – and even though it grew across and over the mats it did not take root, keeping competition to a minimum. Survival was high (Table 3.6).

Table 3.6: Percentage survival of ash after two growing seasons in the mulch mat trial at Aclamon, Co Wexford.

Mat Type	% Survival (2 years)
Acorn	94%
Brush	95%
Control	93%
Cool	94%
Jute	95%
Shaws	94%
Tildenet	96%
Visipore	94%

Discussion

Mulch mats improved the growth of ash. However, subsequent die-back, probably caused by waterlogging, is likely to have reduced the impact of the different treatments.

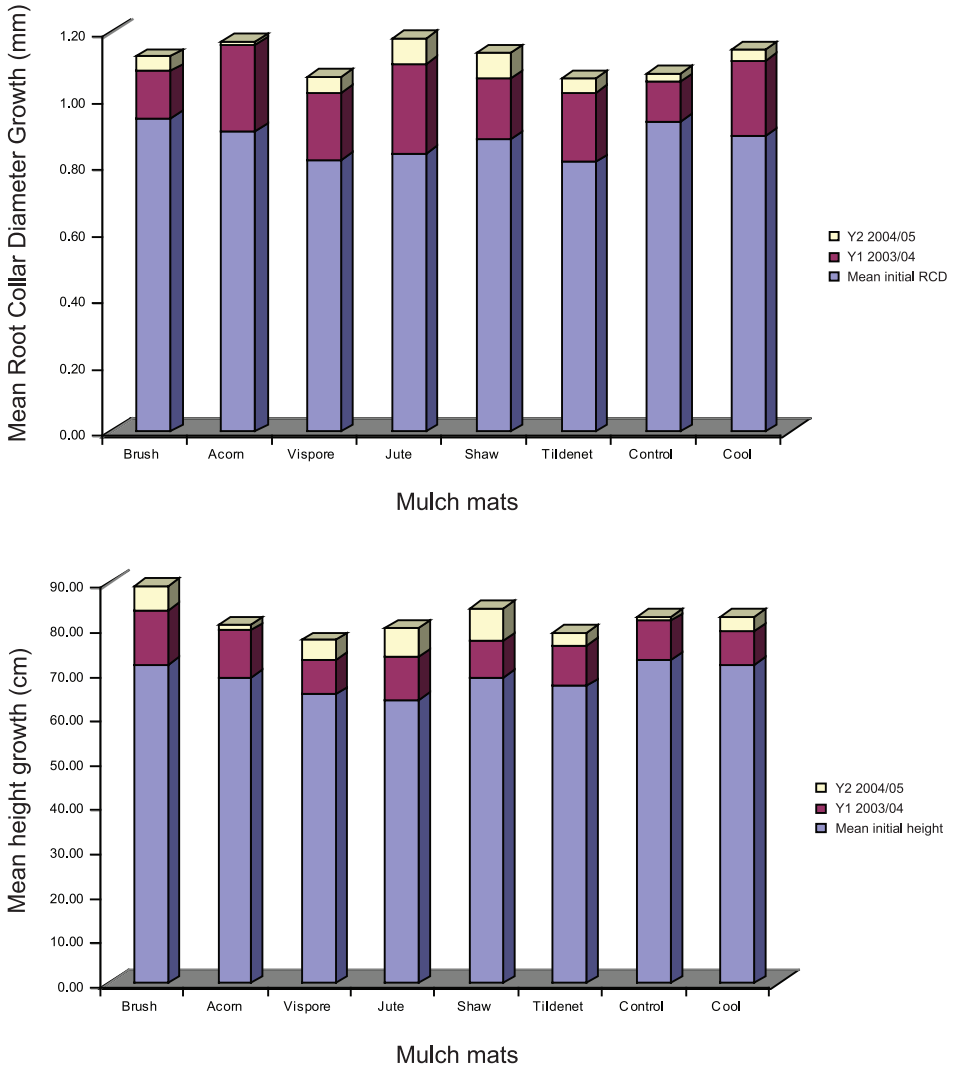

Figure 3.5: Effect of mulch mat type on mean root collar diameter (RCD) and height growth of *Fraxinus excelsior* over two growing seasons - 2003/04 (Y1), 2004/05 (Y2). (Vegetation in the control plot was treated as described in the text.)

Experiment 4: Sitka spruce (*Picea sitchensis*). Crop planted on a reforestation site. Aclamon, New Ross, Co Wexford.

Site preparation and methods

Site preparation was the same as in the ash experiment.

A summary of operations carried out is given in Table 3.7.

Table 3.7: Summary of work carried out on the Sitka spruce experimental site at Aclamon, Co Wexford.

Operation	Date
Sitka spruce (Washington) planted	December 2002
Mulch mats installed	December 2002
Vegetation assessment	June 2003
Year 1 Measurements	December 2003
Year 2 Measurements	December 2004

Treatments

(1) Acorn polypropylene mulch mat (Treatment 1, Chapter 2);

(2) Jute mulch mat (Treatment 2, Chapter 2);

(3) Visipore plastic (Treatment 3, Chapter 2);

(4) Tildenet mulch mat (Treatment 7, Chapter 2);

(5) Brush Blanket (Treatment 5, Chapter 2);

(6) Cool Blanket (Treatment 6, Chapter 2);

(7) Shaw fabric mulch (Treatment 4, Chapter 2);

(8) Control.

The control plots were treated with Glyphosate for the first two years to control grasses and broadleaved weeds. Triclopyr was spot applied in 2004 to control bramble and furze where necessary.

Results

Seedling growth

Mulch mats had no significant effect on either height growth or root collar diameter (Figure 3.7). However, it was interesting to note that the trees with the cool blanket had the lowest means for both height and RCD.

Tildenet mulch mats around Sitka spruce seedlings on a mounded reforestation site in Co Wexford in 2002.

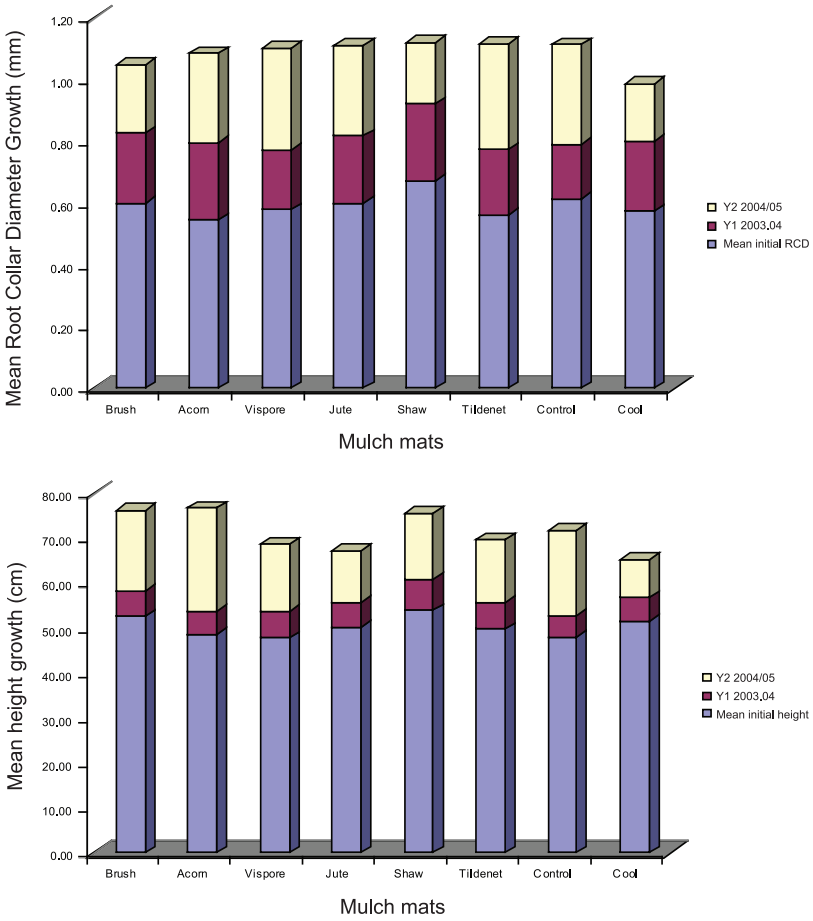

Figure 3.7: Effect of mulch mat type on mean root collar diameter (RCD) and height growth of Sitka spruce over two growing seasons - 2003/04 (Y1), 2004/05 (Y2).

Vegetation and survival

Competing vegetation was the same as in the ash trial. Survival (Table 3.8) was high despite the high level of competing weeds. The main problems were weed incursion from the windrows, and control of furze, even with mulch mats in place. If allowed to grow on, it has the potential to out-compete trees and eventually kill them.

Table 3.8: Survival of *Picea sitchensis* after 3 years in the mulch mat trial at Aclamon, Co Wexford.

Mat Type	% Survival (3 years)
Acorn	98%
Brush	96%
Control	98%
Cool	99%
Jute	99%
Shaws	96%
Tildenet	98%
Visipore	99%

Discussion

During a site visit in May 2006 it was observed that the Sitka spruce had outgrown vegetation competition, apart from occasional furze that would need to be spot treated. This observation supports the growth results. Root collars and heights of the trees in the mulch mat treatments were generally the same as those of the control, with those in the Cool Blanket treatment generally poorer. This result concurs with many studies, including one in Canada (VMAP 1994) that indicated that hardwood seedlings treated with Brush Blanket mulches grew as well as seedlings treated annually with Vision or Simazine herbicide sprays, and better than seedlings that received no vegetation control. In other words, the mulch mats performed as well as the normal conventional herbicides in achieving vegetation control while at the same time not inhibiting the growth or quality of the trees.

However, laying mats on a reforestation site is more difficult and time consuming than the same operation on former agricultural land, or a Christmas tree farm, and will cost far more than herbicides.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Seedling growth characteristics

Table 4.1 shows the overall performance of the mulch mats in the four trials.

In the trials only eucalyptus (root collar diameter) and Sitka spruce (height) in the Cool Blanket treatment grew poorer than those in the herbicide control. Most mulch mats are therefore at least as good as conventional herbicide in controlling weeds. Only the Cool and Brush Blankets, and IP Plastic resulted in higher soil moisture deficits compared with the control, and these disappeared following prolonged heavy rainfall.

None of the mats tested were biodegradable, which may increase costs. Recently developed biodegradable mats (Van Lerberghe 2005) merit further investigation.

Vegetation

Some weeds such as furze and rush reduced the integrity of the mats, especially those with thinner plastic films. Provided mats are put in pace around the same time as trees are planted, and there are no large weeds present, good weed control around the tree was achieved.

Cost

Estimates of the time taken to lay the mats were made at each site, and were used to calculate, together with the cost of the mats, a cost per hectare (the cost for mulches includes a €2 cost for the mulch mat and pegs). Mulch mat prices when bought in bulk are all similar in price. This was compared to the cost for conventional vegetation management using herbicides.

The cost of using mulches to control vegetation can be over seven times the cost of using herbicides (Table 4.2). Willoughby et al. (2004) found similar results. This makes the use of mulches prohibitive. However, with new, stricter regulations on the use of herbicides coming into force in the near future, coupled with a new EC policy document on their

Table 4.1: Overall mulch mat performance at the four sites.

Tree species	Parameter	Significantly lower than control	Lowest	Highest
Nordmann fir	HT	None	Visipore	Brush Blanket
	RCD	None	Visipore	IP Plastic
Eucalyptus	HT	-	-	-
	RCD	Cool Blanket	Cool Blanket	Jute
Ash	HT	None	Control	Brush Blanket
	RCD	None	Control	Jute
Sitka spruce	HT	Cool Blanket	Cool Blanket	Acorn
	RCD	None	Cool Blanket	Tildenet

Table 4.2: Cost of vegetation control using herbicides or mulches in different crops.

	Herbicide application Cost €/ha		Mulches Cost €/ha			
	Former agricultural land	Reforestation	Christmas trees	Foliage	Reforestation	
					Ash	Sitka spruce
Year 1 Year 2 Year 3 Year 4	260 260 130 130	330 330 165 165	5672 (56 hrs/ha)	5672 (56 hrs/ha)	7400 (84 hrs/ha)	5864 (72 hrs/ha)
Total Cost €/ha	780	990	5672	5672	7400	5864

use, it is suggested that further research on mulches may be warranted, particularly those that lend themselves to be put in place mechanically.

Conclusions

- Mulch mats are at least as good as conventional herbicide in controlling weeds.
- They can, however, cost up to seven times more than herbicides.
- All the mats used in these trials were photodegradable, but in the interim biodegradable mulch mats have come on the market, that are more environmentally friendly.
- Policy developments are likely to further reduce the range and use of herbicides for weed control – thus it is prudent to continue investigating and testing alternatives.

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Publications and deliverables

McCarthy N. and Mc Carthy, C. 2004. Herbicides in Irish forestry – A review of the alternatives? *Irish Forestry* 61 (1&2).

McCarthy N., Mc Carthy, C. and O Rathaille, M. 2005. *The use of mulches to control weeds in Christmas tree plantations*. Presented at the 5th International conference on Forest Vegetation Management, Oregon State University, Corvallis, Oregon. June 2005.

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WEBSITE - A website was created dealing with Forest Vegetation management and includes information on Weeds, controls and also has a discussion forum. This was formally launched by the Director of the College and the President of COFORD in March 2004.

British Council/Enterprise Ireland Research Travel Scheme 2003: This award was used to visit vegetation management research trials in Ghent in Belgium along with fellow researchers from the Forestry Commission UK.

COST Action E47: Dr Nick Mc Carthy instigated the setting up ofand chairs the running of COST Action E47 entitled 'European Network for Forest Vegetation Management: Towards environmental sustainability.' This project will run until April 2009.

Conference: Hosted In Waterford Institute of Technology a joint COST/COFORD Conference on 'Forest Vegetation management – a world perspective'. May 2006, WIT.