



EcoCOVER SYSTEM

SUMMARY OF FINDINGS

3 UNIVERSITY RESEARCH STUDIES, LABORATORY ANALYSES, INDEPENDENT FIELD VALIDATION

EcoCover is - patented, organic, compostable, biodegradable, conserves water, reduces plant mortality, controls weeds, promotes plant and crop growth, moderates soil temperature, reduces soil erosion, reduces plant losses, eliminates or reduces herbicide use, a carrier of beneficial additives for the soil, and saves money. A unique delivery mechanism to soil and crop.



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1. WHAT IS MULCH?

1.1 BACKGROUND - MULCHES

1.1.1 DEFINITION

A singular reference to **EcoCover** in this document, applies equally to both the EcoCover and EcoCrop mulch systems unless otherwise stated.

Mulch is a type of protective covering placed on or spread over the soil surface.¹ Mulches can be organic or inorganic and are available in many forms. Plastic film, proprietary mulch fabric, pinebark, straw, wood chips, newspaper, bark, grass clippings and leaf litter are examples.

Mulch helps to conserve soil moisture, suppress weed growth and enrich the soil by supplying elements essential for plant growth.^{1, 2, 3, 7} One of the purposes of mulch is to create a physical barrier to protect the soil against wind and water erosion and extremes in soil temperature.^{2, 3, 4} The physical barrier helps to prevent soil splashing onto crops, which decreases the incidence of disease and reduces the need for washing the crop.

Applying mulch to the soil surface can modify the soil temperature and soil moisture.^{5, 6, 12, 13} In addition, mulching is a well-known way of controlling grass and weed competition, especially in revegetation projects.³ Mulching can encourage healthy plant growth, enabling plants to be more resistant to disease and insect problems and achieve maturity in a shorter time.^{2, 12, 13}

Mulch can substantially increase plant growth and reduce plant mortality rates due to the excellent properties inherent in some mulches - effective weed suppression and water conservation.^{7, 8, 12, 13}

EcoCover is the world's most complete mulch.



EcoCover is the *world's first* internationally certified organic mulch system permitted to biodegrade directly into the soil and not requiring to be completely removed as is the case with black plastic polythene.

1.1.2 WHY USE A MULCH?

Mulches enhance good growing conditions that allow for uniform plant development, higher growth and fewer deformities due to stresses from lack of proper moisture, temperature or nutrient conditions.⁹ Consequently crop quality can be improved through the use of mulches. By reducing the number of weeds, larger amounts of water, nutrients and sunlight are available to the desired plants and seedlings. The procedure enriches the soil for plant development while at the same time, preventing erosion and decreasing the evaporation of moisture from the ground.^{10, 11, 13}

Mulching has numerous beneficial effects upon the soil and plants.



More than three years of research by two leading universities, the Southern Cross University [Australia] and Massey University [New Zealand], has scientifically and independently proven all of the EcoCover product attributes detailed in this document.

Patent protection validates EcoCover's uniqueness

2. EcoCOVER PRODUCT ATTRIBUTES

2.1 CERTIFIED ORGANIC & ENVIRONMENTALLY SAFE

Definition

“Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.”^{1, 4}



EcoCover enhances agro-ecosystem health by improving the air and water movement through the soil; providing moist conditions thereby promoting micro organisms and worm populations; promoting leaf litter build up and helping to improve the pH balance in the soil.

EcoCover can significantly reduce the labour input for weeding and digging activities in relation to weed control where organic management practises prohibit the use of herbicides.³⁶

Research has shown that there is nothing in black or white or colour paper that will damage plants or harm soil. Studies have confirmed that mulching with the black and white pages from office waste paper, newspaper, including regular newsprint pages with colour photos on them introduces no toxic chemical into the soil.² Independent research on the leachate resulting from the biodegradation of EcoCover has proven the product to be perfectly safe – the laboratory report is available on request.

The **EcoCover** mulch system has IFOAM organic certification certified with AgriQuality New Zealand Limited.

AgriQuality, New Zealand's leading organic certifier has approved EcoCover in respect of granting organic certification. AgriQuality's organic standard is based on the international Codex Alinorm 99/22 EU regulations, and the Australian National standard. AgriQuality, a State Owned Enterprise of the New Zealand Government, certify all of New Zealand's dairy exports, along with the produce and products, of many other leading New Zealand manufacturing exporters.

This approval, as for EcoCrop detailed below, allows for the use of coloured inks (but not glossy inks) in office paper and newsprint waste. EcoCover / EcoCrop is not required to be removed from the soil, as is the case with plastic film and other common mulches (refer Table 2.1) when used with certified organic management practices.

The **EcoCrop** mulch system has IFOAM organic certification certified with BioGro New Zealand Limited.

BioGro is New Zealand's first IFOAM accredited certifier. Established in 1983, BioGro now certifies over 700 operations across New Zealand's primary production, processing, farm input supply, export, and retail sectors. BioGro trademarks more than \$100 million worth of product every year. EcoCrop has gained full organic accreditation with BioGro for use in broadacre cropping.

Furthermore, EcoCover (NZ) Limited has received approval to use the prestigious label **Environmental Choice New Zealand**. Similar approvals may be available in other countries on the basis of the New Zealand eco-label accredited specification.

Governments subscribing to a 'Buy Green or Greening of Purchase' use such accreditation to determine their preferred suppliers. EcoCover is environmentally beneficial (not neutral) and the New Zealand Government through the Ministry for the Environment has 19 core Government agencies including the country's largest roading / roading landscape enterprise signed up to this standard. A company with the approved accreditation, such as Environmental Choice Labelling will be a preferred supplier to all such agencies. A copy of the New Zealand Government's press release is available upon request, confirming their commitment to this label and purchasing preference.

EcoCover is one of only a handful of companies in New Zealand to achieve such high environmental product standard's certification.



Paper Mulch Mat
License No. EC2304018



Table 1**Recognised organic mulches³**

These are generally unsuitable for commercial growers due to the (lack of) availability of a continuous economic supply, and inherent laying difficulties

| MULCH TYPE | Conserves moisture | Durability | Weed prevention | On existing vegetable bed | On existing ornamental bed | Any kind of new bed | How much to use |
|------------------------|--------------------|------------|-----------------|---------------------------|----------------------------|---------------------|---------------------------------|
| Leaves | *** | ** | *** | *** | **** | *** | 4" loose; 1-2" compressed |
| Grass clippings | *** | ** | *** | **** | *** | **** | 4" loose; 1-2" compressed |
| Compost | *** | ** | ** | *** | *** | **** | 1-2" loose |
| Newspaper/ Kraft paper | * | * | **** | ** | ** | **** | 2 or more sheets or 6" shredded |
| Pine needles | ** | ** | ** | ** | *** | ** | 1-2" loose |
| Straw | ** | *** | *** | *** | * | ** | 4" loose |
| Wood chips | ** | *** | ** | * | ** | * | 2" small chips; 3" large |
| Bark | * | **** | ** | * | *** | ** | 3" + paper layer |

Organic Gardening. July/August 1997³

| | | | | | | | |
|---|------|-----|------|------|------|------|----------------|
|  | **** | *** | **** | **** | **** | **** | 1 layer |
|---|------|-----|------|------|------|------|----------------|

Suitability (* poor **** excellent)^{3, 36}

2.2 COMPOSTABLE

Definition

“Capable of decaying as organic matter and fertilizing or conditioning the land.”



EcoCover will decay over time as organic matter when buried in soil.^{5, 36} A system with enhanced features such as fertiliser and soil conditioners incorporated into the product will improve the quality of the soil once decayed or composted.

Massey University Research Results³⁶

Massey investigated the rate at which EcoCover decomposed when buried beneath the soil at a depth of 9cm. Samples from the buried treatment were only measured for 3 months. At this point the product became too decomposed to weigh – more than 55% of the mat had fully degraded within 90 days, with the remaining mat expected to degrade at an even faster rate. Earthworm specimens were found moving freely beneath the surface mulch and around the buried mulch in the soil. Earthworms had begun to move through the buried mulch by the second month and were found throughout this mulch after the third month.

EcoCover uniquely organically certified, fertiliser enriched mats, will deliver a substantial nutrient boost of essential trace elements replenishing the soils depleted

reserves as the mat biodegrades. Independently assessed by New Zealand's leading soil laboratory.³⁹

Picture 1

Evidence of worms having penetrated buried EcoCover long life mulch mat and the disintegration of the mat composite. Photographs courtesy Massey

EcoCrop, a shorter life mulch mat will biodegrade / compost at an even faster rate. Mat buried to 9cm depth in fine sandy loam soil – photo taken 90 days after burial.



Rich worm life, healthy soil under EcoCover

2.3 BIODEGRADABLE

Definition

Biodegradable - *adjective*.

“Capable of being broken down especially into innocuous products by the action of living things (as micro organisms).”

Biodegradability - *noun*

Biodegradation - *noun*

Biodegrade - *verb*



EcoCover will completely break down or decay over time, leaving neither harmful residual evidence nor contaminants of any type in the soil³⁶ while at the same time enhancing and feeding organic matter to the soil during biodegradation.

Scientists involved with newspaper mulch research received queries about the safety of polycyclic aromatic hydrocarbons (PAHs) and heavy metals present in newspaper inks. However wheat grown with newspaper mulch did not have a marked increase in PAHs when compared to that grown in peat.⁵ Newspaper is not presently used in the EcoCover laminate.

No detrimental effects on the soil have been observed through the use of office paper mulch.^{34, 35} In one experiment continuous use of paper mulch over four years had no detrimental affects on soil or plant growth. This mulch was ploughed into the soil at the finish of each crop.³⁵

Heavy metals (lead, nickel, chromium, copper and zinc) do not accumulate in a soil mulched with newspaper.⁶ In another study, levels of cadmium, lead, nickel, cobalt, chromium, zinc, molybdenum, manganese, and iron were lower in newspapers (collected in New Jersey) than in rye straw. In contrast, sodium and aluminium levels were higher in newspaper than in rye straw.⁷

Research has also confirmed that despite theoretical fears that the level of nitrogen in the soil may temporarily drop as microbes use up some nitrogen to process the cellulose in the paper; no symptoms of nitrogen deficiency were found.^{8, 9, 10}

Massey University Research Results³⁶

Massey investigated the rate at which EcoCover mulch decomposes over an extended period, both on the soil surface and when buried beneath the soil at a depth of 9cm. Samples from the buried treatment were only measured for 3 months. At this point the mulch became too decomposed to weigh – more than 55% of the mat had fully degraded within 90 days, with the remaining mat expected to degrade at an even faster rate. Earthworm species were found moving freely beneath the surface mulch and around the buried mulch in the soil. Earthworms had begun to move through the buried mulch by the second month and were found throughout this mulch after the third month. EcoCrop, a lighter weight mat will biodegrade even faster.

EcoCover mulch cultivated into the soil at the end of a crop would decompose quickly, unlike plastic mulches and is therefore able to be left on the soil surface around perennial crops with no requirements for removal. It is also able to be incorporated into the soil after use on shorter-term broadacre crops. The mat does not remain in the soil as a pollutant.

Picture Montage 2

Massey University (surface and buried) biodegradation trials

EcoCover's rate of biodegradation is subject to a number of important factors including local climatic / soil conditions. Refer *Product Life 9.2* below. Photographs courtesy Massey



3 months – surface*

6 months – surface*

9+ months – surface*

***Note** – the trial site at Massey University experienced the wettest summer in more than 90 years during the test period – accelerating the degradation of the product above the soil.

Buried mat – biodegradation trial



Disintegrating mat, after 90 days buried to a depth of 9cm

2.4 WATER CONSERVATION

Definition

“The careful preservation and protection by way of planned management of this natural resource to prevent exploitation, destruction or neglect.”



Water conservation is of vital concern globally and will be of even greater importance in the future. By 2020 it is estimated the world's population will be 7.5b. Predictions have been made that unless it stabilises at between 8.5b and 10b by 2050, all available arable land will be dedicated to producing food of plant origin. This in turn will bring enormous pressure on the world's available water of which only 70% is available for use and of that 70%, 65% is used in agriculture, 22% by industry and only 7% remains for households (Lappe, 1999). Population pressure on land resources will increase dramatically in the near future unless agricultural productivity (yield per unit area) grows concomitantly with population. New technology will be needed to increase crop productivity in a sustainable fashion, without converting more natural areas to cropland. EcoCover is representative of this new technology.

EcoCover conserves soil moisture by reducing the evaporation of water from the soil by wind and sun. Air movement (wind velocity) is reduced to nil at the soil surface. Soil moisture moves by capillary action to the surface and considerable losses may occur if the soil surface is not covered by a mulch.^{11, 12}

Mulch acts as a vapour barrier that reduces the frequency that soil moisture must be replenished and also reduces the chance of water stress on plants. Since evaporation is reduced, soil moisture is likely to be higher in a mulched soil.^{12, 13} EcoCover is particularly effective when used in conjunction with drip irrigation. Traditional spray irrigation loses about a third of the water to evaporation and winds.²⁰

Mulching is an important practice for establishing plantings as it helps to conserve moisture in the root ball of the new plant until it establishes roots in the adjacent landscape.¹³

EcoCover will shade the soil surface and provide a physical barrier, reducing weed growth and shield the soil and plant roots from the effects of solar radiation and temperature extremes.^{12, 13, 14, 36}

The degree of soil temperature modification is primarily determined by both the optical and thermal properties of the mulch. The most effective mulch mats act as a soil insulator that maintains a more uniform soil temperature, reducing the difference between day and night temperatures (diurnal) and keeps the soil cooler in summer and warmer in winter. Microorganism activity in the soil is more constant under mulched soil when compared to bare soil due to fewer extremes in temperature.¹¹ Dark mulch can however absorb more solar radiation and may increase soil surface temperature. Transparent plastic mulches can increase soil temperature via a greenhouse effect.^{4, 12}

EcoCover reduces evaporation and can prevent up to 75% water (10-50% is more common depending on the thickness and type of mulch¹⁵) loss due to evaporation.¹⁰

EcoCover slows evaporation in even the hottest conditions reducing the need for watering. Increased moisture retention means less cracking in the soil and vital air and water movement through the soil is also improved. Moisture retention results in better temperature stability in hot and cold conditions, reducing the risk of stress to new plantings and frost damage during winter.

Pooling and ponding is reduced due to the transfer of water. This is particularly important with crops such as strawberries for example that can suffer from excess water stress.

Integrated pest management, nitrogen fixation, soil conservation, and the efficient use of water are important components of new crop production methods.

The application of the really effective mulches can conserve soil moisture and provide earthworms with protection from sudden changes in temperature. It can also provide them with an additional food source. Consequently earthworm survival is usually favoured where mulches are applied.¹⁶

The use of mulches for tree and shrub planting has become increasingly popular in recent years.¹⁷ Competition for moisture in the soil makes the elimination of weeds essential in the planting of tree seedlings for forestry particularly in drought prone areas where the water conservation properties of the mulch can substantially reduce early mortality in seedling.¹⁸ In drought prone areas of New Zealand it has been recommended that new plantings do not take place unless mulch is used.¹⁸

In Queensland, Australia, some property sales have demonstrated that water license values represented around 75% of the total value of properties being sold. Water is a valuable and increasingly scarce resource.¹⁹ The projected growth in world population will make nearly all environmental problems worse. One of the first effects, though not necessarily the most visible, is likely to be a shortage of fresh water. Rivers are running dry. Water tables are shrinking. The demand for water is simply outrunning the supply. A new balance needs to be re-established between the supply of water and the use of water.²⁰


Conserving water under a mulch will enhance plant and crop growth and survivability.

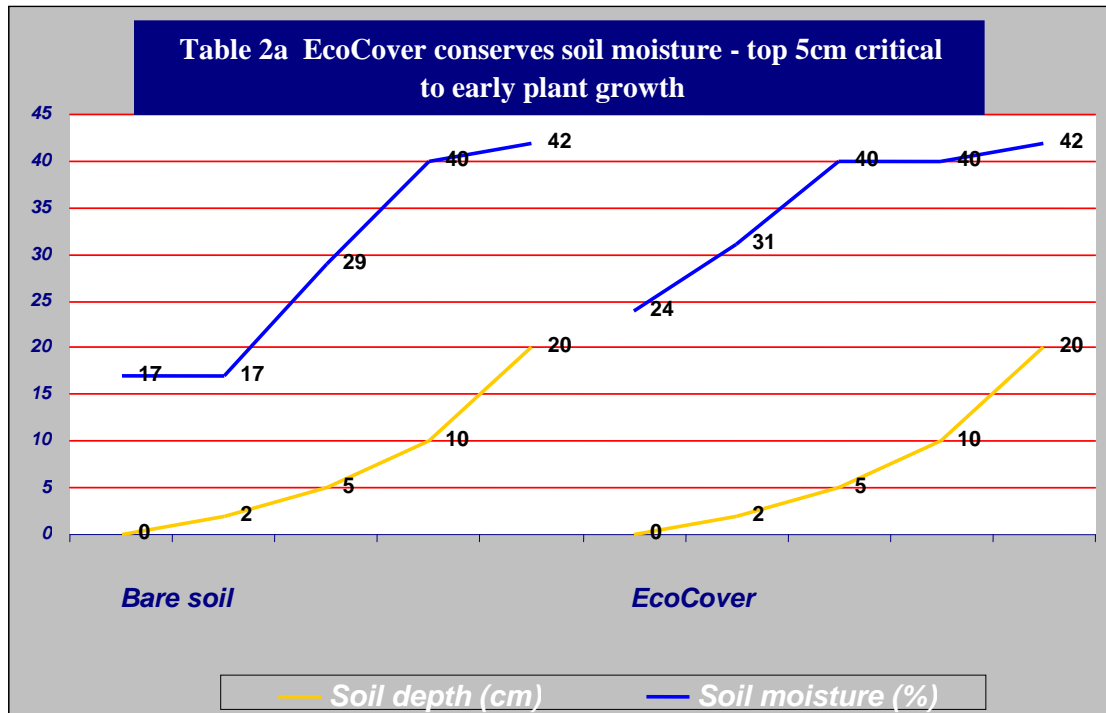
Table 2

Laboratory soil moisture profile to a soil depth of 20cm

Soil moisture profile achieved after constant heat was applied for four days to the columns of soil in a laboratory situation.

Southern Cross University Research Results¹⁰

| | Soil depth (cm) | Soil moisture (%) | % Increase |
|---|------------------------|--------------------------|-------------------|
| Bare soil | surface | 17 | - |
| | 2 | 17 | - |
| | 5 | 29 | - |
| | 10 | 40 | - |
| | 20 | 42 | - |
|  | surface | 24 | + 41% |
| | 2 | 31 | + 82% |
| | 5 | 40 | + 38% |
| | 10 | 40 | no change |
| | 20 | 42 | no change |



The top 5cm of soil is the most critical in terms of moisture conservation. The soil moisture content is substantially improved by the use of EcoCover long life mulch mat compared to that of bare soil.

Research clearly demonstrates the difference in moisture conservation that EcoCover makes to the soil. Further tests were conducted on soil moisture profiles, namely: field soil moisture at 2cm soil depth. All confirmed the results of previously published data on the benefits of mulch mats in regard to soil moisture retention.

Massey University Research Results³⁶

Massey's research proved EcoCover mulch mat to have greater efficiency than either bare soil or black plastic in conserving soil moisture, with significantly higher moisture levels in the soil. Moisture content in black plastic and bare soil treatments were very similar.

Bare soil allows for the evaporation of valuable moisture and black plastic film prevents the transfer of moisture through the film into the soil and therefore exhibits a similar soil moisture profile to that of bare soil. Black plastic prevents the transfer of moisture through to the soil other than a minimal amount through the plant stem hole.

2.5 WEED CONTROL

Definition

"To reduce the incidence of or severity of, especially to innocuous levels."

The most common *definition* of a weed is "a plant growing where it is not wanted, interfering with human activities."



It is estimated that there are approximately 250,000 different species of plants in the

world. However there are only about 8000 species that are thought of as weeds in agriculture (3% of the total).

New research shows that with more carbon dioxide being released into the air, plants are growing faster, but weeds grow even faster. This is due to the world's rising carbon dioxide levels which are expected to rise some 30% above present levels over the next three decades.⁹

Weeds can probably be best summarised as follows:

- Aggressive and competitive
- Adaptable
- Thrive in disturbed habitats
- Have efficient reproduction
- Survive unfavourable conditions
- Will strongly compete with plants for light, nutrients and water

EcoCover is exceptionally effective at suppressing and inhibiting weed growth, thereby reducing weeding and digging activity. EcoCover stops light reaching the soil thereby preventing photosynthesis and is rated as a weed stop. The life of the mat and therefore its effectiveness as a weed stop depends on local climatic conditions and the type of EcoCover supplied. Further labour and other cost savings can be made with the ploughing under the soil of the mat, as opposed to removing the mat from the ground then storing or dumping where dumping is still permitted.

The soil can also benefit from this method of disposal with a gradual increase in soil organic matter. Higher nitrogen fertilization would be advantageous for the growth of newspaper-mulched crops since paper has a high carbon/nitrogen ratio.⁸

Research has shown paper to be exceptionally effective at suppressing weeds, especially Kraft paper.⁸ Research has also confirmed that despite theoretical fears that the level of nitrogen in the soil may temporarily drop as microbes use up some nitrogen to process the cellulose in the paper no symptoms of nitrogen deficiency were found.

Kraft paper has been found to be even more effective at preventing weeds than newspaper.²¹ EcoCover uses a unique combination of both Kraft and office waste paper. Competition for nutrients and moisture in the soil makes the elimination of weeds essential for many crop applications. One such example is in the planting of tree seedlings for forestry. Benefiting from the mulch properties of being both an effective weed control and having excellent water conservation characteristics, mulch has been proven to reduce the mortality rate in early forestry plantings, especially in areas subject to low rainfall.¹⁸

Although some weed seeds germinate in the dark, the majority of them require light for maximum germination. This signifies to the seed that it is not buried deeply and therefore will have enough food reserves for the shoot of the germinating seedling to reach full sunlight. An effective mulch will block out the light. Another benefit of paper mulches is that they are weed free, unlike bark, sawdust and similar mulches.

Some crops do not have suitable herbicides for effective weed control. The crop may be particularly sensitive to herbicides (e.g. water melons); or there may be a lot of weed species closely related to the crop species and so are not different enough from the crop to allow a selective herbicide to kill the weed without killing the crop.

One mistake that is made with mulches is to leave the perennial weeds intact and alive when the mulches are laid. EcoCover will kill weeds due to lack of light and this is certainly true for annual weeds and some perennials. Other weeds that have good storage organs will have sufficient sugars in these organs to be used to fuel regrowth from the new shoots that grow under the mulch until they reach light, either around the edges or through holes made at the base of the planting. There are a number of ways weeds can reinvade apart from regrowth from poorly controlled weeds. Lateral growth of perennials can occur from adjacent lawns or nearby weed areas. Once they emerge they are hard to kill without causing disturbance to the mulch. Perennial weeds should be properly killed

before mulch is laid, either by thorough hand weeding or careful use of glyphosate. To avoid problems it is best to kill all weeds before laying mulch.

Once the EcoCover is correctly laid, a good strategy is to plant carpet forming ground cover species known as live mulches. Perennial evergreens are preferable for ground covers as they keep the garden or landscape covered in vegetation 12 months of the year. Many are small carpet forming herbaceous perennials such as aluminium plant and ivy. There are also low growing conifers with wide reaching branches that may be used.

Massey University Research Results^{36, 37}

Massey's research showed EcoCover was successful in suppressing many different weed species, both annuals and perennials. All weeds in EcoCover plots grew through the planting holes with no physical penetration of the mulch. Far fewer weeds grew through the EcoCover planting holes than through the black plastic planting holes, primarily due to the flexibility of the paper mulch that allows it to be folded back after slitting. No weed germination was apparent under the EcoCover mat throughout the trial, suggesting no light is able to infiltrate the mulch mat. As black plastic is lighter than EcoCover, re-growth of the weed 'dock' (*Rumex* spp.) was able to lift the plastic material in places. A slight problem occurred with black plastic mulch covering crop plants when they were small, due to movement in the wind. EcoCover was superior in this respect.

Massey's research proved that EcoCover is a longer lasting weed control than some of the most persistent residual herbicides (for example terbuthylazine and hexazinone). EcoCover also gives longer weed control than knockdown herbicides with little residual activity, even if these are applied more than once. EcoCover is able to control a wide range of weeds, both annual and perennial, and will control more weeds in some crops than the herbicides available. For example, both triflurin and clethodim are used for weed control in cabbages, but these herbicides are unable to control a number of other weed species.

Massey's 2006 research findings documented a careful time / productivity analysis for hand weeding. Massey concluded, intensive hand weeding is required every 90 days to keep soil weed free. Careful records were kept in a time log. The labourers took 30 minutes to thoroughly weed 1 sq.m. (or 3 minutes per sq.ft.) allowing for travel time and necessary rest breaks during the day. Larger leaf canopy crops may be less weed intensive and require less time to weed.

Case Study. Living Systems Limited, Auckland, New Zealand consultant's report Case Study 1, refer EcoCover website [www.ecocover.com], highlights the significant benefits to effective weed control using the EcoCover protection system and the difference in plant growth and appearance, plant mortality and post planting maintenance costs where not used.

Table 3

Comparison with the number of weeds per m² between EcoCover, black plastic and bare soil treatments

Weeds were counted 6 weeks after the mulch treatments were laid

Massey University Research Results³⁶



| New Zealand Weed species | Treatment | | |
|---|--------------|---------------|---|
| | Bare soil | Black plastic |  |
| twin cress (<i>Coronopus didymus</i>) | 228.9 | 0.0 | 0.3 |
| chickweed (<i>Stellaria media</i>) | 120.0 | 3.0 | 0.0 |
| sow thistle (<i>Sonchus oleraceus</i>) | 90.0 | 1.0 | 0.0 |
| mallow (<i>Malva</i> spp.) | 78.9 | 1.0 | 1.7 |
| red dead-nettle (<i>Lamium purpureum</i>) | 61.1 | 0.0 | 0.0 |
| dock (<i>Rumex</i> spp.) | 42.2 | 5.9 | 3.0 |
| scrambling speedwell (<i>Veronica persica</i>) | 38.9 | 7.0 | 0.7 |
| groundsel (<i>Senecio vulgaris</i>) | 35.6 | 0.3 | 0.0 |
| white clover (<i>Trifolium repens</i>) | 26.7 | 2.3 | 2.0 |
| annual poa (<i>Poa annua</i>) | 11.1 | 0.0 | 0.0 |
| black nightshade (<i>Solanum nigrum</i>) | 6.7 | 0.0 | 0.0 |
| hawkbit (<i>Leontodon taraxacoides</i>) | 5.6 | 0.0 | 0.0 |
| milkweed (<i>Euphorbia peplus</i>) | 3.3 | 0.0 | 0.0 |
| scarlet pimpernel (<i>Anagallis arvensis</i>) | 3.3 | 0.0 | 1.7 |
| oxalis (<i>Oxalis</i> spp.) | 2.2 | 0.0 | 0.0 |
| prickly sow thistle (<i>Sonchus asper</i>) | 2.2 | 0.0 | 0.0 |
| daisy (<i>Bellis perennis</i>) | 1.1 | 0.0 | 0.0 |
| narrow-leaved plantain (<i>Plantago lanceolata</i>) | 1.1 | 0.0 | 0.0 |
| nettle (<i>Urtica urens</i>) | 1.1 | 0.0 | 0.0 |
| spurrey (<i>Spergula arvensis</i>) | 1.1 | 0.0 | 0.0 |
| broad-leaved plantain (<i>Plantago major</i>) | 0.0 | 0.0 | 0.3 |
| cleavers (<i>Galium aparine</i>) | 0.0 | 0.3 | 0.0 |
| Total weed number per m² | 761.0 | 20.8 | 9.7 |

Table 4**Dry weight (mg) per m² of weeds under treatments of EcoCover mulch, black plastic and bare soil**

Weeds were harvested 23 weeks after mulches were laid and oven-dried at 75°C for 24 hours

Massey University Research Results³⁶

| Treatment | | | |
|---|------------------|----------------------|---|
| New Zealand weed species | Bare soil | Black plastic |  |
| twin cress (<i>Coronopus didymus</i>) | 126477 | 14 | 103 |
| shepherd's purse (<i>Capsella bursa-pastoris</i>) | 21952 | 0 | 0 |
| scrambling speedwell (<i>Veronica persica</i>) | 19029 | 2530 | 642 |
| sow thistle (<i>Sonchus oleraceus</i>) | 16183 | 286 | 222 |
| red dead-nettle (<i>Lamium purpureum</i>) | 15420 | 923 | 393 |
| mallow (<i>Malva</i> spp.) | 8689 | 14 | 23 |
| white clover (<i>Trifolium repens</i>) | 6522 | 437 | 122 |
| groundsel (<i>Senecio vulgaris</i>) | 5317 | 0 | 0 |
| dandelion (<i>Taraxacum officinale</i>) | 1699 | 0 | 0 |
| bitter cress (<i>Cardamine hirsuta</i>) | 977 | 49 | 0 |
| spurrey (<i>Spergula arvensis</i>) | 768 | 0 | 0 |
| annual poa (<i>Poa annua</i>) | 678 | 86 | 7 |
| milkweed (<i>Euphorbia peplus</i>) | 395 | 0 | 0 |
| broad-leaved plantain (<i>Plantago major</i>) | 363 | 0 | 0 |
| toad rush (<i>Juncas bufonius</i>) | 118 | 0 | 0 |
| chickweed (<i>Stellaria media</i>) | 56 | 195 | 332 |
| cleavers (<i>Galium aparine</i>) | 0 | 141 | 0 |
| dock (<i>Rumex</i> spp.) | 0 | 1175 | 289 |
| broad-leaved fleabane (<i>Conyza albida</i>) | 0 | 0 | 8 |
| prickly sow thistle (<i>Sonchus asper</i>) | 0 | 42 | 0 |
| Total dry weight (g) per m² | 280.3 | 5.89 | 2.14 |

Estimates have been calculated for the effect of weeds in New Zealand and a recent survey estimated weeds were costing the country as much as NZD340 million in lost production and NZD53 million in control measures per annum.²⁴

2.5.1 PROBLEMS CAUSED BY WEEDS IN GARDENS AND LANDSCAPING²⁴

Dense weed infestations reduce the air movement near the soil surface, thus raising the humidity and making ornamental plants more susceptible to disease problems. Weeds seldom get this dense in gardens; however the main problem caused by weeds in gardens is that they look unsightly. The level of weed control in gardens needs to be very high if they are to remain aesthetically pleasing, yet by clearing those weeds, no income is generated to pay for this. The same situation exists for most turf areas.

In public gardens, parks and reserves, there is usually a fixed budget available from the body responsible for the maintenance of these areas (e.g. from the local council, funded by rate payers). Post planting maintenance for public garden amenities and motorway berms can be as high as 70% more than the original cost of the plants. For home gardens of course generally the costs are only for materials such as mulch and herbicides, but the homeowner provides the labour. As the average homeowner does not enjoy using too many of their precious leisure hours pulling out weeds, techniques are sought to minimise the weeding necessary to maintain an attractive garden.

Picture Montage 3

EcoCover mulch mat used in domestic landscaping



Preparation and pinning

Planting

Bark covering over mulch mat

2.5.2 PROBLEMS CAUSED BY WEEDS IN ORCHARDS²⁴

Competition is obviously a major issue. The trees and vines are generally taller than the weeds so the competition for light is often not a problem. However, there can be exceptions, such as tall weeds around young trees and vines in their first year, or clambering weeds that may cover a crop. But it is normally competition for water and nutrients that is the concern.

Competition for water will only be a problem at dry times of the year, and many orchards have irrigation systems to help out at these times. But a lot of vegetation under trees means that there is a large leaf area which can be losing water to the air by transpiration, resulting in the soil being dried out faster than if the soil was bare. Thus uncontrolled vegetation growing under trees can result in greater water requirements for an orchard, and so more irrigation will be needed during dry times of the year. Irrigation water can be scarce in summer, resulting in charges for water and possible rationing; keeping weeds under control can reduce water requirements.

Nutrients can be applied to orchards in the form of fertilisers, however weeds can take up nutrients very rapidly with many weed species taking up more nutrients than they actually require. Having a lot of weeds present under trees can result in

nutrients being removed from the soil quite rapidly. Equally, if the orchard floor were just bare soil, nutrients would be more likely to leach down into the groundwater. This leaching results not only because of nutrients being left unabsorbed in the soil, but also because there is no vegetation to intercept rainwater and prevent it moving down through the soil, taking nutrients with it.

Where the soil is covered in vegetation, trees tend to have fewer roots near the soil surface than if the soil is bare. Competition with the roots of weeds and grasses results in trees positioning their roots deeper down. As nutrients exist at highest concentrations at the soil surface where fertilisers are applied, tree roots are not as well positioned to intercept these nutrients if they are growing deeper in the soil.

Picture Montage 4

EcoCover in orchard and vineyard applications



Fence line weed control

Vine weed protection

Orchard weed protection

Uncontrolled weeds can grow up into the level of lower branches of trees sometimes shading fruit that are growing there and affecting their colour. These weeds can allow insects to climb from the soil up on to the fruit. Tall weeds can impede good spread of water from irrigation sprinklers. Dense weeds can create a high humidity near the soil due to reduced air movement, which can increase the chances of disease organisms building up.

If the soil is left bare, the surface tends to become quite crusted and compacted from constant raindrop impaction and also passage of vehicles. Earthworm numbers decline dramatically as they have less plant material to feed on, and the burrowing activity of earthworms increases the macro porosity of the soil.

EcoCover can assist in keeping the soil structure, natural fertility and water holding capacity of the soil at optimum levels.

All bare soil can result in slippery conditions when it is wet and fairly dusty conditions when it is dry, with more heat being reflected up off the ground on sunny days. This heat reflection can be considered good by some growers though as it helps improve the colour of fruit on lower branches.

With tree fruit and vine, mulches are generally only used in the first few years in the life of a crop when weed competition can have severe effects on the establishment of the crop. There are also fewer herbicide options due to the vulnerability of young crop plants to residual herbicides.

EcoCover can act as an insulation blanket, absorbing heat and releasing it at night, which will reduce the risk of frost damage at some times of the year.

Picture Montage 5

Massey University weed trials – lettuce and cabbage crops³⁶ Photographs courtesy Massey
EcoCover plant stem hole minimises weed growth. Polythene stem hole remains open and is subject to weed invasion. Refer *Tables 4 and 5* below for respective weed count.



2.5.3 PROBLEMS CAUSED BY WEEDS IN FORESTRY²⁴

Forestry is a large user of herbicides. Competition between forest trees and weeds for light, nutrients and water is probably the main problem caused by weeds in exotic forests. This effect is of most importance during the first few years of the life of the forest, as the trees are most susceptible to the effects of competition at this stage. If competition is severe enough, trees can be killed during the first year after planting. If trees do survive the first year, major checks in growth at this stage can cause a delay in the development of the trees. Research has shown that trees are affected by the initial check in growth for quite a few years afterwards, causing a delay of several years before the trees will reach a harvestable size.

Case Study. A trial there was no weed control for year 1 then excellent control for the following 2 years resulted in the mean volume per tree being 3180 cm^3 after three years. In comparison, trees with good weed control for all 3 years had a volume of 8674 cm^3 , **2.7 times** that of the other trees.²⁴ Although scrub weeds can be very competitive in establishing forests, perennial grasses can be just as damaging.

Loss of moisture is a problem to new planting as is frost damage in certain areas. Dense weeds around young trees can reduce air movement and thus increase humidity, which many lead to disease problems. Weeds can also attract pest and disease organisms into forests and lead to problems. Weeds can also make maintenance more difficult and forests more vulnerable to damage by fires.²⁴

Picture Montage 6

Massey University *Pinus radiata* weed trials comparing four different treatments³⁶

Period 1 - at planting. Photographs courtesy Massey



Picture Montage 7

Massey University *Pinus radiata* weed trials³⁶

Period 2 - 6 months+ after planting. Photographs courtesy Massey



Bare soil

EcoCover

Polythene

Fluted cardboard



Radiata seedling with no mulch protection competing with weeds for light, nutrients and moisture

2.5.4 PROBLEMS CAUSED BY WEEDS IN NURSERIES²⁴

Nurseries are keen to get plants to a saleable size as quickly as possible so they can be moved on and the next lot of plants grown. Weeds can slow down this process if they're allowed to establish, through competing with the young plants for light, nutrients and water. Although most nurseries are irrigated and a lot of fertiliser is used, weeds can grow very rapidly under these conditions and use up the water and nutrients sufficiently to limit growth by the desirable plants. Once the weeds are tall enough, light competition can occur.

Weeds growing around a nursery, can also act as a source of infection of pest and disease organisms, for new crops.

A weed free nursery gives buyer's confidence that the owners are efficient managers that produce high quality produce. Likewise. The public buying plants from a garden centre won't want plants with weeds growing in the bags, so Garden Centres won't buy weedy plants from the nursery.

Future R&D may provide nurseries with an EcoCover fertiliser enriched planter bag. Bury the entire container along with the plant – zero plastic waste.

Picture Montage 8 EcoPotTops



EcoPotTops in a variety of nursery situations – controlling weeds, conserving moisture

2.5.5 OTHER WEED PROBLEM AREAS

Pastures, turf, aquatic environments; roadsides and other waste areas (adjacent to railways lines and so on); and urban environments (footpaths etc).

Picture 9 Weed infestation smothering new plantings




Auckland motorway berm

Table 5

Effectiveness of EcoCover mulch mat as a weed suppressant. Australian weeds species

Southern Cross University Research Results¹⁰

| | Time period. 3 weekly | Weed cover (%) |
|---|-----------------------|----------------|
| Bare soil | 1 | 41% |
| | 2 | 57% |
| | 3 | 75% |
| | 4 | 89% |
| | 5 | 92% |
| | 6 | 92% |
|  | 1 | 0% |
| | 2 | 0% |
| | 3 | 0% |
| | 4 | 0% |
| | 5 | 0% |
| | 6 | 0% |

Massey University Research Results³⁶

Table 6

Numbers of weeds per m² six weeks after mulch treatments were laid
Refer Table 3 for New Zealand weed species type and count

EcoCover has a small weed count due to weed growth through plant stem hole.



| Treatment | | |
|------------------|----------------------|---|
| Bare soil | Black plastic |  |
| 761 | 21 | 10 |

Table 7

Dry weight (mg) per m² of weeds

Refer Table 4 for New Zealand weed species type and count

Weeds harvested 23 weeks after mulches laid, oven dried at 75⁰C for 24 hours.³⁶

| Treatment | | |
|------------------|----------------------|---|
| Bare soil | Black plastic |  |
| 280.3 | 5.89 | 2.14 |

EcoCover (may) offer superior weed control compared to black plastic.

2.6 PROMOTES PLANT GROWTH AND REDUCES LOSSES

Definition

“An increase in the process of growing.”



EcoCover provides moist conditions beneath the mat promoting microorganisms and worm populations, thus promoting stronger plant and crop growth rates. The pH balance of the soil is also improved. EcoCover also provides for better temperature stability in hot and cold conditions, reducing the risk of stress to new plantings.¹⁰

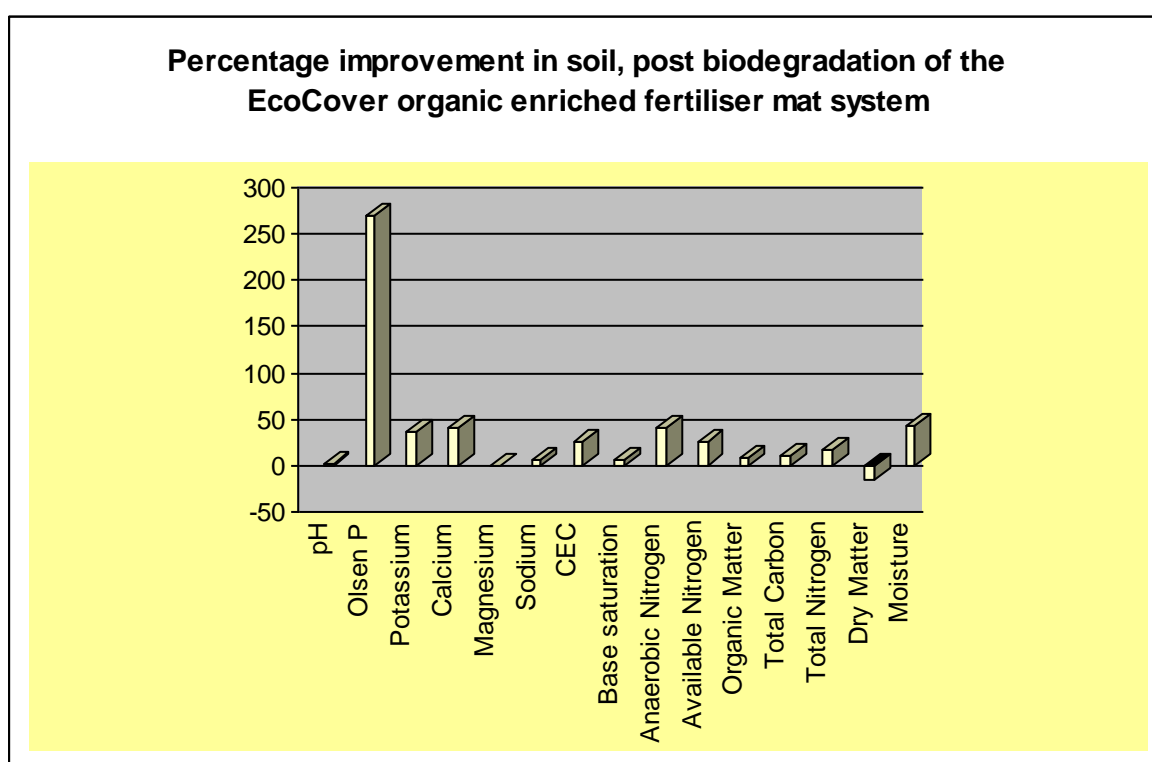
EcoCover's uniquely organically certified, fertiliser enriched mats, will deliver a substantial nutrient boost of essential trace elements replenishing the soils depleted reserves as the mat biodegrades, feeding plant roots.

Independently assessed by New Zealand's leading soil laboratory.³⁹

Table 8

Increase in percentage of certain soil essential minerals after the biodegradation of EcoCover's organic fertiliser enriched mat system

Soil samples were adjacent to each other – one sample having had no EcoCover benefit, the other, some 15 months after the EcoCover was first laid, now fully biodegraded³⁹



Weed control is also essential for maximum yields and high quality and EcoCover is exceptionally effective at suppressing and inhibiting weed growth.⁸

Paper products convey benefits well beyond reducing weeding. Sweet corn, soybeans and tomatoes mulched with 6 to 8 inch layers of shredded newspaper yielded significantly and consistently more than plots that went unmulched or that were mulched with 4 to 6 inches of straw in a 2-year study.⁶

Raspberry plants mulched with shredded newspaper out produced those mulched with black plastic (and no mulch).²⁶

Research showed significant increases in the stem diameter, a more realistic indicator of growth than height, of young *Casuarina Cunninghamiana* (River Oak: species 3) seedlings when planted out with EcoCover than in bare soil, during early planting.¹⁰

Tree seedling establishment is enhanced using mulches, reducing mortality rates, especially in areas subject to low rainfall.¹⁸

Case Study. Of potentially huge significance, trials using mulch in a vineyard situation recently proved in a year of low rainfall, that mulched vines were

dramatically greener and healthier, with superior shoot growth compared with the untreated portion of the vineyard.²⁷

A mulched crop is cleaner and less subject to rots due to elimination of soil splashing on the plants or fruit.²⁸ One of the most common causes of fungal diseases in many plants (particularly solanums and cucurbits) is mud splashing on the under surfaces of leaves. Mud is loaded with spores and the under surfaces of leaves do not have the tough, protective, impervious cutin of the upper surfaces. Mulches completely eliminate mud splashing during heavy rain or overhead watering and thereby greatly reduce the risk from this very common cause of infestation.

Case Study. Massey University cites research undertaken in New Zealand clearly showing that effective weed control can substantially improve growth rates in *Pinus Radiata* early plantings. A trial in which there was no weed control for the first year then excellent control for the following two years resulted in the mean volume per tree being **3180 cm³** after three years. In comparison, trees which had good weed control for all three years had a volume of **8674 cm³**, **2.7 times** that of the other trees.


Furthermore, if competition between forest trees and weeds for light, nutrients and water is severe enough, trees can be killed during the first year after planting. If trees do survive this first year, major checks in growth at this early stage can cause quite a delay in the development of the trees.²⁴

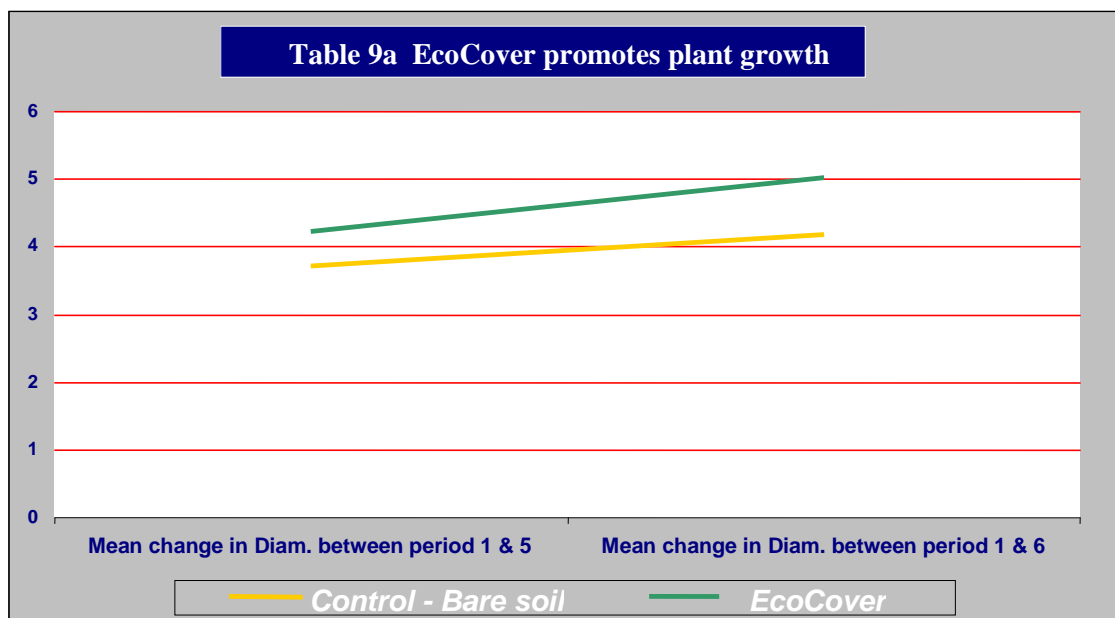
Table 9

Effect of EcoCover long life mat on Casuarina seedling growth¹⁰

Statistical analysis of the Casuarina seedling stem growth was conducted using the SPSS computer package. Mean Changes in Stem Diameter between the First and Fifth Measurement of Time and the First and Sixth Measurement of Time for each treatment were measured.

Southern Cross University Research Results¹⁰

| | Mean change in diam. between time 1 & 5 | Mean change in diam. between time 1 & 6 |
|--|--|--|
| Control - bare soil | 3.72 | 4.19 |
|  eco cover | 4.22 Increase of +13.44% | 5.03 Increase of +20.05% |




The effectiveness of EcoCover long life mat in promoting an increase in the seedling stem diameter was substantially higher than the growth rate produced by the control (in bare soil).

Table 10

The effect of two mulch treatments compared to bare soil on crop yield for lettuce and cabbage crops planted May 2003³⁶

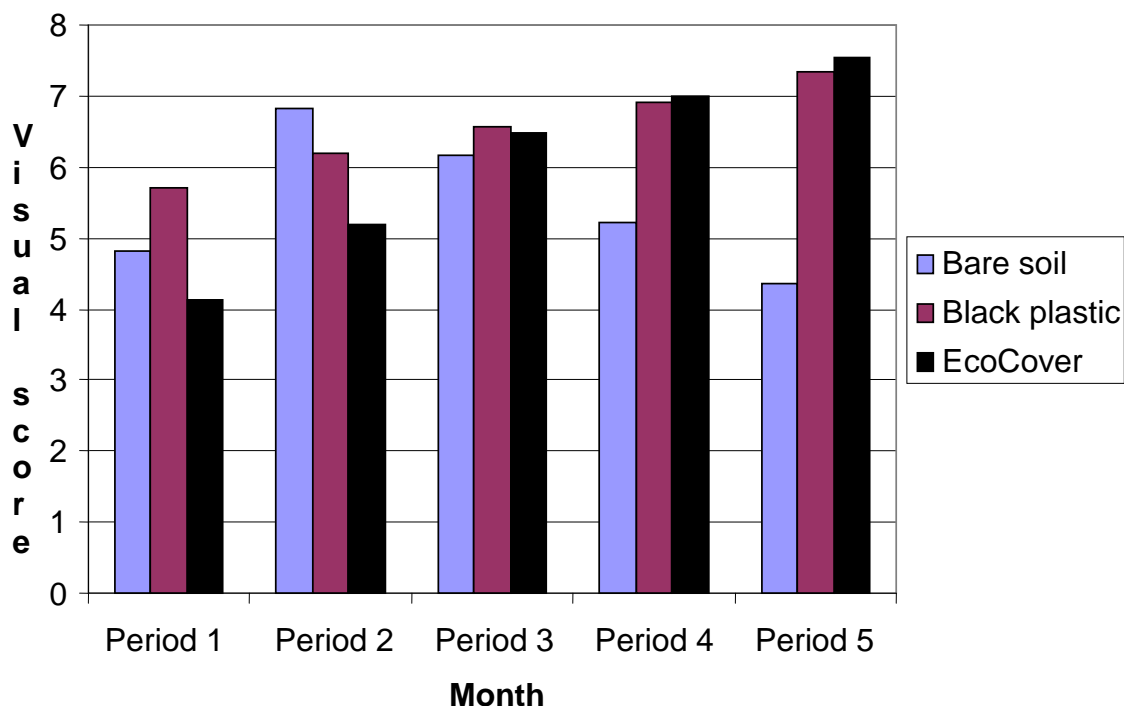
Massey University Research Results^{36, 37}

| | Black polythene film | Bare soil |  | % increase in growth v bare soil |
|---|-----------------------------|------------------|--|---|
| Lettuce (g / plant) after 23 weeks | 550 | 170 | 480 | +282% |
| Cabbage (g / plant) after 25 weeks | 1120 | 560 | 1170 | +209% |

Average crop weights recorded for each treatment at harvest show heaviest weights were recorded for crops grown under EcoCover and black plastic mulch treatments. Bare soil treatments resulted in low plant weights when compared to mulch treatments. EcoCover provided greater plant fresh weights and faster crop maturity compared to un-mulched treatments. Improved head formation was also observed. EcoCover mulch improved crop growth and reduced time to maturity.

Table 10a

Mean scores of appearance (0 = dead, 10 = big and healthy) for both cabbage (cv. Emerald) and lettuce (cv. Impact) plants grown under three different treatments



EcoCover commissioned a further research project with Massey University in 2006 to investigate the growth and crop yield effect of EcoCropP (plain coloured mat) and EcoCropR (red) and compare the results to those of using black plastic film and hand weeded bare soil, duplicating high labour input costs for organic farming practises. Two worldwide high value crops were used, namely tomato [cv. Scorsby Dwarf] and capsicum or sweet pepper [cv. Zola F1]. No chemical fertilisers, herbicides or pesticides were used in the trial

A brief summary of Massey's 2006 published research findings are:

- Intensive hand weeding is required every 90 days to keep soil weed free. Careful records were kept in a time log. Massey's labourers took 30 minutes to thoroughly weed 1 sq.m. (or 3 minutes per sq.ft.) allowing for paid travel time and necessary rest breaks during the day. Tomatoes were marginally less due to their leaf canopy that inhibited some weed growth.
- EcoCrop outperformed black plastic film by increasing tomato yields 29.4%. EcoCrop produced the largest tomatoes.
- EcoCrop outperformed black plastic film by increasing capsicum yields 42.3%. EcoCrop produced the largest sweet peppers.
- The effects of black plastic on advancing fruit maturity supports the idea that dark coloured mulches heat the soil (or the canopy by re-radiating heat), and can thereby increase crop maturity. However, the insulating properties of the paper mulches that reduce diurnal temperature fluctuation and extremes can also have a positive effect on plant longevity, fruit size, and cumulative yield.

Picture Montage 10

Massey research field comparing crop yield using EcoCropR, EcoCropP, plastic film and bare soil

Photographs courtesy Massey University



Table 11

The effect of 2 different EcoCrop mulch treatments compared to black plastic on the marketable yield (g) for capsicums, over 3 consecutive harvests ³⁷

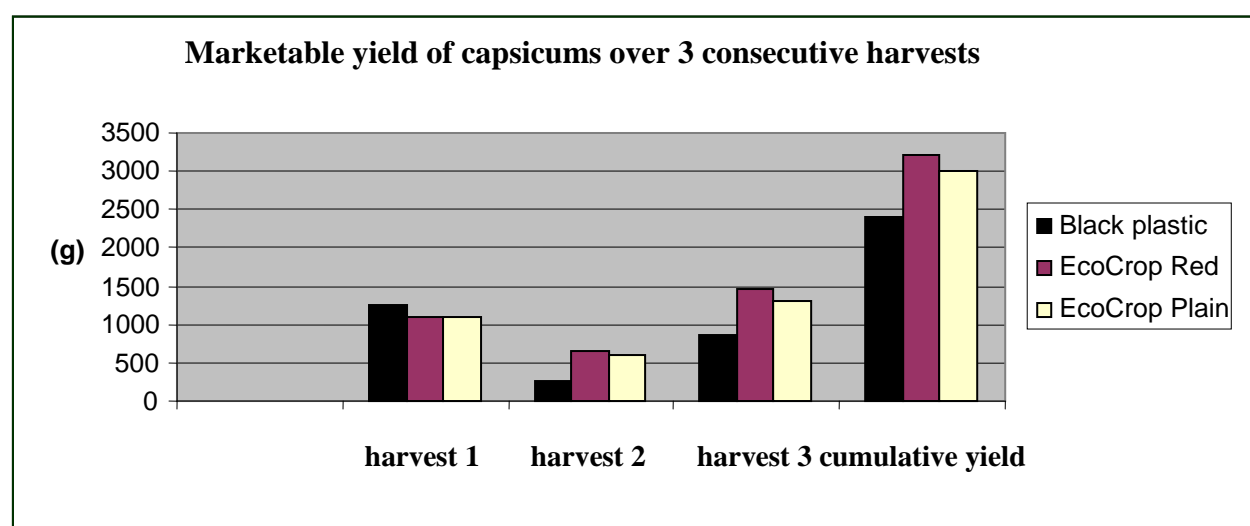


Table 12

The effect of 2 different EcoCrop mulch treatments compared to black plastic on the number of tomatoes per plant, over 2 consecutive harvests ³⁷

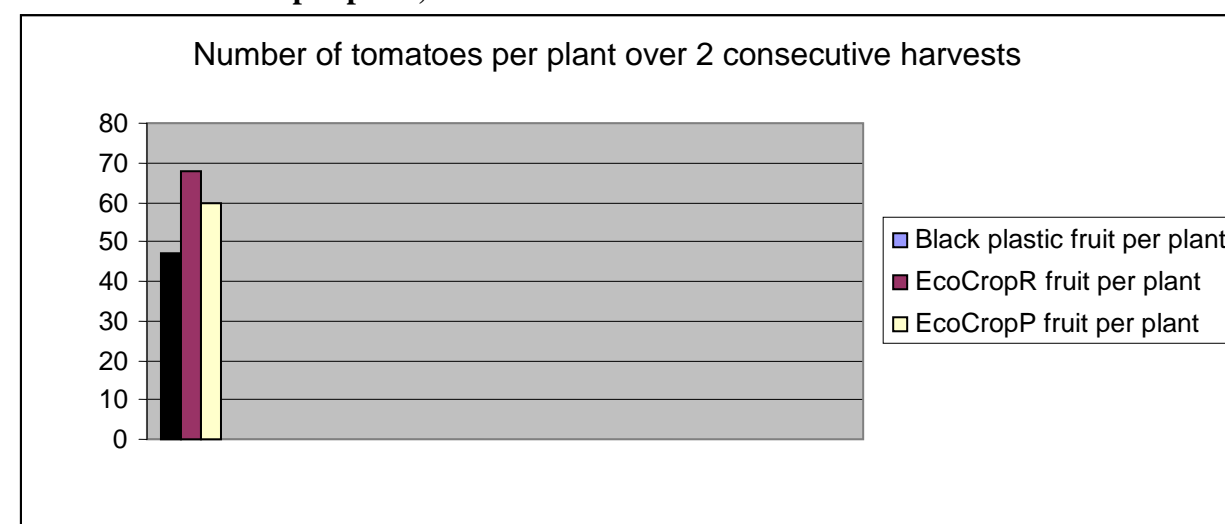
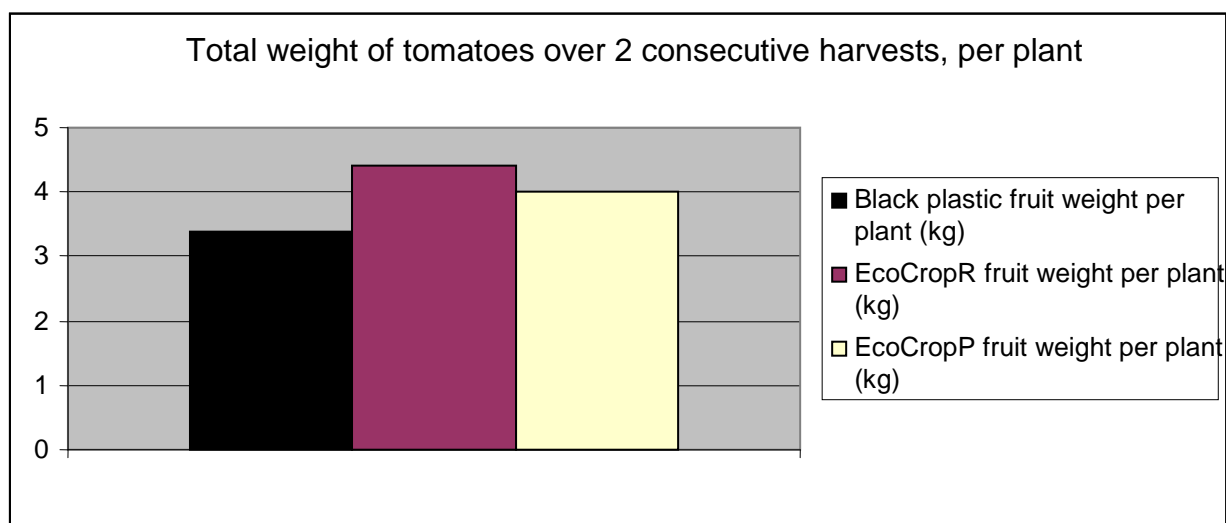


Table 13

The effect of 2 different EcoCrop mulch treatments compared to black plastic on tomato crop total yield (kg) per plant, over 2 consecutive harvests ³⁷



Picture Montage 11

Massey University plant growth trials Photographs courtesy Massey

Worm population directly under EcoCover mulch mat. Nil count under black plastic



Soil under EcoCover mulch mat is rich in worm population



Lettuce (cv. Impact) and EcoCover mulch - 16 weeks after planting

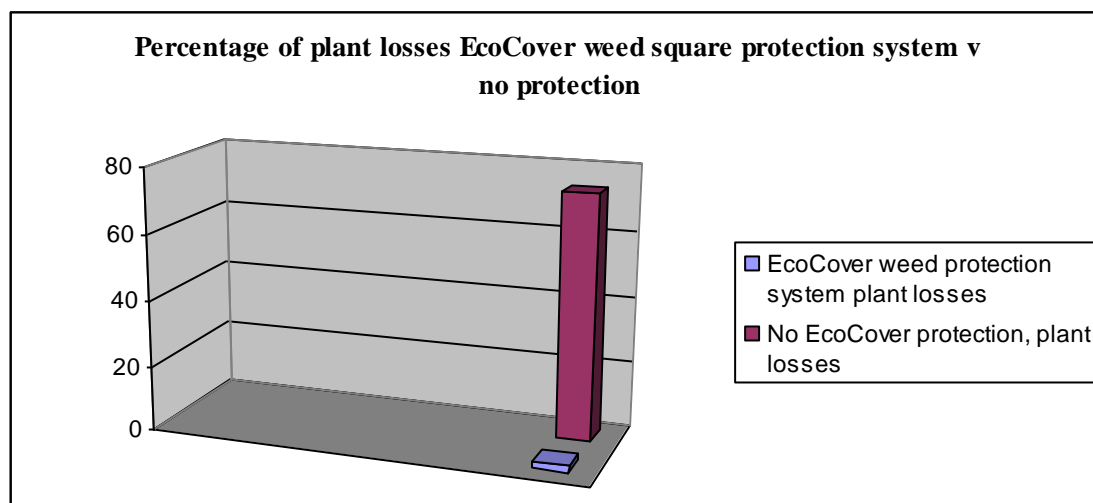
The Massey vegetable growth trial was undertaken in soil with no previous mulch history. Results may well have been even more favourable to EcoCover had the trial compared vegetable growth in a soil suffering from prolonged polythene use (poor soil structure and composition) with a further polythene mulch and an EcoCover mulch over the same bed. Future research will be undertaken with a variety of crops.

EcoCover will increase the chances of an early strike rate in new plantings, providing a total mulch solution.

Case Study. Living Systems, sustainability consultant to EcoCover carefully reviewed a major revegetation planting in the Bay of Plenty, New Zealand. Approximately 50% of the planting used the EcoCover weed square protection system and 50% did not. Planted in September 2006 and monitored regularly throughout the very dry summer, the final analysis was undertaken with the contractor in April 2007. The results are noted in the table and photo montage below.

Table 14

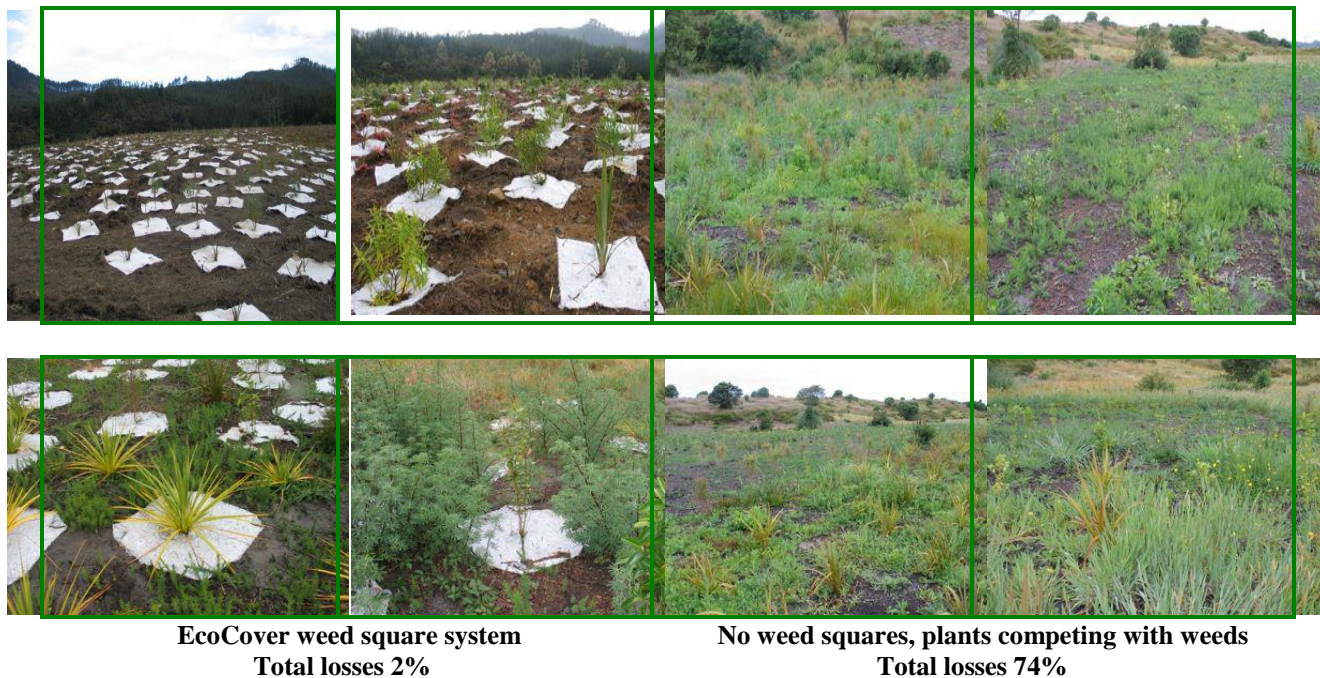
The benefits of using the EcoCover weed management system to improve plant survival rates, save money on replanting and post planting maintenance



Picture Montage 12

Bay of Plenty arid revegetation site.

Photographs courtesy Living Systems, Sustainability Consultants



2.7 REDUCES AND CONSERVES SOIL TEMPERATURE



EcoCover can significantly reduce soil temperature, an important product attribute for soil and plant health in warm climates. Polythene is frequently used as a soil sterilising agent, absorbing heat from the sun and effectively burning the soil with very high temperature. For specific outcomes such as sterilising the soil, this is an admirable use for polythene however in a planting situation where polythene is used as a weed inhibitor, the adverse effect of high temperatures will sour the soil, kill the microbes and worms close to the soil surface and evaporate off any retained moisture.


EcoCover moderates soil temperature, keeping the soil healthy and thus providing a perfect environment for plant growth.

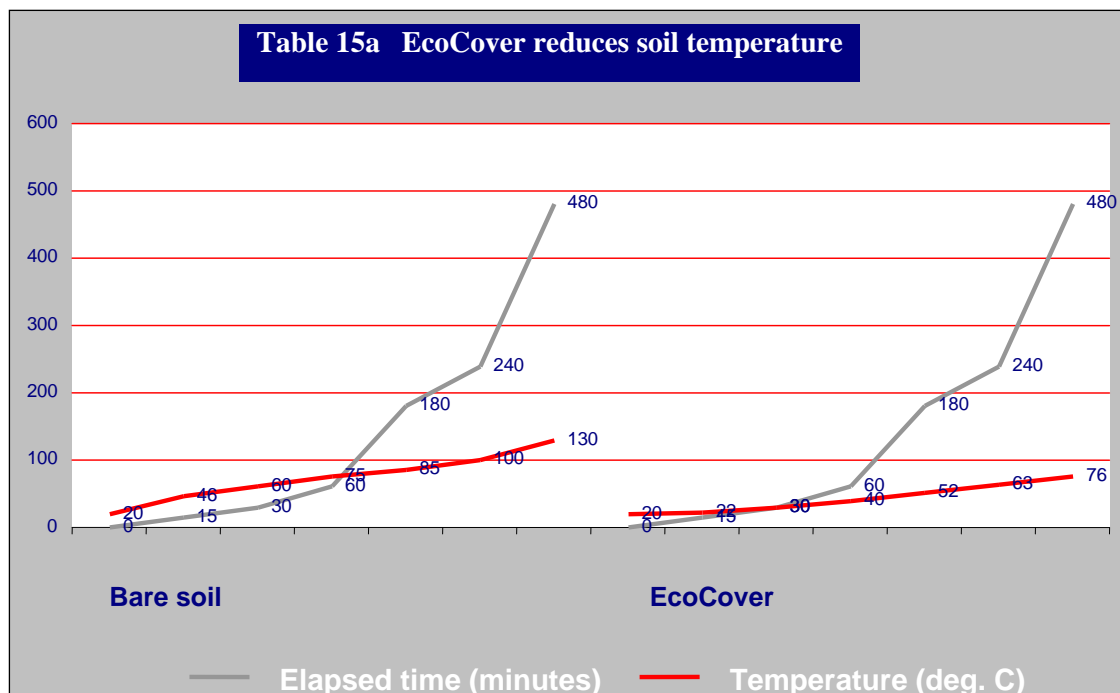
Equally in particularly cold climatic conditions, EcoCover mulch mat will act as an insulation blanket for crops and plants, significantly reducing frost damage if not preventing it entirely. EcoCover will also dramatically reduce the possibility of soil heaving and crop loss even during sustained sub zero temperatures.

Table 15

Laboratory soil temperatures were taken at 2.5cm depth with standard error. The heat source used was an infrared lamp

Southern Cross University Research Results¹⁰

| | Elapsed time (minutes) | Temperature (deg. C) | Temperature decrease (%) |
|---|---------------------------|-------------------------|-----------------------------|
| Bare soil | 0 | 20 | |
| | 15 | 46 | |
| | 30 | 60 | |
| | 60 | 75 | |
| | 180 | 85 | |
| | 240 | 100 | |
| | 480 | 130 | |
|  | 0 | 20 | = No change |
| | 15 | 22 | = 52% reduction |
| | 30 | 30 | = 50% reduction |
| | 60 | 40 | = 47% reduction |
| | 180 | 52 | = 39% reduction |
| | 240 | 63 | = 37% reduction |
| | 480 | 76 | = 42% reduction |



The soil temperature is substantially modified by the use of EcoCover long life mulch mat compared to bare soil.

A number of other tests were conducted on soil temperature namely: laboratory soil temperature after 15 minutes at a variety of depths; laboratory soil temperature after 8 hours and a variety of soil depths; 24 hour field surface treatment temperature profile and morning: treatment surface temperature profile; 24 hour field soil temperature profile at 2cm soil depth; 24 hour soil temperature profile at 10cm soil depth; laboratory soil moisture profile to a soil depth of 20cm. All confirmed the results of previously published data on the benefits of mulch in regard to soil temperature.

Massey University Research Results^{36, 37}

Massey University research proved EcoCover mulch to be successful in reducing temperature extremes around the rooting zone of crops, an advantage over summer especially when soil temperatures are often high.

EcoCropR increased average soil temperatures and increased average plant height in the 2006 study on tomatoes and capsicums compared to plain EcoCrop. Both paper mulches reduced the diurnal temperature range by reducing the loss of heat from the soil overnight and insulating against excessive daytime temperatures compared to both bare soil and black plastic film.

Picture 13
Massey University soil temperature trials

Soil temperature moderation promotes worm life beneath EcoCover mulch mat, producing a healthy soil. Photograph courtesy Massey



2.8 EROSION CONTROL

Definition

“The action or process of erosion. The state of being eroded.”



EcoCover is effective as an aid in erosion control. EcoCover helps to prevent the soil becoming dry and crusty and less permeable to water penetration. Water droplets lose their velocity and cannot therefore puddle and pan soil surfaces to produce a thin cement like surface crust upon drying, a common fault of bare soil surfaces that contain clays. The irregular fibres of the lower surface of EcoCover actually mesh (over time) with the topsoil surface thereby physically preventing crusting. This greatly increases surface porosity, allowing for rapid entry of water and completely eliminating run-off problems on sloping ground. Seed mats will assist in further stabilizing batters and faces. Once saturated, EcoCover absorbs and spreads evenly further water at a rate accepted by the contact between the mat and the soil, with any surplus being shed. This minimises excess water build up under the mat and the forming of rivulets in the soil leading to soil erosion and/or soil loss.

Under the present system of production, over 40% of the cultivable land in the United States is losing topsoil at annual rates exceeding 5 tons per acre. Such rates are considered unsustainable. Loss of topsoil results in declining fertility.³²

Soil under mulch remains loose, friable and well aerated. Roots have access to adequate oxygen and microbial activity is excellent. Soil stabilization is enhanced and erosion minimised.

Picture Montage 14

Bark over EcoCover mulch mat and plastic on a 35 - 40 degree slope and erosion control

EcoCover stabilises and consolidates the ground cover, whereas plastic causes the bark to slip and slump.



Left side – EcoCover consolidates bark
Right side – Bark over plastic causes slippage



Right side – EcoCover consolidates bark
Left side – Bark over plastic causes slippage



Govt. sponsored native moss trial for erosion control



Public revegetation to minimise erosion

2.9 HERBICIDE REDUCTION OR ELIMINATION

Definition

“The amount by which something is reduced.”



EcoCover, being exceptionally effective at suppressing and inhibiting weed growth can reduce or eliminate the need for certain chemical and herbicide applications. Plant damage is consequently reduced.

Herbicides can make their way into ground water, an increasing global problem.

Mulches are being increasingly used for native species susceptible to carelessly applied chemicals.³³

Some crops do not have suitable herbicides for effective weed control. The crop may be particularly sensitive to herbicides (for example, water melons); there may be a lot of weed species closely related to the crop species and so are not different enough from the crop to allow a selective herbicide to kill the weed without killing the crop.²⁴

Massey University Research Results³⁶

Massey's research proved that EcoCover is a longer lasting weed control than some of the most persistent residual herbicides (for example terbuthylazine and hexazinone). EcoCover also gives longer weed control than knockdown herbicides with little residual activity, even if these are applied more than once. EcoCover is able to control a wide range of weeds, both annual and perennial, and will control more weeds in some crops than the herbicides available. For example, both triflurin and clethodim are used for weed control in cabbages, but these herbicides are unable to control a number of other weed species.

Picture Montage 15

Massey University Pinus radiata trial – weed control using herbicides

Photographs courtesy Massey



Herbicides do not always effectively kill and/or control all weed species – weeds may grow over time

Picture Montage 16

Post planting maintenance damage resulting from the careless use of herbicides



Post planting herbicide damage, photos 1 and 3 show 100% loss

3. ECOCOVER MAT - AS A CARRIER

(subject to ongoing international R. & D.)

Definition

“A device that carries.”



EcoCover mulch mat can be used as a device for carrying a wide range of agricultural and horticultural value added benefits. Many are still in the research stage, however future applications identified to date, include:

■ **Seeds.** Native seeds for soil rehabilitation; erosion protection; grass and lawn mats; herb and flower mats for example

■ **Fertilisers** liquid organically certified. **Completed**

■ **Soil conditioners.** Enzymes, organic acids and beneficial bacteria for example.¹

■ **Trace elements and nutrients.** To condition and replenish certain soil deficiencies.

■ **Pesticide control.** A selective organic insect deterrent. Integrated pest management, along with nitrogen fixation, soil conservation, and efficient use of water are important components of new crop production methods²

■ **Coloured mats,** top coated with environmentally safe dyes³ for particular crop applications. Plants are competitive organisms. They are always competing for space, nutrients, sunshine and water. Plants must endure hardship such as disease, insects and weather. They must also have defence mechanisms and sensor structures to battle these environmental factors. Plants also have to battle each other. They have a way to detect each other and a method to compete with their surrounding neighbours. Plants have a substance called phytochrome that acts as a sensor to detect changes in the colour of light that is reflected from their surroundings. They do not know if the signal is a neighbouring plant, dead plants on the surface of the soil or even the colour of the soil. The plant recognises far-red light as the signal. If the plant detects an abundance of far-red reflection, it thinks that there must be other plants growing nearby. The phytochrome will then signal the plant to put more energy (photosynthate) in the top of the plant (shoot) instead of the bottom of the plant (roots). The plant, in effect, is trying to outgrow its competition and is 'tricked' into putting more energy into shoots to outgrow other plants.^{5, 6}

EcoCover is very easily coloured. A spray of a vegetable based ink (fully organic) on the top surface will provide a red or blue mat, which depending on the crop can substantially improve quality and size. Further research around the world is proceeding with strawberries, turnips, peppers, peas, beans, carrots, and cotton.

When coloured mulch is used in agriculture, crops are expected to produce larger fruit and possibly even better tasting fruit. Scientists have found that certain colours of reflected light can change the flavour of some fruits and edible roots (such as turnips and carrots).⁴

Picture Montage 17

EcoCropR (red) in commercial use and under research



EcoCropR melon crop under cloche, NZ

EcoCropR Massey University research

■ **Water gel crystals.** Encapsulated in EcoCover, water gel crystals could store hundreds of times their own weight in moisture and in some climates, make the difference between, the survival and failure of the plantings.

■ **Fragrances, scents and rodent control.** Particularly for landfill covers. A report on ‘*New Zealand Landfills*’ and the EcoCover opportunity are available on request.

Picture Montage 18

EcoCover, landfill cover research



New Zealand central north island landfill research

4. RECYCLED CONTENT

Definition

“To use again especially after reclaiming or reprocessing.”



EcoCover is manufactured primarily from reclaimed waste paper and certain adhesives, which are then reprocessed into a wide variety of application specific products.

60% of landfill problems are due directly to the paper industry in the United States. Recycled paper and waste paper recovery saves valuable natural resources, saves energy, saves trees, creates less toxic bi-products (landfills leak toxic wastes and incinerator plants emit volatile organic compounds) and reduces landfill use.²

Recycling provides opportunities that will provide long-term benefits to the community and the environment. The availability of weed suppressants and mulch products manufactured from biodegradable and recycled materials such as shredded wastepaper, can provide alternatives to synthetic and non-biodegradable products currently on the market. Potentially these products can reduce the resources, energy and pollution associated with weed management and plant establishment.

A single manufacturing plant operating one shift per day can *recycle up to 9MT of waste paper per week* depending on the mulch mat construction. Refer to the *Appendix* (Page 39) at the end of this document for specific raw material usage by weight.

The total percentage of EcoCover mulch mat raw material inputs returned to the soil in a beneficial / productive form can be as high 87.77% depending on mat construction.

Picture 19

Massey University trial - EcoCover biodegrades into the soil ³⁶ Photograph courtesy Massey



**EcoCover biodegrades safely into the soil over time
Equally, it may be ploughed under**

5. PRODUCT STRENGTH

Definition

“The multi directional strength of the finished product under a variety of climatic conditions.”



EcoCover, being essentially a paper product, has minimal wet strength and therefore care must be taken in handling (laying, walking on, planting through, and so on) under wet conditions. Upon drying the product quickly regains its multi directional strength, which is dependent upon the original thickness (and remaining life) of the particular mat. Long life EcoCover has greater multi directional strength than short life mat under dry conditions for example. Both have minimal wet strength.

EcoCover is to be laid over clean, even ground and pinned in place. The type of pin and pin spacing is important to the life and performance of the mat.

Picture Montage 20

EcoCover is easily cut, pinned and laid, even around existing vegetation

The mat is easily handled, may be walked on and will withstand robust treatment when dry



Preparation and pinning around existing planting - EcoCover is easily cut and placed



EcoCover's new EcoPin development – 100% biodegradable

6. ENVIRONMENTAL BENEFITS

Definition

“Something that promotes well being to the circumstances, objects or conditions by which one is surrounded.”



It is increasingly recognized the world's resources are finite, and that they need to be managed and used more carefully. Paper products have a vital role in many of society's activities and basic needs. The recycling of used paper is becoming more important as a means of maximising the utilisation of wood fibre and reducing the environmental impact of wastes. Recycling is the creation of a new product from materials, which would be otherwise discarded or disposed of as solid waste. Recycling is seen as a practical way of reducing waste disposal problems (landfills) and it is seen as both economically and environmentally sensible.¹⁰

An approximate rule of thumb is as follows. In most countries of the world, each and every man, woman and child generates approximately 1,000kg (2,240lb) of waste per annum, 50% of which is bio-waste.

EcoCover mulch mat:

1. Eliminates certain plastic waste disposal problems. In 1991, it was estimated that 24,000 tonnes (53 million lbs) of plastic film was used in the agricultural and construction sectors in Canada alone.^{1, 2}
2. Reduces ground pollution by both replacing plastic mulch¹⁰ and easing pressure on landfills, with paper occupying up to 30% of most landfills. EcoCover contains up to 87% by weight recycled waste content, primarily paper.
In the United States, 60% of landfill problems are due directly to the paper industry. Recycled paper and waste paper recovery saves valuable natural resources, saves energy, saves trees, creates less toxic bi-products (landfills leak toxic wastes and incinerator plants emit volatile organic compounds) and reduces landfill use.³
3. Certified organic. Fully compostable.^{4, 10} Fully biodegradable.^{5, 10}
4. Reduces water usage for irrigation purposes by conserving the loss of moisture due to evaporation.^{6, 10}
5. Reduces the risk of groundwater contamination with the reduction or elimination in the use of herbicides for weed control.¹⁰
6. Increases worm populations and microorganisms in the soil, promoting healthy soil and encouraging plant growth.^{7, 10}

7. EcoCover reduces soil erosion and fertility losses in the soil due to erosion.¹⁰
8. Saves fibre from forests, more specifically native forests, by substituting recycled materials for virgin fibre. It has the possibility of contributing to the reduction in the 'Greenhouse Effect' by maintaining forest resources. It reduces the reliance on imports of both paper and of pulp or fibre.

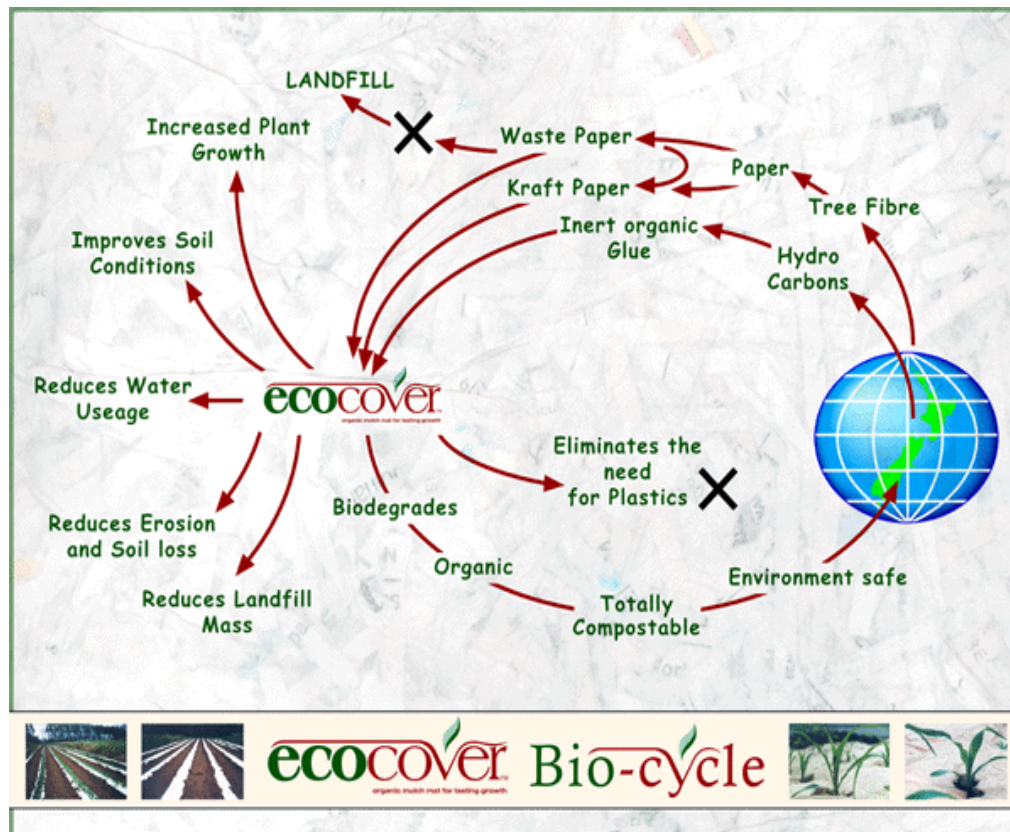
According to the National Office Paper Recycling Project in the USA, more than 12 million tons of waste paper is generated each year by office workers, almost all of which ends up in landfills. Since 1978, more than 80 per cent of all US landfills have reached capacity and closed. Less than one third of the 88 million tons of waste paper generated in the US each year is recycled. Certain US landfills will no longer accept paper and or plastic waste.¹⁰ Worldwide paper consumption is expected to expand 46 percent by the year 2040. In 1996 worldwide paper consumption was 280 million tons.^{8,9}

Massey University Research Results³⁷

The 2006 Massey research report quotes, “although widely used, synthetic plastic mulches are an unsustainable product of the oil industry whose cost is likely to increase significantly in the short and medium term. Plastic mulches are also environmentally polluting, whether they are incorporated into the soil or disposed of in landfills, mainly because of their resistance to biodegradation. The EcoCover system is made from recycled waste paper that has advantages over other mulch materials. Compared to other organic mulches it offers the grower ready availability, and ease of handling and installation. Unlike plastic it is a renewable resource, is completely biodegradable, and eventually adds nutrients to the soil”.

Figure 1

The EcoCover Bio-cycle demonstrating environment sustainability



An EcoCover plant operating a single shift per day could remove up to 2,250m³ of paper from the waste stream annually. A direct quantifiable benefit to landfill owners / operators.

Picture Montage 21

Examples - EcoCover weed square; EcoCrop broadacre application; EcoCoverRF landscape application



Pinus radiata



Calla lilies, early planting



EcoCrop - calla lilies



EcoCoverRF roading landscape

7. PRODUCT LIFE

The useful product life or durability of the mat is dependent upon the thickness of the shred (primarily) and the quantity of binder that holds the shred together as a composite mat.

The mat is produced to a maximum width of approx. 2m and may be cut to any variable of this width with no wastage, e.g. 500mm (approx.), 650mm, 1m and so on.

Extensive testing to date in the Cudgen, NSW, Australia region has provided quantifiable results in respect of product life for both the long life mat (with a useful life of approximately 24 months) and short life EcoCrop mat (with a useful life of approximately 6 months). The useful life of the product is heavily influenced however by any one of a number of external factors, some of which are region specific.

Such factors may include any one of, or a combination of the following:

- The prevailing climatic conditions. For example a wet environment will shorten product life whereas a drier more arid climate will increase product life. Temperature, sunshine (particularly UV which breaks down the binder), humidity and other climatic factors can all impact to some degree on the product life
- Site preparation. The preparation of the ground surface and the laying techniques are important to ensure the product is laid down under optimum conditions. The product should be laid down on ground that has been cleared of weeds, long grasses, stones and any other obstructions. The ground should also be as smooth as possible to ensure a good interface with the soil surface. The normal site preparation practise for existing ground cover applications applies to EcoCover site preparation
- The pinning technique is important to ensure the product is securely pinned to the ground, the edges in particular, preventing wind damage and product movement. Large areas may be held with string and pins
- Product life can be shortened if the mat is damaged during planting though, especially if the mat is wet when product strength is below optimum
- Slugs and snails can affect the integrity of the mat. It is in the best interest of the plantings that such pests are minimised
- The application of a covering (such as bark) over the mulch mat is likely to decrease the life expectancy
- Mulch mat thickness will affect product life. Thick mats last longer

Massey University Research Results³⁷

At the end of the 5 month EcoCrop trial, Massey reports the EcoCrop mulches, both red and plain were still intact and could have been used for a 3rd crop.

There is emerging ever-increasing pressure for products to conform to environmentally friendly standards. EcoCover has unique attributes and values in this respect. The current absence of other like products within this environment of change provides the opportunity for EcoCover products to offer solutions to a wide range of existing and emerging markets.

APPENDIX TO SECTION 4 – RECYCLED CONTENT & USAGE PER WEEK

Weekly EcoCover raw material usage (*assumes 100% long life production for this calculation*)
per manufacturing plant, operating a single shift per day

| | | | |
|---|-------------|----------------|-----------------------|
| 1 | Waste paper | Per 5 day week | 8,325kg approx |
| 2 | Adhesive | Per 5 day week | 1,000kg approx |
| 3 | Kraft paper | Per 5 day week | 1440kg approx |

Recycled content usage 'per annum' – per plant

An EcoCover plant operating a single shift per day will use a maximum of **425MT** recycled waste (9,045kg [8325 + 50% of 1440 kraft weight] x 47 weeks) annually.

REFERENCES AND LITERATURE CITED

1. WHAT IS MULCH?

1. Rose, M.A. and Smith, E. 1996. Mulching landscape plants: Fact sheet HYG-1083-96. Horticultural and Crop Science, Ohio State University Extension, Ohio, USA
2. Porter, D. n.d., Are mulches a good idea? West Virginia Farming and Forestry Bulletin, West Virginia, USA
3. Oates, N. and Clarke, B. 1987. Trees for the back paddock. Goddard and Dobson, Victoria, Australia
4. Brinen, G.H. 1994. Fact sheet #7
[Online]. Available: <http://gnv.ifas.ufl.edu/~alachua/Mulch.htm>
5. Rose, C.W. 1966. Agricultural Physics. Pergamon Press Limited, London
6. Blake, C.D. 1967. Fundamentals of modern agriculture. Sydney University Press, Sydney, Australia
7. Bradshaw, K. 1998. What are some strategies for dealing with first year trees in drought conditions? New Zealand Tree Grower. November 1998. 34-35
8. Massey University College of Sciences. Institute of Natural Resources. Plant Protection Group. Controlling Weeds Study Guides One, Two and Three, 2001 Paper 171.385. Compiled by Dr. K Harrington
9. Anon, 1997. Irrigation, mulches and frost control B672, Ohio State University Extension Bulletin, Ohio, USA
10. Porter, D. n.d., Are mulches a good idea? West Virginia Farming and Forestry Bulletin, West Virginia, USA
11. Rose, M.A. and Smith, E. 1996. Mulching landscape plants: Fact sheet HYG-1083-96. Horticultural and Crop Science, Ohio State University Extension, Ohio, USA
12. L.M. Johnston. 1997. The efficacy of mulch mat as a biodegradable paper mulch. Faculty of Resource Science and Management, Southern Cross University, NSW, Australia
13. Bedford, T.A. 2004. Assessment of a Paper Mulch for Weed Control. Institute of Natural Resources, Massey University, Palmerston North, New Zealand

2. ECOCOVER PRODUCT ATTRIBUTES & RESEARCH DATA

1. As given by the *Codex Alimentarius Commission of the Food and Agriculture Organization of the United Nations*, dated June 1999
2. Chaney, R. using newsprint as mulch. USDA-ARS environmental research laboratory in Beltsville, Maryland, USA. [Online] <http://bowlinggreen.ky.net/DailyNews/mulch.html>
3. Organic Gardening. July/August 1997. 50-55
4. Black, R.J., Gilman, E.F., Knox, G.W., Ruppert, K.C. Mulches for the Landscape. University of Florida. Florida Cooperative Extension Service. Fact Sheet ENH 103. March 1994
5. McGrath, M. 1991. Newspaper in the garden, round two (newspapers as compost) Organic Gardening 38:16
6. Munn, D.A. 1992. Comparisons of shredded newspaper and wheat straw as crop mulches. HortTechnology 2:361-366
7. Heckman, J. 1993. using newspapers in agriculture. The Soil Profile Newsletter (Rutgers Coop. Ext. Serv.). Vol. 3 (2):2-4
8. Pellet, N.E. and D. Heleba, June 1995. Chopped Newspaper for Weed Control in Nursery Crops. J. Environ. Hort. 13(2):77-81
9. [Online]. Available: <http://www.ifgb.uni-hannover.de/gabainfo/ulmer/gabawiss/695/6006280.Htm>. G. Matitschka and M. Ernst. Effect of mulch on N-Content in soil, N-Uptake, and Growth of Lettuce
10. L.M. Johnston. 1997. The efficacy of mulch mat as a biodegradable paper mulch. Faculty of Resource Science and Management, Southern Cross University, NSW, Australia
11. Brinen, G.H. 1994. Fact sheet #7
[Online]. Available: <http://gnv.ifas.ufl.edu/~alachua/Mulch.htm>
12. Porter, D. n.d., Are mulches a good idea? West Virginia Farming and Forestry Bulletin, West Virginia, USA
13. Blake, C.D. 1967. Fundamentals of modern agriculture. Sydney University Press, Sydney, Australia

14. Macleod, D.A., Francis, R.G., Brown, L.H., Harris, H.C., Hindmarsh, R.R., Lovett, J.V. and Ramsay, B.A. 1984. Soils and climate in agricultural production systems. University of New England, Armidale
15. Rose, M.A. and Smith, E. 1996. Mulching landscape plants: Fact sheet HYG-1083-96. Horticultural and Crop Science, Ohio State University Extension, Ohio, USA
16. <http://www.crop.cri.nz/curresea/soil/wormulch.htm>. P Fraser, New Zealand Institute for Crop & Food Research, Christchurch, New Zealand
17. Buchanan, R.A. 1989. Bush regeneration – recovering Australian landscapes. TAFE Student Learning Publications, NSW, Australia
18. Bradshaw, K. 1998. What are some strategies for dealing with first year trees in drought conditions?. New Zealand Tree Grower. November 1998. 34-35
19. Australian Financial Review. Water licenses seen as a priceless asset. Friday 11 June 1999 edition. 64
20. Environmental News Service. Growing population faces diminishing resources [Online]. Available: <http://ens.lycos.com/ens/jan2000/2000L-01-18-06.html>
21. Barker, Allen. Professor of Plant Nutrition. University of Massachusetts, USA
22. Boyce, B.R. and D. Heleba. 1991. Mulching strawberries with chopped newspaper – a preliminary trial. HortScience 26:481 (Abstract)
23. Wooten, T.E. and R.S. Helms, 1981. Paper mulches for vegetation control in Christmas tree plantations. Forestry Bull. No. 23. Dept of Forestry, Clemson University
24. Massey University College of Sciences. Institute of Natural Resources. Plant Protection Group. Controlling Weeds Study Guides One, Two and Three, 2001 Paper 171.385. Compiled by Dr. K Harrington
Reference: http://www.hortnet.co.nz/publications/nzpps/proceedings/97/97_373.pdf
25. New Zealand Herald. 31 May 2004, Page A12 Worms and weeds to flourish. AgResearch report
26. M.R. Warmund and C.J. Starbuck. Micro propagated ‘Redwing’ Raspberry plants mulched with recycled newspaper produce greater yields than those grown with black polyethylene. Journal of Small Fruit & Viticulture. Vol. 3(1) 1995
27. Wardle, P. 1998. Mulching gets rid of prunings, disease. New Zealand Horticultural News, November 1998. 21
28. Sanders, D.C. North Carolina State University at Raleigh, USA.. North Carolina Cooperative Extension Service. July 1994 (Revised). Leaflet No: 33
29. Pellett, N. and D. Heleba 1994. Comparison of chopped newspaper and microfoam for winter protection of container grown nursery stock. HortTechnology 4:55-57
30. Warmund, M.R., C.E. Finn, and C.J. Starbuck. 1994. Yield of micro propagated black raspberry plants reduced by bark mulch, shade cloth, and folicote treatments. J. Small Fruit and Viticulture 3(1):15-24
31. Wallbrown, R.M. n.d. Rolled paper as a mulch in tomatoes. Agriculture and Forestry, WVU Extension Service, Mason County, USA
32. Sustainable production of fresh market tomatoes and other summer vegetables with organic mulches. USDA Agricultural Research Service, Farmers Bulletin No. 2279, Revised August 1997
33. Oates, N. and Clarke, B. 1987. Trees for the back paddock. Goddard and Dobson, Victoria, Australia
34. Unger, P.W. 2001. Waste management: paper pellets as a mulch for dryland grain sorghum production. *Agronomy Journal* 93: 349-357
35. Runham, S.R.: Town, S.J.; 1995. An economic assessment of mulches in field scale vegetable crops. *Brighton Crop Protection Conference*: 925-930
36. Bedford, T.A. 2004. Assessment of a Paper Mulch for Weed Control. Institute of Natural Resources, Massey University, Palmerston North, New Zealand
37. Morton, A.R. and Cameron E.A. 2006. EcoCover Paper Mulch: A Viable Alternative For Vegetable Growers. Institute of Natural Resources, Massey University, Palmerston North.
38. Trondheim University, Norway. 2006. Chromatographic analysis of EcoCover chemical composition in wet and dry states.
39. Hills Laboratories, New Zealand. Leachate soil analysis of biodegraded fertilised enriched mat compared with adjacent bare soil plots

3. ECOCOVER MAT - AS A CARRIER

1. [Online]. Available: <http://www.ars.usda.gov/is/pr/1999/990331.htm>. Compost, Mulch and Microbes may protect strawberries. C.T. Bull, ARS Crop Improvement and Production Research Unit, Calif., USA

2. [Online]. Available: <http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/pathintro.html>
3. Elfving, D.C., C.A. Bache and D.J. Lisk, 1979. Lead content of vegetables, millet and apple trees grown on soils amended with colored newsprint. *J. Agric. Food Chem.* 27:138-140
4. [Online]. Available: <http://www.net.USda.gov/florence/kasper/mulch4.html>
How scientists are tricking plants – Colored mulch research
5. [Online]. Available: <http://www.cstone.net/~agmulch/ref5.html>. Use of colored mulches. Michel D. Orzolek, Dept. of Horticulture, Penn. State. Uni. USA
6. *Agr. Research Magazine*. Oct 1997. Colored mulch starves Nematodes. M.J. Kasperbauer, ARS Coastal Plains Soil, Water and Plant Research Lab. Florence, SC 29501-1242, USA
7. S.S. Miller. USDA-ARS, Appalachian Fruit Research Station, WV 25430, USA. and G.M. Green II, Dept of Hort, Penn. State Uni. Fruit Research & Extension Centre, PA 17307, USA.. Reflective groundcovers for improved red color in apples
8. J.J. Stapleton, C.G. Summers, R.A Duncan and A.S. Newton. Reflective mulches repel aphids and protect cucurbitaceous crops from virus diseases. *Plant Protection Quarterly* 5(1):4-5. 1995

4. RECYCLED CONTENT

1. The EcoCover manufacturing process in its most basic form has three raw material inputs:
 - a. A top and bottom carrier, usually Kraft paper, of a high-percentage (by weight) recycled content
 - b. 100% waste paper of various kinds incorporated into the mulch mat at variety of grammages per square metre, depending upon the product (end use) application
 - c. Adhesive to a certain specified grammage per square metre. Under certain circumstances and for very specific product applications, this may be up to 100% waste adhesive (usually labelled for dumping in landfills)
2. [Online]. Available: <http://ecomall.com/greenshopping/paper.htm>

5. PRODUCT STRENGTH

6. ENVIRONMENTAL BENEFITS

1. Ministry of Agriculture, Food and Rural Affairs. Factsheet – Recycling farm plastic films. Agdex#: 120/732, Publication date: 02/95
2. Ministry of Agriculture, Food and Rural Affairs. Factsheet – What to do with plastic mulch. October 28, 1998
3. [Online]. Available: <http://ecomall.com/greenshopping/paper.htm>
4. McGrath, M. 1991. Newspaper in the garden, round two (newspapers as compost. *Organic Gardening* 38:16
5. Dr Chaney, research scientist at the USDA-ARS environmental research laboratory in Beltsville, Maryland confirms there is nothing in black or white or colour newsprint that will damage your plants or harm your soil. His studies have confirmed that mulching with the black and white pages from the newspaper, including regular newsprint pages with colour photos on them introduces no toxic chemical into the soil
6. L.M. Johnston. 1997. The efficacy of mulch mat as a biodegradable paper mulch. Faculty of Resource Science and Management, Southern Cross University, NSW, Australia
7. <http://www.crop.cri.nz/curresea/soil/wormulch.htm>. P Fraser, New Zealand Institute for Crop & Food Research, Christchurch, New Zealand
8. Huck, P. Recycled and tree-free paper. Better sustaining natural resources. *Organic and Natural News*. May 1999. 28-31
9. [Online]. Available: <http://www.zerowaste.co.nz>
10. Bedford, T.A. 2004. Assessment of a Paper Mulch for Weed Control. Institute of Natural Resources, Massey University, Palmerston North, New Zealand