Mulch a Growth Control Mechanism©

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INTRODUCTION

Mulch creates distinctive microclimates. Understanding these aspects enables us to use mulch as a growth control mechanism. A historical account by Jacks et al. (1955) notes that the practice of mulching is as old as agriculture itself. The English word mulch, which has been used as a noun since the 17th century, and is probably, derived from the German vernacular *molsch,* meaning soft, beginning to decay. This no doubt referred to a mixture of wet straw, leaves, and lose earth spread on top of the ground to protect the roots of newly planted trees and shrubs. Since 1802 the practice of spreading mulch on the soil has been referred to in English as mulching. Flint's (1928) definition of a mulch as " an artificial modification of the soil surface " is not a good one as this could also refer to a tillage operation and erosion by man made processes. Phillips and Phillips (1984) defined mulch as any material on the soil surface through which a continuous liquid water film from the soil is not present. This is because microscopic soil water moves up against gravity, provided there is continuous liquid film. A comparison can be made with paraffin moving up a wick in a lamp. Currently mulching is defined as a covering using material(s) that act as a blanket. Mulching helps your garden's soil retain the essential moisture plants need to flourish (Rand Water Mulching brochure, 2000). Other aspects that could be included into a definition are the environmental alteration, the soil structure improvement, the microbial enhancement, and the albedo changes on the soil surface.

When evaluating mulches for landscape use both positive aspect and concerns raised by various researchers should be considered. They are summarized below with appropriate references for further information. The benefits of mulch, using wood and bark (organic) byproducts as horticultural mulch over the root zones of landscape plants are well-established (Watson, 1988; Stinson et al., 1990).

POSITIVE ASPECT OF MULCHING

- Mulches can prevent the loss of water from the soil by evaporation. Moisture moves by capillary action to the surface and evaporates if the soil is not covered by mulch.
- Mulches suppress weeds when the mulch material itself is weed-free and applied deeply enough to prevent weed germination or to smother existing small weeds (Mohler, 2003).
- A more uniform soil temperature can be maintained by mulching. The mulch acts as an insulator that keeps the soil cool under intense sunlight and warm during cold weather (Watson, 1994).
- Mulching will prevent crusting of the soil surface, thus improving absorption and percolation of water into the soil and, at the same time, reducing erosion.
- Organic materials used as mulch can improve soil structure and tilth. As mulch decays, the material becomes topsoil. Decaying mulch may also add nutrients to the soil.

- Mulches also add to the beauty of the landscape by providing a cover of uniform color and interesting texture to the surface.
- Mulched plants will produce roots in the mulch that surrounds them. These roots are produced in addition to the roots that a plant normally produces in the soil. As a result, mulched plants have more roots than unmulched plants.
- Minimizing soil-borne foliar diseases (Appleton and Kauffman, 1999).
- Soil structural improvement as a result of improved earth worm activity.
- Enhanced environment for microbial activity.
- Yield increase (Otsuki et al., 2000).

CONCERNS RAISED WITH CERTAIN MULCHES

Several actual or perceived problems associated with organic mulches exist, such as:

1) The unacceptable appearance.
2) The creation of a temporary soil nitrogen deficiency with some uncomposted mulches (Ashworth and Harrison, 1983; Lloyd et al., 1999).
3) Mulch becoming sour (relates to storage).
4) A fire hazard.
5) Rapid decomposition of the mulch itself.
6) Many types of mulch, if put on too thick or against the trunk, actually tend to increase stress, disease and insect troubles, especially on poorly drained clay soils (Cornell Cooperative Extension, 2002).
7) Termite destructiveness (Duryea et al., 1999.).
8) The greying of the mulch colour (Stinson et al., 1990; Khatamian, 1985).
9) The settling of mulch.

ASPECTS THAT CONTRIBUTE TO THE CREATION OF DISTINCTIVE MICROCLIMATES

Microclimates will greatly affect the response a plant has in its environment. Mulching can alter microclimate in various ways:

1) Reduction of evaporation creating more moist soils.
2) Temperature changes as a result of radiation changes.
    - Below ground.
    - Above ground.
    - Change in surface albedo.
3) Soil improvements.
    - Improved soil fauna.
    - Granulation of soil particles.

Mulch Limits Evaporation. Evaporation from the soil surface after wetting by rain or irrigation takes place in three stages. Stage 1, which is an initial rate, occurs when the soil is wet and conductive enough to supply water to the site of evaporation on soil surface at a rate equal to evaporative demand. During this stage, evaporation rate is controlled by external meteorological conditions rather than by properties of the soil profile. However, soil surface conditions, such as reflectivity and the presence of mulch, can modify effects of meteorological factors acting on the soil. In dry climate, duration of Stage 1 is generally short and may last only a few hours to a few days.

During Stage 2, which is an intermediate falling-rate stage, evaporation rate falls progressively below the rate of potential evaporation. At this stage surface evaporation is determined by the rate at which the drying soil profile can supply water to the site of evaporation. Stage 2 may last for a much longer period than Stage 1. Eventually a third residual slow-rate stage (Stage 3) is established. Stage 3 may persist at a nearly steady rate for many days, weeks, or even months. During Stage 3, water transmission through the desiccated surface layer occurs primarily by the slow process of vapour diffusion. Hence it is affected by the vapour diffusivity of the dried surface zone and the adsorptive forces acting on the water vapor as it moves to the surface.

Mulching can reduce evaporation losses from the soil surface. However, usually only the initial evaporation rate, during Stage 1, is reduced. This means water is saved if rains are frequent, or irrigation cycles are short. Figure 1 shows a two-stage evaporation sequence occurring during the initial stages of evaporation.

The following graphs (Figs. 2 and 3) were crated from data collected at the Rand Water nursery in Alberton, South Africa. A trial was set up to see what the water-saving potential of organic mulches could be for landscapes.

The treatment, mulching over fallow soil, shows how water harvesting is possible using mulch. A 0 (zero) on the y axis refers to field capacity with 50% depletion of available water occurring at 48 mm. The mulched fallow soil takes longer to reach the 48-mm depletion point. This period received very light rain that did not affect the profile. The slight dips on the graph correlate to rain events.

Temperature Changes. Temperature influences growth according to Sutcliffe (1977). Growth is slow at temperatures close to 0°C and increases rapidly with temperature up to a maximum value, which for mesophilic plants is commonly in the order of 20 to 30°C. Beyond this, rate of growth, begins to level out, and then declines until a temperature is reached at which growth stops. At a still higher temperature than this death occurs. Respiration usually has a higher optimal temperature, while that of photosynthesis is commonly lower than that of growth. Changes in one part of the plant, say the roots may affect growth of another part of that same plant (e.g., the shoots) even when the temperature of the latter is kept constant. Temperature differences between day and night temperatures are important to many plants. Tomatoes require lower night temperatures than day temperatures to do well. They do best with day temperatures of 26°C and night

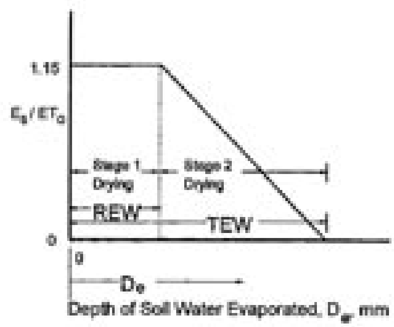
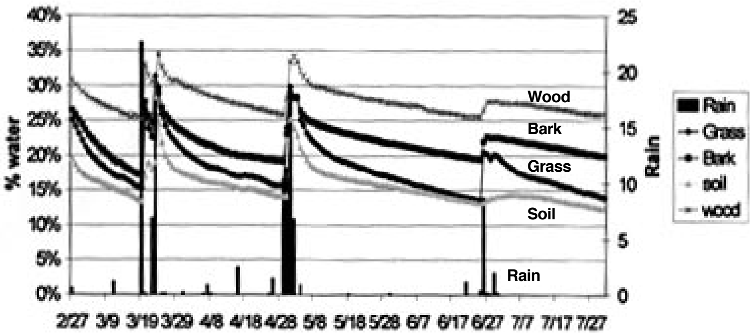


Figure 1. Shows two-stage evaporation during initial stages. Es is surface evaporation, ETo is reference crop evapotranspiration, De Depth of soil Water evaporated, REW is readily evaporable water, TEW is Total evaporable water.



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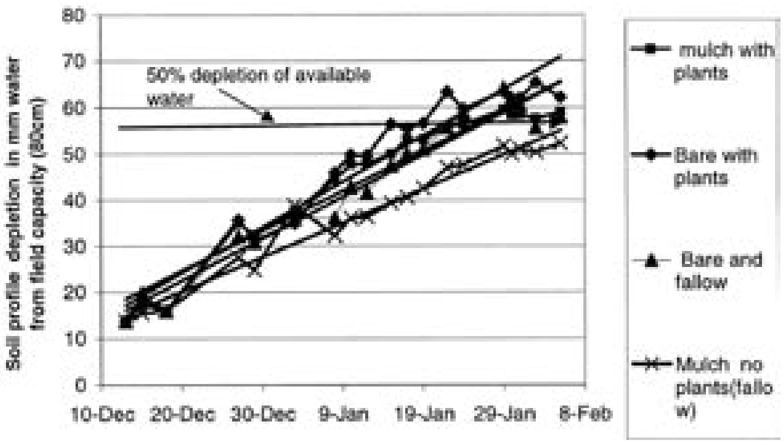

Figure 2. Shows the soil profile (80cm) depletion over December and January 2000. Average ETo for December 4.45 mm day^{-1} January 4 mm day^{-1} ; (ETo) refers to reference crop evaporation.

temperatures of 17°C. Sugar content of some plants is increased with lower night than day temperatures, which lead to improved root growth and will initiate the formation of tubers in potatoes.

Below Ground — Roots and Temperatures. Soil temperature affects many biological, chemical, and physical processes, and management practices such as mulching can have large impacts on soil temperatures. Soil temperature management offers the potential to grow crops that require a temperature regime different from the unmanaged environment. Tindall et al. (1991) found that straw mulches have the potential to improve tomato yields in high temperature environments such as that of the state of Georgia, U.S.A. Soil temperature management can aid in controlling diseases such as aflatoxin development in peanuts. Soil temperatures are also critical in biological and chemical processes that control nutrient cycling.

It is often observed that there is a proliferation of fine roots close to the base of the tree when using mulch. Bryla et al. (2001) reports that the root systems of plants represent a tremendous carbohydrate cost to plants. Although plants require roots for water and nutrient uptake, when more carbohydrates are invested in roots, fewer carbohydrates will be available for shoot growth and yield. As these fine roots are primarily found close to the base of the stem, the tree does not use as much carbohydrates to grow longer roots to obtain its nutrient and moisture. Watson (1988) found that organic mulch reduced the competition by grass. These trees showed increased root hairs and fine roots close to the base of the tree. He also cautioned about the negative effects of a deep mulch layer on the soil environment. This caused tree root growth to become negative as this limited air movement for root respiration. Otsuki et al. (2000) found a direct correlation in root proliferation as well as positive yield when using paper mulch that insulated the soil against temperature and moisture fluctuations, which he describes as creating a more favorable growing environment. It is the unproved opinion of the author that insulation of soil temperature variations might be simulating similar soil conditions of spring and autumn when in nature

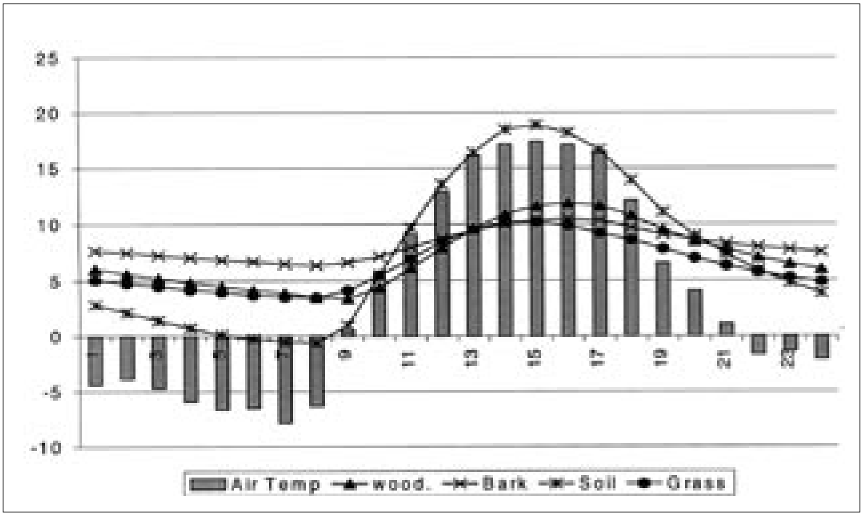

Figure 4. Shows the temperature variation during a cold day with and without mulch on fallow soil, 5 cm deep.

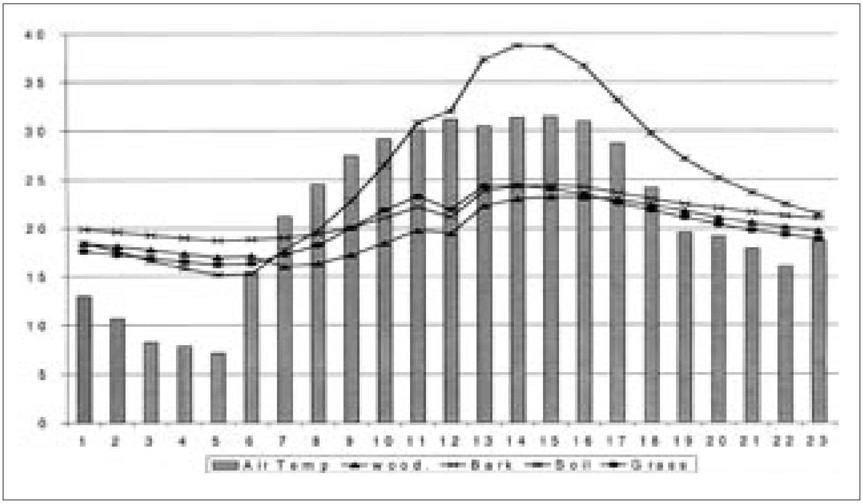

Figure 5. Shows the temperature variation on a hot day with and without mulch on fallow soil, 5 cm deep.

there are not huge and often sudden, temperature fluctuations expected. Spring and autumn are the periods when root proliferation appears to be highest in plants. This has been well observed in ornamentals such as *Hedera helix* (ivy) and documented in mangoes. However the spring and autumn root proliferation might also be a result of the stomatal activity in this period. During this period they do not close as much as in the heat of summer. This opening and closing may effect root growth.

Figures 4 and 5 show the potential differences in temperature variation though one 24-h hot and cold day. Air temperature is represented in the bold blocks, while temperatures under wood chip, bark, grass, and bare-soil lines represent mulches. The mulch depth is 10 cm. Note that soil temperatures below freezing cause root damage in the cell structures.

Above Ground Changes in Temperature. Nonvegetative and vegetative urban landscape surfaces create distinctive microclimates (Kjelgren and Clark, 1992; Whitlow and Bassuk, 1987). A surface receiving solar radiation can disperse energy in different ways: warm the air above it by convection, conduct energy into the soil, convert energy to latent heat during transpiration, or re-radiate energy as long wave radiation. Because of the lack of transpirational cooling, heat convection, and long-wave radiation from nonvegetative surfaces release large amounts of energy into the air (Whitlow and Bassuk, 1987). These factors have been found to increase air temperature and decrease relative humidity in urban areas (Kjelgren and Clark, 1992). Leaves of woody plants placed over nonvegetative surfaces intercept more convected and long-wave energy than plants over a vegetative surface (Whitlow and Bassuk, 1987). Consequently, plants over nonvegetative surfaces have higher leaf temperatures (Whitlow and Bassuk, 1988) and are exposed to greater evaporative demand (high leaf to air vapor pressure difference) than plants over vegetative surfaces (Whitlow and Bassuk, 1987). These plants that grow below the main crop do however compete for water. The positive cooling needs to weigh up against the competition for water.

According to Kjelgren and Clark (1992), "Plant response will depend on species adaptation to foliage heating. We saw reduced growth and gas exchange of a number of broadleaf deciduous trees over fairly large mulched areas due to increased energy loading on the foliage from high long-wave radiation flux. A coniferous species that more effectively dissipates energy through smaller leaves would likely be unaffected. Desert and probably many pioneer species would respond similarly."

Change in Surface Albedo by Changing Surface Colour. Coloured woodchips, stones, and bark are becoming more regularly used in landscaping. These colours could affect plants more than we think. Firstly they will influence the warming of the environment depending on their albedo and secondly they could affect plant responses to the environment. During photosynthesis plants respond to different wavelengths produced by different colours. Plastic mulches have been used to intensify this effect.

- Red suppresses nematodes and increase tomato yield by 12% to 20%. It has the effect of producing more above ground growth rather than root growth. Basil produces bigger leaves grown over red plastic with higher concentrations of aroma compounds than compared to white or blue. Basil grown on yellow or green produces phenolics, some of which are antioxidants. Strawberries over red produce better taste.
- Co-extruded yellow brown increased tomato yield (Northern province South Africa). This cover allows infrared light in and blocks PAR light (photosynthetic active range) in, thereby depriving weeds of the necessary light for growth.
- When comparing clear, black, and white plastic to bare soil, aphids were most numerous on the bare soil and least on the clear plastic.
- Blue produced sharper taste due to higher glucosinolates for turnips compared to green–mulched turnips. While shoots developed longer leaves and smaller roots when compared to white covers
- Yellow plastics attract insects.
- White on black is often used in hot houses and orchids to reflect visible light into canopies. White on black is used with lettuce as it prefers a cool colour to prevent leaf damage.
- Silver on brown, silver on black, and red on brown are other options available to consider.

Soil Improvement. Organic matter added to soil can increase the activity of native mycorrhizal fungi, which provide nutritional benefits to mulched plants. They also protect the trees from stress and even infections from plant pathogens. Westhuizen (1999) notes that soil fertility will probably be judged on microbial activity in the future. Ideally, microbial organisms prefer moist soil with limited temperature fluctuations and organic matter. Mulching thus provides the perfect environment for them.

Soil granulation is observed under mulching. This leads to a stable crumb structure, which rebuilds the soil slowly after cultivation. Cultivation tends to break down crumb structure into a powder. This results in compaction that leads to soil crusting. Soil crusting limits water infiltration and results in higher runoff of water.

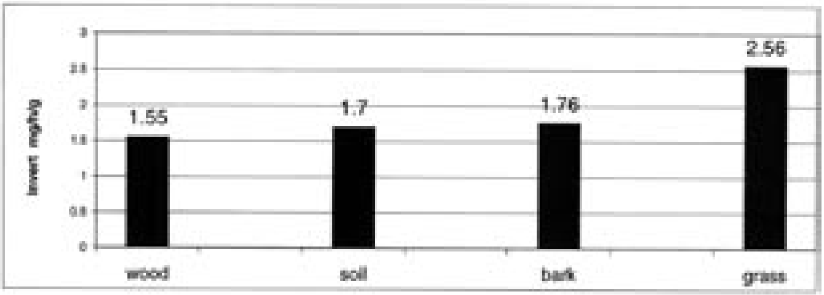

Figure 6. Shows the invert average counts over 30 cm sampled every 15 cm. Three replications for wood chip, bare soil, bark, and grass mulch under a *Spiraea aguta* species were used.

CONCLUSION

In conclusion I believe that mulching has a role to play in controlling the growth of plants and changing our environment. The effects will however be species' specific depending on whether they are hardy or more tropical taxa. Soil types will also influence the amount of water available for evaporation. Mulch thickness influences the efficiency, but a too thick layer will hamper root growth by depriving the roots of air. The greatest benefit obtained from mulch is in newly planted landscapes where plants do not have well established roots and the soil textural differences, between the container soil and the site soil, inhibit soil water movement towards the roots. During this period mulch breaks the water movement to the soil surface and cools the soil, which helps to limit evaporation. Mulch emulates nature's own wisdom.

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Buckawayo Research Project©

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INTRODUCTION

In August 1998 I planted my very first cycad in the ground at Buckawayo. With this very first planting I had assumed a very major responsibility towards the conservation of cycads. My aims with this venture were fourfold:

Firstly the totally hedonistic experience, cycads give me lots of pleasure.

Secondly, the very important job of trying to become involved with the conservation of cycads.

Thirdly this facility would be available for the training of University and Technikon students in the conservation and cultivation of cycads.

Lastly the venture would not succeed if the commercial aspect were not part of the entire conservation ethic.

IN THE BEGINNING

I had to be very aware of the accuracy of seed and seedling sources. This was achieved by careful and thorough purchases. I was able to ascertain in our local journal, *Encephalartos,* that seed collecting trips had been done to certain African states. I contacted the person who led the expedition and from that person I was able to buy many species of local and African cycads. Over the next year I was able to buy about 1000 African cycads. As fate would have it I received a call from a person one day saying that he had decided to emigrate and would I be interested in buying his cycads. Wow!! What a question? Of course I would and somehow I did.

The plants were all duly loaded and transported over a period of 1 month to our