Water Savings and Weed Control with Mulches and Plastics

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It has generally been stated that cover crops and living vegetation use 20 to 30% more water than bare soil. Unqualified, this assertion is very misleading and has influenced poor decisions for some time. It is also misleading (without stating the conditions) to say that mulches save a given amount of water. In assessing the water savings associated with a mulching practice, it is imperative that we consider the types of mulch being utilized and the processes through which water is lost from a system.

Water loss from soil is primarily from two processes: 1) transpiration from the leaves of plants and 2) evaporation from the soil surface. The rates of these processes depend on radiation intensity, temperature (influenced by radiation), and wind and soil surface texture. The presence of a plant canopy, the amount of transpirational surface, and the addition of a mulch to retard evaporative loss greatly affect the rate of soil water loss.

There are four types of mulches that I would like to discuss. The first is the dry mulch. This mulch is formed every time that cultivation, which breaks and roughens the soil surface, is followed by rainfall or irrigation. As the upper portion of the soil surface dries, a boundary layer of dryer air forms above the soil surface. This boundary layer helps to prevent evaporative loss of subsurface soil moisture. Dry mulching is particularly useful in large seeded crops such as beans and corn. The field is preirrigated and the seeds are planted into the moist soil where they can germinate and establish before a second irrigation is needed. A dry mulch can also be created by cultivating dry soil and applying it to the base of corn, beans, cotton, or other crops during the growing season. In addition to preventing water loss, dry mulches also provide excellent annual weed control in many crops.

A second method of mulching involves the use of living mulches or cover crops. Kempen (1991) stated that a cover crop in an orchard uses about 25% more water than an orchard with no weeds. Indeed, resident vegetation (weeds) or an average cover crop may use 25% more water than bare soil. However, water use ranges widely depending on the cover crop selected and the orchard conditions. For example, Pritchard et. al. (1989) found that water use by perennial strawberry clover in a three year old almond orchard was 23% higher than bare soil, while water use by resident vegetation was only 19% higher than bare soil. In the same orchard, consumptive water use by a winter annual cover of Blando bromegrass was equal to that of bare soil. In addition to using water from winter rainfall, the bromegrass died back in spring providing a mulch to reduce evaporation in the summer.

In a mature orchard (9 years old), Pritchard et. al. (1989) found that water use by strawberry clover was only 14 to 23% higher than bare soil. The difference in water use between the young and the mature orchards was probably due to the shading effect of the mature trees. The strawberry clover stand and growth was much weaker in the shaded mature orchard relative to the vigorous growth in the young open orchard. While water use by the Blando bromegrass in the three year old orchard was equal to that of bare ground, the seasonal water use by the bromegrass in the mature orchard was 1 to 4% less than bare soil. Water use associated with chemical mowing of resident vegetation with glyphosate (Roundup) four times a year in the mature orchard was the same as that associated with bare soil. In a similar study in mature almond orchards, Kempen and Gonzales (1991) found no differences in soil moisture between resident vegetation plots which had been flail or chemical mowed and bare ground herbicide treated plots. These results are consistent with the idea that evaporative water loss will decrease as the canopy of an older orchard excludes more light and reduces temperatures. Overall water use, however, should increase due to greater transpirational loss from mature trees.

The third and fourth types of mulch I would like to discuss are landscape mulches. These mulches can be of two types. The first type is organic, and is usually derived from plant by-products such as grass clippings, wood chips, sawdust, bark, newsprint, rice hulls, or straw. Crushed rock or small stones used in the landscape are also considered organic mulches. The second type of landscape mulch is non-organic and includes polyethylene (plastic), polypropylene, or polyester mulches. Some of these materials are woven fabrics and others are nonwoven or spunbound. As a group these materials are referred to as landscape fabrics. Some examples include: Typar Landscape fabric, Duon Landscape fabric, Weed Arrest, DeWitt Weed Barrier, and Earth Blanket to name a few of the many on the market. All of these mulches can be considered barrier-type mulches, since the degree of weed control they provide depends principally on their light blocking properties.

Mulch Effect on Water

Mulches retard water loss by reducing or eliminating evaporation from the soil surface. They also reduce transpirational water loss by preventing weed growth. For example, plots mulched with organic materials such as straw, rice husks, and bark have improved soil moisture retention relative to bare soil plots (Ashworth and Harrison, 1983; Robinson, 1988; Mandal and Gnosh, 1983). However, the degree of water savings depends on soil and mulch properties. For example, Borland (1990) demonstrated that organic mulch that was coarser than soil decreased soil moisture loss, whereas materials that were finer than the soil acted to compact the soil and thus increased moisture loss. Gartner (1978) demonstrated the importance of mulch particle size with regard to water holding ability. He found that finely ground bark (particle sizes < 25 mm) retained more moisture than coarsely ground bark (particle sizes > 75 mm), and that medium ground bark (particle sizes < 50 mm) retained an intermediate amount of moisture.

Several studies show that moisture holding characteristics of organic mulches can vary considerably. Harris (1923) rated straw as the most effective water holding mulch. Hay grass and wood shavings were rated as intermediate, and manure was rated as least effective. Munn (1992) found in the first year of his study that wheat straw or shredded newspaper mulch decreased soil moisture loss in the summer, however in June of the following year there was less soil moisture under the straw than under the paper or in the bare soil. When moisture was measured in September, the bare soil had retained more moisture than the soil mulched with paper. Beyond stating that the mulches did not appear to store moisture from one year to the next, no explanation was given for these variations in soil moisture for the second year.

Non-organic or synthetic materials also vary in their affect on soil moisture. Plastics (clear or black) decreased moisture loss, however they also restricted the movement of water into the soil. Although manufacturer's technical data for the various fabrics show differences in water flow rates, these rates are determined in the laboratory rather than in the field. Appleton et. al. (1990) was able to show that plastic alone decreased the loss of water compared to bare soil, but the loss was not significantly different from that associated with bare soil plus mulch. Soil moisture was no different underneath plastic, plastic plus mulch, or eight different soil coverings.

Whitcomb (1980) reported soil moisture as 1.1% in bare soil plots, 4.4% in bark mulch plots (2 inch deep mulch layer), and 6.5% in plots covered with black plastic plus 2 inches of bark mulch. Moisture was measured after a prolonged dry period in Oklahoma.

Weed Control with Organic Mulches

Mulches which block sunlight from the soil may prevent weed seed germination or prevent weed establishment. Many small seeded annual weeds which do germinate lack adequate seed reserves to emerge through a mulch layer. Perennial weeds are suppressed in the same manner, however their seeds generally have more stored reserves, thus they may grow through or out from under the mulch. Most organic mulch layers are from 5 to 15 cm (2 to 6 inches) deep. Gartner (1978) obtained better weed control with a deep mulch (10 cm) than with a shallow mulch (5 cm) using the same materials. Finely pulverized mulches may be better able to exclude light from the soil than coarser mulches, however blow in weed seeds often establish rapidly in this type of mulch, as it provides an excellent growth medium (Campbell-Lloyd, 1986).

Many different organic materials are used as mulch for weed control. Bark mulches are reported to be more effective than straw mulch (Ashworth and Harrison 1983). Bark not only reduces light but can also release chemicals such as tannins and phenols which may reduce weed growth. Billeaud and Zajicek (1989) found that decorative pinebark nuggets reduced weed numbers when compared to the pinebark mulch and control treatments. There was also trend toward greater weed control with coarser bark. An additional benefit to mulching for weed control is that annual weeds that are growing in the mulch are generally easier to pull than weeds rooted in unmulched soil.

Weed Control with Synthetic Mulches

In the first field study of synthetic mulches Ashworth and Harrison (1983) compared 6 synthetic mulches with 2 organic mulches measuring weed control, moisture conservation, and mulch effect on plant growth. Over a 4 month period, heavy duty green plastic, black polyethylene, and woven black polypropylene provided the best weed control. Shredded hardwood bark 5 cm deep provided slightly less control, and clear polyethylene, straw mulch, and untreated plots showed the poorest weed control.

In greenhouse studies, Derr and Appleton (1990) found that *Digitaria sanquinalis* (large crabgrass) shoots and roots and *Cyperus esculentus* (yellow nutsedge) shoots penetrated six different polypropylene fabrics covered with 2.5 cm of pine bark mulch. While the polypropylene fabrics were penetrated by the weeds, black polyethylene controlled crabgrass when seeds were planted above or below the plastic, and also controlled yellow nutsedge bulbs planted below the plastic.

Martin et. al. (1991), working in flats in the greenhouse, found that growth of the broadleaf species *Cassia obtusifolia* (sicklepod) and *Jacquemontia tamnifolia* (small flower morningglory) was suppressed by five different landscape fabrics. *Amaranthus* sp. (pigweed) growth was suppressed by two of the five fabrics (DeWitt and Geoscape), and partially suppressed by two others (Amoco Rit-a-Weed and Phillips Fibers Duon). Growth of the perennials *Cynodon dactylon* (bermudagrass) and *Sorghum halepense* (johnsongrass) was suppressed more by spun-bound nonwoven fabrics than by meshed nonwoven fabrics. All mulches gave partial control of *Cyperus esculentus*. For all weed species, weed control was rated relative to untreated control plots.

In field studies, Billeaud and Zajicek planted *Cyperus rotundus* (purple nutsedge) and large crabgrass into soil before laying organic mulches at different depths, with or without woven polypropylene fabric (DeWitt Landscape Pro5) beneath the organic mulch. Weed control in the plots with fabric mulch alone was significantly better than in the plots with organic mulch (5 and 10 cm deep) alone, however when a 15 cm deep organic mulch was applied alone it was as effective as the fabric mulch. Applying organic mulch (5, 10, and 15 cm deep) over the fabric mulch provided no better weed control than mulching with fabric alone.

To summarize, the addition of mulch to the soil surface affects both soil moisture and weed control. Depending upon the mulch material, the placement of the material, the depth of mulch, the combination of products used, and the maintenance of the mulch, the degree of water savings and weed control will vary. However, there is no question that an appropriately selected mulch will increase soil moisture and inhibit weed growth.

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