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Research Article

The Role of Mulching on Soil Characteristics

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ABSTRACT

Mulching is the process of covering the soil surface around the plants with an organic or synthetic material to create congenial condition for the plant growth, development and efficient production. Mulch is any material applied to the soil surface for protection or improvement of the covered area. Organic mulches have the advantage of being biodegradable, but decomposition may result in a temporary reduction in soil mineral nitrogen. In addition, the natural phytotoxins released when organic materials decompose may not only inhibit the growing of weeds but also the crop plants. mulch to regulate the temperature of soil by reducing the daily range and creating a more constant temperature suitable for root activity. The ability of organic mulches to regulate the soil temperature is closely correlated with its ability to reduce evaporative water loss.

Key words: Soil temperature, Soil micro-flora, Soil water, Infiltration rate

INTRODUCTION

Definition of mulch

Any material used (spread) at surface or vertically in soil to assist soil and water conservation and soil productivity is called mulch. Mulching is the process of covering the soil surface around the plants with an organic or synthetic material to create congenial condition for the plant growth, development and efficient production. Mulch is any material applied to the soil surface for protection or improvement of the covered area. Mulch is a protective layer of either organic or inorganic material that is spread on the topsoil and is divide into two categories based on type of mulch used that is, organic mulch and inorganic mulch. The word mulch has been probably derived from the German word "molsch" means soft to decay, which apparently referred to the use of straw and leaves by gardeners as a spread over the ground as mulch. Rowe-Dutton and Patricia (1957) defined mulching as an application of layer of covering material on the soil surface. As quoted by Bhavani (1960), mulching appears to be a very ancient Chinese practice employed to conserve the scanty supply of moisture available for growing melons. The practice of applying mulches to soil is possibly as old as agriculture itself. Mulches are used for various reasons but water conservation and erosion control are the most important objective for it"s use in agriculture in dry regions. Other reason for high mulching use includes soil temperature modification, soil conservation, nutrient addition, improvement in soil structure, weed control and crop quality control ((Murugan and Gopinath, 2001). Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds Mulches are either organic or inorganic. Organic mulches are those derived from plant and animal materials. Those most frequently used include plant residues such as straw, hay, peanut hulls, leaf mold and compost, wood products such as sawdust, wood chips and shavings and animal manures. Organic mulch properly utilized can perform all the benefits of any mulch with the possible exception of early season soil warming. However, natural mulch materials are often not available in adequate quantities for commercial operations or must be transported to the place of use (Murugan and Gopinath, 2001).

Living mulch

Living mulch technology is a form of reduced tillage. Organic matter conservation under living mulch may result from a combination of increased residue inputs and reduced stimulation of decomposition from tillage. Microbial decomposition decreases as the soil temperature

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decreases within the range normally found under field conditions. Living mulches, like sods in general, lower mean growing season soil temperatures (Bennet *et al.,* 1976; Newhouse and Dana, 1989). Living mulch studies that have measured soil organic matter changes generally confirm earlier green manure research. Organic matter losses may be minimized and, in rare cases where initial levels are very low, there may be an increase. Welker and Glenn (1988) found that organic matter levels were maintained but not increased after three years under a mowed tall fescue living mulch in peach orchards in West Virginia. Bare soil treatments, whether achieved by cultivation or herbicides, dropped from 2.4% to 2.1%. Akobundu (1984) found that a living legume mulch of Psophocarpus palustris Desv. dramatically reduced organic matter losses after two years of corn production in Nigeria. Initial levels were reduced 32% and 8% under conventional tillage and living mulch, respectively. Lanini *et al*. (1989) measured organic matter changes under subterranean clover living mulch in sweet corn and lettuce at Riverside, California. Initial levels of 0.78% rose marginally to 0.86% under sub clover and dropped significantly to 0.66% under clean cultivation.

Polyethylene mulch

Now a day application of black plastic mulch film is becoming popular and very good results have been achieved particularly in rainfed agriculture. Use of polyethylene mulch has been reported to conserve soil moisture appreciably. Hence, under prevailing drought and water scarcity conditions, conservation of soil moisture and to ensure availability of soil moisture to crop is of much importance.

The black polyethylene mulch also checks all types of weeds in addition to soil moisture conservation, therefore, black plastic mulch is more beneficial. Plastic mulches have various beneficial effects on crop product in arid regions, including an increase in soil temperature the conservation of soil moisture, texture and fertility and the control of weeds, pests and diseases. The beneficial effects of organic and synthetic mulches for crop production have been widely discussed by Ravi and Lourduraj (1996).

Soil temperature

Gur *et al.* (1972) stated that the optimum root growth temperature for several apple rootstocks seems to be near 25°C. Furthermore, they reported that increased supra optimal root temperatures of 35°C caused anaerobic respiration in the roots, with the formation of acetaldehyde and ethanol due to lack of oxygen supply.

These products are transported upwards in the tree and cause damage to the leaves. Symptoms in the leaf can be detected by a decrease in chlorophyll content and the formation of intervenous necrosis. These supra-optimal root temperatures are also responsible for a decrease in the production of cytokinin in the roots. In summer, upper soil temperatures can be very high. This will have an effect on the activity of the roots and even kill some finer roots (Trisdal, 1989). Pinamonti *et al*. (1995) found a compost mulch to regulate the temperature of soil by reducing the daily range and creating a more constant temperature suitable for root activity. The ability of organic mulches to regulate the soil temperature is closely correlated with its ability to reduce evaporative water loss (Othieno, 1971). The combined effects of water availability and temperature regulation will increase the effective utilization of the soil surface layers for mineral uptake (Othieno, 1971; Trisdal, 1989). Mathews *et al*. (2002) reported that a synthetic mulch controlled evaporative water loss as effective as organic mulches, but it lacked some of the other benefits organic material in the soil. According to Glover *et al*. (2000), addition of organic material with mulching together with the effect of water availability in the soil will influence the soil biological aspects such as, nutrient cycling and mineralization rates which could further increase crop performance (Wooldridge, 1992).

Fig.1: Plastic mulches are completely impermeable; they therefore prevent direct soil evaporation and limit water losses and erosion via the soil surface.

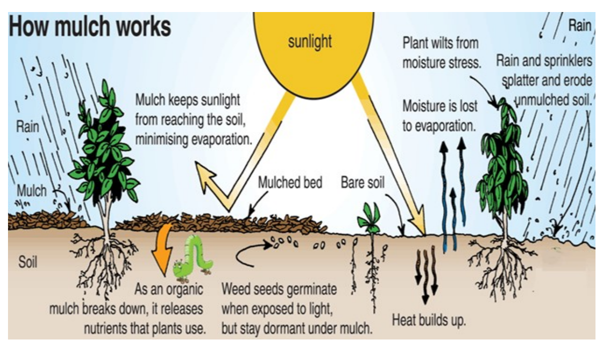

Fig. 2: Influence of mulch

Fig. 3: During summer months, they keep soil cool by blocking direct sunlight exposure of the soil surface.

Stimulate soil micro-flora

Mulching stimulates soil micro-organisms such as algae, mosses, fungi, bacteria, actinomycetes and other organisms like earth worms etc., owing to loose, well aerated soil conditions, uniform moisture and temperatures thus resulting in a more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth. Under the mulch layer earth worms proliferate and help to improve the soil aggregate stability and infiltration etc. The variation in the microbial load of the different organic mulches on bacterial population could be due to their different chemical composition and their decomposition rates (Mukherjee *et al*., 1991; Wu *et al*., 1993). The higher moisture of soil profile under mulch has important implications on the utilization of water by crop and on soil reactions that control the availability of nutrients and biological nitrogen fixation (Surya *et al*., 2000). Brown *et al*. (2001) mentioned that mulching practices gave positive effect on the soil biota. An important role of mulch is to support existence of most species of soil macro invertebrates. Soil biota increases under mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years (Holland, 2004). Organic mulching technology support diversity of beneficial soil macro invertebrates. Crop residue mulch supplied a lot of food for soil macro invertebrates and nutrient to ensure the vegetation growth and created suitable environment for soil macro invertebrates (Sugiyarto *et al*., 2009).

Organic mulches

Organic mulches have the advantage of being biodegradable, but decomposition may result in a temporary reduction in soil mineral nitrogen. In addition, the natural phytotoxins released when organic materials decompose may not only inhibit the growing of weeds but also the crop plants (Walace, 1992). Black polyethylene mulches are used for weed control in a range of crops under the organic system of crop production. The use of black polypropylene woven mulch is usually restricted to perennial crops. Various colours of woven and solid film plastics have been tested for weed control in the field (Horovilz, 1993). There are additionalenvironmental benefits if the mulch is made from recycled materials (Cooke, 1996). Murugan and Gopinath (2001) verified the efficacy of organic mulches (dried leaves, coconut fronds and coir pith) and inorganic mulches (black polyethylene 25, 50 and 100 μ) on growth of "Saundrya‟ cv of crossandra at Bangalore. The growth attributes were significantly influenced by organic and inorganic mulches. The black polyethylene mulch was found to be superior to other mulches. Likewise, different cultivars of carnation in poly house significantly improved plant height, number of branches, flower size and yield with the application of black polyethylene mulch (Arora *et al*., 2002).

Reduced fertilizer leaching

As excessive rainfall is shed from the root zone, fertilizer loss due to leaching is reduced. This is particularly true in sandy soils. This allows the grower to place more pre plant fertilizer in the row prior to planting the crop. Patil and Singh (1983) observed that application of sunflower stover mulch 20 t/ha in hot and dry season significantly increased the N, P and K uptake over no mulch. In okra, the highest uptake of N, P and K was observed in sugarcane trash mulched plots over unmulched. Borthakur and Bhattacharya (1992) reported that the influence of mulches on soil pH was found to be highest in water hyacinth and paddy husk mulch (5.56 pH) and lowest in no mulch (4.98). Mulching with coconut fronds increased leaf N, P and K content in chilli. Vos and Sumarni (1997) indicated faster plant growth, early fruiting, reduced P concentration and increased N concentration in leaves and fruits and also increased fruit weight and yield of hot pepper with straw mulching compared to control. Further, they reported that rice straw mulch increased K- content and decreased P-concentration in leaves of bell pepper over no-mulch. Hundal *et al.* (2000) reported that concentration of nitrogen and phosphorus and nutrient uptake was significantly higher in mulched plots over unmulched plots in tomato. According to Worthington (2001), an increase in available nitrogen contents stimulates protein production, in cabbage following serradella and vetch mulches which, living in symbiosis with nitrogen-fixing bacteria, are additional sources of available nitrogen. Tolk *et al*. (1999) and Liu *et al*. (2002) concluded that mulch increases soil moisture and nutrients availability to plant roots, in turn, leading to higher grain yield. Mulch protects the surface of the soil against unfavourable factors, reduces nutrient leaching and improves growing conditions for vegetables.

Soil water

A major factor in apple quality is fruit size. Since, fruit size is greatly influenced by water deficit, it is recommended that water supply be optimized to enhance the number of large fruit (Naor *et al*., 1997). On soils where herbicides are used to control the weeds, a crust may form on the bare surface. This crust may cause low infiltration of water and high runoff rates. When these bare soils are on a slope, runoff can cause erosion (Trisdal, 1989). Organic mulches can reduce the impact of raindrops on surface sealing and thereby increase the infiltration tempo. This way erosion is reduced by the increased water infiltration rate and the decrease in runoff velocity (Smets *et al*., 2008). In frequently tilled soils, initial water infiltration is high in the loose soil. Thereafter, it is restricted by the subsoil with small pores. Further infiltration rates will then be controlled by the subsoil. Crusts tend to form in the subsoil when upper soils are tilled extensively. This will restrict penetration by water and roots (Trisdal, 1989). In contrast, simple mulches such as straw has shown to increase soil aggregate stability, which improved the soil permeability for water penetration and aeration to the deeper layers (Pinamonti *et al*., 1995). Organic mulches, such as straw, have further shown to increase the amount of available water in the soil (Trisdal, 1989), by reducing evaporation from the soil surface (Pinamonti *et al.,* 1995). This will reduce moisture stress between irrigations and can even increase irrigation intervals (Baxter, 1970). In addition, the availability of water in the surface layers, which are prone to drought conditions, would enable root to utilize this area and effectively increase the root zone (Trisdal, 1989; Pinamonti *et al*., 1995).

Fig. 4: Adding mulch around veggies such as tomatoes will help keep the soil moist longer

Reduced infiltration rate

The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater and evaporation. Mulch cover reduces surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil (Khurshid *et al.*, 2006). Abu-Awwad (1999) showed that covering of soil surface reduced the amount of irrigation water required by the pepper and the onion crop by about 14 to 29 and 70 per cent respectively. Trials conducted in the higher potential areas of Zimbabwe indicated that mulching significantly reduced surface runoff and infiltration (Erenstein, 2002).

MATERIALS AND METHODS

This article is review and the aims of the role of mulching on soil characteristics. The experiment 1 was conducted by Bert and Schutzki (2009). The study was installed in Aug. 2004 at the Michigan State University Teaching and Research Center near East Lansing, MI. The study area is flat and the soils are a Capac loam (fine-loamy, mixed, active, mesic Aquic Glossudalfs). The area had not been in crop production for the past 3 years and the existing vegetation was primarily perennial grasses that were mowed periodically. We prepared 24 3.7 m · 3.7-m (12-ft · 12-ft) plots by trenching around each plot to a depth of 0.9 m (3 ft) and lining the perimeter of the plots with heavy (6-mm thick) black plastic (Bert and Schutzki, 2009). Vegetation in the plots was sprayed with glyphosate and then rototilled _1 month before installation of the experiment. We planted 10 shrubs from eight taxa in each plot. Taxa used were burning bush (Euonymus alatus 'Compactus'), 'Goldflame' spirea (Spiraea ·bumalda 'Goldflame'), 'Java red' weigela (Weigela florida 'Java red'), 'Runyan' yew (Taxus ·media 'Runyan'), 'Golden globe' arborvitae (Thuja occidentalis 'Golden Globe'), Tardiva hydrangea (Hydrangea paniculata 'Tardiva'), Chicago Lustre_ arrowwood viburnum (Viburnum dentatum 'Synnestvedt'), and cranberry bush viburnum (Viburnum trilobum 'Compactum') (Bert and Schutzki, 2009). One shrub of each taxa was planted in each plot except for 'Golden Globe' arborvitae and 'Runyan' yew, which were represented by two plants per plot as a result of greater availability. All plants were donated from a local wholesale nursery and grown in No. 3 (10.5-L) containers. Some plants exhibited circling roots, which were teased apart and separated by hand before planting. Root systems were not sliced or ''butterflied.'' After planting, we mulched plots to an uncompact depth of 8 cm with one of four organic mulches: ground red pine bark, ground recycled pallets, hardwood bark fines, or ground cypress mulch (Table 1) (Bert and Schutzki, 2009). Two additional plots in each replication were not mulched; one plot served as an unmulched control and the other was maintained weed free by hand-weeding and directed sprays of glyphosate (Bert and Schutzki, 2009). The study was installed as a split plot in a randomized complete block with four blocks. Mulch was applied as the main plot factor and shrub taxa was considered the subplot factor. Blocks were arranged to account for potential variation in soil across the field. All plots were irrigated weekly in August and early Sept. 2004 to aid in initial plant establishment. Survival of all plants at the initiation of measurements in Spring 2005 was 100%. No fertilization was added during the study and no additional mulch was added after plot installation, i.e., plots were not ''top-dressed (Bert and Schutzki, 2009). We measured plant height (h) and crown width in two directions (w1 and w2) on each shrub at the beginning and end of the 2005, 2006, and 2007 growing seasons. Crown volume index (V) was calculated as $V = h \cdot w1 \cdot w2$. Rainfall and reference evapotranspiation (ETo) for the site was compiled from the Michigan Automated Weather Network weather station located _600 m from the study. Reference evapotranspiration was estimated by the FAO Penment-Montheith calculation. We measured soil moisture every 7 to 14 d on each plot through the 2005 and 2006 growing seasons using a portable TDR system (TRASE; Soil Moisture Equipment, Inc., Santa Barbara, CA). Soil moisture was measured at 0 to 15 cm and 0 to 45 cm below the soil surface near the center of each plot. Photosynthetic gas exchange and stomatal conductance (gS) to water vapor were measured on Hydrangea paniculata, Viburnum dentatum, and Viburnum trilobum plants on two dates in 2006 and two dates in 2007 using a portable photosynthesis system (LI-6400; LI-COR, Inc., Lincoln, NE). Hydrangea and the two Viburnum species were selected for gas exchange measurements because they have relatively large leaves that completely covered the 2 · 3-cm leaf chamber of the portable photosynthesis system. This approach simplified gas exchange measurements and eliminated the need to correct.

The experiment 2 was conducted by Singh and Kamal (2012). The present experiment was carried out at the farm of Krishi Vigyan Kendra in Jakhdhar, Rudraprayag (an altitude of 1718 m and Northern latitude of 30°19'), during three summers seasons of 2006, 2007 and 2008. High yielding indeterminate tomato hybrid, that is, Naveen 2000^{+} was planted and 100 µm thick black recycled. Low Density Polyethylene (LDPE) sheet was used for mulch in this experiment. After preparing the field, the raised beds, measuring 5 × 1.8 × 0.15 m were arranged in a Randomized Complete Block Design (RCBD) with ten replications. Full doses of Farmyard Manure (FYM) at 250 quintal/hectare (q/ha) and 50 kg N/ha, 60 kg P/ha and 60 kg K/ha were applied before laying the black plastic mulch on the bed. Each. plot had three rows with ten tomato plants (30 plants). Seedlings of 4 leaf stage were planted using 60 × 50 cm plant spacing.

Then 10 kg of N/ha were applied as foliar spray by dividing it into two equal parts during the plant growth (Singh and Kamal, 2012). Soil temperature was measured throughout the plant growth period using mercury-in-glass geothermometers in one plot of each mulching treatment. Geothermometers were buried at 10 cm depths in the mulched plots within rows of tomato plants. Daily soil temperature measurements were taken at 11: 00 am local standard time. Crop yield was determined on the basis of area per plot and converted into quintals (100 kg/ha) (Singh and Kamal, 2012).

RESULTS AND DISCUSSION

In the experiment 1 was conducted by Bert and Schutzki (2009).The results showed that Weather patterns varied among the 3 years of the study. Year 2005 was the driest year during the study. Over the 2005 growing season, reference potential evapotranspiration exceeded rainfall by 341 mm. Reference ET exceeded rainfall in 18 of 23 weeks between 1 Apr. and 15 Sept. 2005. A late-season dry spell was noteworthy because only 19 mm of rain fell during a 7- week span from late July to mid-September. Rainfall was more consistent in 2006 than in 2005 and the rainfall deficit (–112 mm) was the smallest of the 3 study years (Bert and Schutzki, 2009). Year 2007 was intermediate between 2005 and 2006 in terms of total rainfall and rainfall deficit. A 7- week dry period occurred from early July until mid-Aug. 2007 during which only 31 mm of rain fed. Mulching increased ($P < 0.05$) soil moisture compared with no mulch + weed control at 0 to 15 cm and 0 to 45 cm in 2005 and 2006 (Table 1).

There was no difference in soil moisture among mulches in either year at either depth. At 0- to 15-cm depth, soil moisture was slightly, but not significantly, lower in no mulch + weed control than without weed control. At 0 to 45 cm, soil moisture in the no weed control plot was greater than no mulch + weed control. Also, soil moisture increased without weed control in 2006 compared with 2005. Seasonal patterns of soil moisture without mulch + weed control and without weed control closely followed rainfall in 2005. Soil moisture peaked after heavy rainfall in late June and late July and then declined. Soil moisture reached the lowest levels during the dry-down period in August and early Sept. 2005. In 2006, rainfall was more consistent than in 2005 and soil moisture was generally higher and treatment effects were less pronounced at the 0- to 15- cm depth (Bert and Schutzki, 2009). For the entire study, there were no differences in soil moisture among any of the mulches on any of the 27 measurements dates at either 0- to 15-cm or 0- to 45-cm soil depth. Soil pH. Soil pH did not vary

Table 1: Mean (± SE) volumetric soil moisture at 0- to 15-cm and 0- to 45-cm depth under mulches and without mulch, Michigan State University Mulch Study, 2005–2006 (Bert and Schutzki 2009).

Depth: 0 to 15 cm	Volumetric soil moisture (%)			
Treatment	2005		2006	
No mulch + no weed control	18.74z a	(1.11)	22.96 ab	(1.52)
No mulch + weed control	16.81a	(1.11)	18.65 a	(1.56)
Cypress mulch	26.90 b	(1.15)	24.59 ab	(1.47)
Recycled pallets	24.72 b	(1.11)	21.38 ab	(1.49)
Hardwood fines	26.73 b	(1.12)	25.70 b	(1.47)
Pine bark	25.70 b	(1.11)	25.74 b	(1.44)
Depth: 0 to 45 cm	Volumetric soil moisture (%)			
Treatment	2005		2006	
No mulch + no weed control	22.27 b	(1.05)	26.65 b	(0.94)
No mulch + weed control	16.15 a	(1.04)	17.00 a	(0.95)
Cypress mulch	25.82 b	(1.05)	26.86 b	(0.91)
Recycled pallets	24.64 b	(1.03)	24.71 b	(0.92)
Hardwood fines	26.47 b	(1.03)	26.86 b	(0.91)
Pine bark	23.61 b	(1.04)	25.26 b	(0.88)

zMeans followed by the same letter are not different at the $P < 0.05$ level. Mean separation by Tukey's Studentized range test.

Table 2: Mean weed counts in plots with organic mulches or unmulched with and without weed control, Michigan State University Horticulture Teaching and Research, East Lansing, MI, Sept. 2006 (Bert and Schutzki 2009)

	Weed count/m2					
Weed	No mulch + no weed control	No mulch + weed control	Cypress	Pallet	Hard-wood	Pine-bark
Common dandelion (Taraxacum officinale Webber in Wiggers)	16.1za	0.0 b	2.9 b	2.2 b	4.9 b	0.7 b
Annual grasses	15.9 a	0.0 b	1.3 b	1.7 b	5.8 b	0.7 b
Annual sowthistle (Sonchus oleraceus L.)	0.8 c	0.0 c	4.6 ab	5.6 a	7.5 a	1.6 bc
Redroot pigweed (Amaranthus retroflexus L.)	1.6 a	0.0 b	0.6 b	0.2 b	0.1 b	0.4 b
Yellow nutsedge (Cyperus esculentus L.)	0.0 a	0.0 a	0.8 a	0.0 a	0.2 a	2.0 a
Common ragweed (Ambrosia artemisifolia L.)	1.6 a	0.0 a	0.1 a	0.0 a	0.2 a	0.0 a
Common lambsquarters (Chenopodium album L.)	1.3 a	0.0 a	0.1 a	0.6 a	0.2 a	0.3 a
Wild carrot (Daucus carota L.)	1.3 a	0.0 a	0.1 a	0.1 a	0.2 a	0.0 a
Horseweed [Conyza canadensis (L.) Cronq.]	1.0 a	0.0 b	0.0 b	0.0 b	0.1 b	0.0 b
Buckhorn plantain (Plantago lanceolata L.)	0.0 a	0.0 a	0.8 a	0.0 a	0.0 a	0.1 a
Others	1. 1.1 a	0.0 a	a 0.2 a	0.3 a	0.6 a	1.1 a

zMeans within a row followed by the same letter are not different at the $P < 0.05$ level. Mean separation according to Fisher's protected least significant difference test.

Table 3: Effect of black plastic mulch on soil temperature

Month	Soil temperature (°C) at 10 cm depth					
May	31.4	34.1	30.9	33.8	31.9	34.4
June	31.1	33.7	30.8	33.2	31.7	33.9
July	30.8	33.4	30.1	32.3	29.8	32.2
August	29.4	32.8	28.9	31.8	29.1	31.8
September	28.3	31.2	27.8	30.4	28.8	31.4

Average of monthly soil temperature taken in °C.

(P>0.05) among the treatments (data not shown). Mean pH of all treatments ranged from neutral to slightly acidic. Weed control. Mulches were effective in reducing many of the most common weeds in the study area (Table 2).

Populations of common dandelion, annual grasses, redroot pigweed, and horseweed were lower ($P < 0.05$) on mulched plots than plots with no weed control. Populations of annual sowthistle, however, were greater ($P < 0.05$) on plots mulched with cypress, ground pallets, or hardwood fines than the no weed control plots. This suggests that the mulch itself may have provided an adequate seedbed for germination and development of sowthistle or that the mulch depth was insufficient to provide adequate control. The results of this study support the preponderance of data in the literature, which show that organic mulches improve growth of landscape plants by controlling weeds and conserving soil moisture (Bert and Schutzki 2009). There were, however, several key observations that departed from commonly observed trends or perceptions regarding the effects of mulch on the landscape environment and growth of landscape plants. Subsequently, we discuss some of these key observations. Improved soil moisture on no weed control plots compared with no mulch + weed control. Our a priori hypothesis was that, among all treatments, soil moisture would be lowest without weed control and next lowest on no mulch + weed control plots based on the assumption that total evapotranspiration from soil would be greater with weeds than without. Counter to our hypothesis, soil moisture was greater without weed control than with weed control (Bert and Schutzki, 2009). We speculate that the increase in soil moisture without weed control is the result of several factors. First, weed populations were dense enough by Summer 2005 to shade a large portion of the soil surface, presumably reducing soil temperature and subsequent evaporation. Second, as annual weeds died, they effectively formed a mulch layer, which functioned similar to the organic mulches, at least in terms of soil moisture retention (Bert and Schutzki, 2009).

In the experiment 2 was conducted by Singh and Kamal (2012). The results showed that soil Temperature and yield of tomato was significantly improved with mulching over control. The highest soil temperature occurred under black polyethylene which was 2.2 to 3.4°C more than the bare soil (Table 3).

In general, this effect was more evident during the early crop season when tomato plants shaded less soil surface. Black plastic mulches are more effective in increasing soil temperature due to a greater net radiation under the mulch compared to bare soil. The yields from plants grown on bare soil were significantly lower than those from plants grown with black plastic mulch. The yield increase in black plastic mulch was 21.7 to 29.8% as compared to bare soil. The difference in tomato yield in the present study appears to be related to the differences in far-red/red (FR/R) ratios received by the plants. In previous investi-gations, modifications in plant growth patterns by very subtle changes in FR/R ratios have been documented in the field (Singh and Kamal, 2012).

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