EFFECT OF PLASTIC MULCH ON SOIL PROPERTIES AND CROP GROWTH - A REVIEW

M. Lalitha. V. Kasthuri Thilagam, N. Balakrishnan and Mostafa Mansour

Dept. of Soil Science and Agricultural Chemistry,
Tamil Nadu Agric. University, Coimbatore - 641 003, India.

ABSTRACT

The term plasticulture is defined as the use of plastics in agriculture. The use of plasticulture in the production of crops helps to mitigate the extreme fluctuations in weather, especially temperature, rainfall and wind. Indian agriculture is known for its multi-functionalities of providing employment, livelihood, food, nutritional and ecological securities. So the adoption of modern technology to overcome natural constraints to successful agriculture with limited water resources is essential. In this context, mulching may prove beneficial for crop growth because of complex change in soil environment through modifying soil temperature, reduction in evaporation, weed competition, soil compaction and erosion. Plastic mulch is a product used, in a similar fashion to mulch, to suppress weeds and conserve water in crop production. Under plastic mulch, soil properties like soil temperature, moisture content, bulk density, aggregate stability and nutrient availability have been improved. Plant growth and yield also positively influenced by the plastic mulch due to the modification of soil microclimate.

Key words: Mulch, Plastic mulch, Soil properties, Crop growth.

Plastic mulch is a product used in a similar fashion to mulch, to suppress weeds and conserve water in crop production. Certain plastic mulches also act as a barrier to keep methyl bromide, both a powerful fumigant and ozone depleter, in the soil. In plastic mulching crops grow through slits or holes in thin plastic sheeting. Plastic mulch is also used in conjunction with drip irrigation to increase WUE. Nowadays use of plastic mulch becomes standard practice for all vegetable farmers. Polyethylene film was first used as mulch in the late 1950’s in USA for high value crops (Emmert 1957, Schales and Sheldrake 1965, Waggoner et al., 1960). It conserves moisture efficiently because water that evaporates from the soil under the plastic film condenses on the lower surface of the film and falls back to the soil as droplets. It accelerates plant growth by increasing the soil temperature and stabilizing soil moisture. Plastic mulches directly affect the microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss (Liakatas et al., 1986). The colour of plastic-film mulch largely determines its energy-radiating behavior and its influence on the microclimate around a plant (Lamont, 1999). Soil temperature under plastic mulch depend on the thermal properties i.e. reflectivity, absorptivity or conductivity of a particular material in relation to incoming solar radiation (Schales and Sheldrake, 1963).

Black plastic mulch: Black plastic mulch is the predominate color used in plant production is an opaque blackbody absorber and radiator. Black mulch absorbs most UV, visible, and infrared wavelengths of incoming solar radiation and re-radiates absorbed energy in the form of thermal radiation or long-wavelength infrared radiation. Soil temperatures under black plastic mulch during the daytime are generally 5° F higher.
at a 2-inch depth and 3° F higher at a 4-inch depth compared to those that of bare soil (Lamont, 1999). The efficiency with which black mulch increases soil temperature can be improved by optimizing the condition for transferring heat from the mulch to the soil (Aniekwe et al., 2004).

**Clear plastic mulch:** Clear plastic mulch absorbs little solar radiation but transmits 85% to 95% of incoming solar radiation. The under surface of clear plastic mulch usually is covered with condensed water droplets and this water is transparent to incoming shortwave radiation but is opaque to outgoing long wave infrared radiation; so much of the heat is retained by clear plastic mulch (Coleman, 1995). Thus, daytime soil temperatures are generally 8 to 14°F higher at a 2-inch depth and 6 to 9°F higher at a 4-inch depth compared to those of bare soil (Lamont, 1999).

**IRT mulch:** Infra Red Transmitting (IRT) mulch is a recent development in plastic mulching. These plastics transmit the warming wavelengths of the sun, but not those that allow weeds to grow. These materials result in warmer soils than black plastic, but cooler soils than clear plastics. IRT mulches are very useful to retard the growth of weeds including nutsedge (Lamont, 1999).

**Red mulches:** It is the first new color mulch to be investigated, and have started to be used commercially. Results from different trials indicated that red mulch might also be reducing the severity of early blight on tomatoes (Lamont, 1999).

**Photodegradable mulch:** Photodegradable film has much the same qualities as other black or clear plastic film, but is formulated to break down after a certain number of days of exposure to sunlight.

**Biodegradable mulches**

Biodegradable plastics are made with starches from plants such as corn, wheat, and potatoes. They are broken down by microbes. Biodegradable mulch on tomato and pepper crops have shown it performs just as well as polyethylene film, and it can simply be plowed into the ground after harvest (Rangarajan et al., 2003).

**Soil temperature**

Soil temperature under plastic film is usually high and also it is based on the color of the plastic mulches. The black plastic-film mulched plots had significantly lower soil temperature (1 to 2.8°C) than the clear plastic-film mulched plots. Because much of the solar energy absorbed by black plastic-film mulch is lost to the atmosphere through radiation and forced convection (Schales and Sheldrake, 1963). Anikwe et al., 2007 observed that the unmulched plots had the lowest soil temperature (about 1-3.8°C lower) at different times since planting compared to plastic film mulched plots. Among different mulching techniques plastic film mulching increases soil surface temperature by influencing the heat balance and thus increased the soil temperature and it also positively influenced the crop emergence (Aniekwe et al., 2004).

**Soil water content**

The black polyethylene mulch maintained high soil water contents compared to the control (no mulch) and the bare soil treatments (Li et al., 2001). Improvement of the water use efficiency by better utilization of soil water appears to be the best way to increase grain yield in the semiarid areas (Zhao et al., 1995). The main ways of increasing the water use efficiency include reducing soil water evaporation, and exploiting deep soil water so as to support shoot biomass accumulation and optimize the dry matter allocation by selectively increasing the reproduction (Li et al., 1997, 2000; Li and Zhao, 1997). The plastic film mulch was promoted root growth and that more roots were distributed in mid- and deep-soil, so that the plant can uptake water from the deep soil and increase the grain yield (Kwabiah, 2004).
Bulk density

Under plastic mulch system soils are loose, friable and well aerated and also roots have ease access to adequate oxygen promotes high microbial activity (Van der et al., 2006). Research results indicated that there is no significant differences in soil dry bulk density were found between plastic mulched (1.40) and unmulched plots (1.43), so the practice of plastic mulching did not cause soil compactness.

Aggregate stability

The aggregate stability index under plastic film mulched plot was higher (0.72) compared to the control (0.48) (Van der et al., 2006). It is mainly due to high OC content by the increased addition of crop biomass and root exudates from plant roots. And also under plastic mulch system there is less impact of rainfall on the breakdown of soil aggregates.

Nutrient availability

The decomposition of organic residues under plastic mulch adds organic acids to the soil resulting in low soil pH, which may increases the bioavailability of micronutrients (Mn, Zn, Cu, and Fe). This was also evident from the increased Fe and Zn content in soil under plastic mulch (Tisdale et al., 1990). The mineral N content (NO₃ and NH₄⁺) in soil is high due to mineralization of organic N with time, thereby; it increases the availability of soil nitrogen. Breakdown of organic material release soluble nutrients like NO₃, NH₄⁺, Ca²⁺, Mg²⁺, K⁺ and fulvic acid to the soil intern increases the soil nutrient availability under plastic mulch.

Prevention of nitrate leaching

When high N mineralization associated with high rainfall or high amount of irrigation water the mineral N will be leached to deep soil profile. It will create two problems one is N loss another one is ground water pollution. Plastic mulch will reduce the nitrate leaching by the way of reducing the excess rainfall percolating into the soil and also by the increased plant biomass under plastic mulch system will uptake the N for its growth will reduce the nitrate loss (Romic et al., 2003). The practice of drip irrigation along with plastic mulch also offers the potential to increase water and N use efficiency and also assists in weed control (Vazquez et al., 2006).

Crop growth parameters

Plastic mulch induces the early crop emergence, so that it increased the biomass production at early stages of the crop growth. Li et al., (1999) reported that plastic film mulching leads to earlier seedling emergence and earlier spike differentiation, which help to develop more spikelets and more grains per spike in wheat. The improvement in soil moisture and topsoil temperature under plastic mulch hastened seedling emergence by 8 days on average in wheat. Plants in mulching treatments entered the maturation phase sooner and their maturation period was longer. This change is favorable to partition assimilate that is stored in vegetative organs, thus facilitating development of the reproductive organs of wheat plants. It increases the duration of reproductive period so the yield will be maximized (Li, et al., 2004). Different plastic mulch techniques have been used to enhance emergence, growth and maturity of many vegetable crops including tomato and cucumber (Wolfe et al., 1989), Chinese cabbage and beet (Gimenez et al., 2002). Hu et al., (1995) also reported increased crop growth (3.2-4.0 cm), dry root mass (12.2-50.1%), nitrogen-fixing activity (3.3-128.7%), chlorophyll content of the fresh leaves (41-78%) and more reproductive buds (63.3-94.1%) in polythene mulched plots than unmulched plots and thereby advanced peak flowering stage by 9 days in groundnut. Plants under plastic mulch had increased relative growth rate is probably because they were exposed to higher air and soil temperature conditions than uncovered plants because of the microclimate modifications (Hemphill and Crabtree, 1988 and Soltani et al., 1995).

Crop Yield

Plastic film mulching techniques have been shown to be effective for increasing grain yield of
The polythene mulched plots produced the highest yields—94.5% higher than the unmulched plots in groundnut (Ramakrishna et al., 2006). Devi Dayal et al., (1991) also observed that early flowering (by 5 days) in plastic mulch treated groundnut crop. The marketable and total yield of muskmelon was highest for polythene-mulched plants and lowest for control plant. This probably indicates that soil-accumulated heat might be more related to plant growth and yield than air-accumulated heat (Jenni et al., 1996) Modification of these microclimate factors influence soil temperature, which affects plant growth and yield (Voorhees et al., 1981). Increased root-zone temperature (RZT) is one of the main benefits associated with use of plastic mulches (Wien and Minotti, 1987). It also reduces some pest and diseases thereby the yield will be increased. In tomato plants, the symptoms of tomato spotted wilt (TSW) were delayed in plants grown on gray, silver, and black mulches, due to increased RZT (26.1 °C) which is favorable for plant growth (Díaz-Pérez et al., 2003).

CONCLUSION

Under plastic mulch, soil properties like soil temperature, moisture content, bulk density, aggregate stability and nutrient availability improved. Plant growth and yield are also positively influenced by the plastic mulch due to the modification of soil microclimate. Even though it has many advantages, high initial cost, removal and disposal of plastic materials are some of the limitations experienced by the farmers. To overcome these limitations photo and biodegradable plastic mulches can be effectively used for sustaining the productivity as well as controlling environmental pollution due to the use of plastics.

REFERENCES


