Effect of mulching on crop production under rainfed conditions: A review

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Abstract
Mulching is an agricultural and horticultural technique in which the use of organic materials and synthetic materials for the purpose of increasing soil productivity is involved. In rainfed area, judicious use of water is essential for increasing the area under crop production with inadequate water supply. Under such situation the uses of moisture conservation measures are essential. Therefore, mulching has been advocated as an effective means for conserving soil moisture. This technique is very useful in protecting the roots of the plants from heat, cold or drought or to keep fruit free from diseases and insect pests. As mulching checks evaporation and modifies the soil and air microclimate and thus provides the congenial environment in which a plant is growing for the better growth and development and also helps in controlling the weed growth. Mulching is also applicable to most field crops. However, it is preferred in fruit orchard, flower, vegetable production, nurseries and forest where frequent cultivation is not required. Most commonly used mulch is black plastic which is also called as agricultural mulch. Due to increased soil warming characteristics of clear plastic mulch, it is used only in some areas. White or aluminum reflective mulch is used where soil cooling is desired. Research has shown that white or aluminum reflective mulch also repels aphids which spread some viral diseases in many horticultural crops.

Keywords: Moisture conservation, soil productivity, microclimate, mulch, organic matter, polyethylene

Introduction
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 as a spread over the ground as mulch. Any material used (spread) at surface or vertically in soil to assist soil and water conservation and soil productivity in arid and semi-arid regions is called as mulch. The practice of applying mulches to soil is possibly as old as agriculture itself. Rowe-Dutton and Patricia (1957) defined mulching as an application of layer of covering material on the soil surface. As stated by Bhavani (1960) [1], mulching appears to be a very ancient Chinese practice employed to conserve the scanty supply of moisture available for growing melons. Other reasons for use of mulching include congenial soil temperature, weed control, soil conservation; water conservation and improvement in soil physical, chemical, and biological properties and after the decomposition of organic mulch add plant nutrients which ultimately enhances the growth and yield of crops (Dilip Kumar et al., 1990) [3].

Mulches are either organic or inorganic. Organic mulches are those derived from plant and animal origin. Those most frequently used include plant residues such as straw, hay, leaf mold and compost, wood products such as sawdust, wood chips and animal manures. However, natural mulch materials are often not available in adequate quantities for commercial operations or such mulch material must be transported to the place of use and thus require considerable hand labour. Inorganic mulch includes plastic mulch such as poly vinyl chloride or polyethylene films and accounts for the greatest volume of mulch use in commercial crop production. Due to greater permeability of plastic mulch to long wave radiation which can increase soil and air temperature around the plants during night in winter. Hence, polyethylene film mulch is preferred as better mulching material for crop production. Now a days, particularly in rainfed agriculture, application of black plastic mulch film is becoming very popular. The beneficial effects of organic and inorganic mulches for crop production have been discussed by Ravi and Lourduraj (1996) [3].
Organic mulches have the advantage of being biodegradable in nature, but consequently decomposition of organic matter may result in a temporary reduction in soil mineral nitrogen and other nutrients also. During the decomposition of the material which is organic in nature various phytotoxins are released which avoids the growth of weeds and sometimes also harmful for the major crop and do not let it to grow properly. The use of black polythene mulch is restricted to the perennial crops but found to be superior than any other mulch. Today the vast majority of plastic mulch is based on LLDPE because it is more economic in use under arid and semi-arid regions.

Murugan and Gopinath (2001) [5] 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 attributes of Saundarya cv of Crossandra at Bangalore. According to Arora et al., 2002 likewise, different cultivars of carnation under poly house showed significantly improved plant height, number of branches, flower size and yield with the application of black polyethylene mulch.

Effect of mulch on soil and plants
Conserve Soil Moisture: The conservation of soil moisture through mulching is one of the important purpose due to modification of micro-climate conditions in the soil. Organic mulch helps to prevent the weed growth, reduces the evapotranspiration rate and also increases the infiltration rate of rainfall in the soil during the crop growing season. In addition plastic mulch helps to prevent the excessive water loss away from the crop root zone during periods of excessive rain fall which can decrease the irrigation frequency and amount of water used. Mulch can also reduces the incidence of the various physiological disorders related to soil moisture such as Blossom end rot in various vegetable crops and fruit cracking in lime and also in pomegranate (Mohapatra et al., 1999) [7]. Thakur et al. (2000) [8] observed that plastic mulch had highest water use efficiency and different mulching materials such as grass, lantana leaves and plastic, helped bell pepper (C. annuum cv. California Wonder) to perform better than unmulched one. Khurshid et al. (2006) [10]. Muhammad et al. (2009) [11, 22, 26] stated the same results that mulching helps to improve the ecological environment of the soil and thus it avoids decrease in soil water levels.

Reduce infiltration rate: The presence of mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater and evaporation by obstructing the solar radiation reaching to soil and there by enhances the total intake of water due to formation of loose soil surface. The water infiltrated in soil can be utilized by crops there-by crop yields are increased. Infiltration and soil evaporation are among the key processes that determine soil water availability to crops in semi arid agriculture.

Abu-Awwad (1999) [12] revealed that covering of soil surface reduced the amount of irrigation water required by the pepper 14 to 29 per cent and the onion crop by 70 per cent, respectively. Erenstein, 2002 conducted the trials in the higher potential areas of Zimbabwe between 1988 and 1995 indicated that mulching significantly reduced surface runoff and infiltration.

Reduce weed growth and keep the crop clean: Mulching provides a physical barrier, thus reduces the germination and nourishment of many weeds. Mulching materials such as wheat straw, dry grasses and saw dust proves to be good for inhibiting the growth of many weeds. According to Pimpini (1974) [14] in a study revealed that the plastic mulching improves the growth of eggplant by checking the weed growth. Because mulching leads to improved and higher soil moisture by favouring the reduction of evaporation. Covering or mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence. Saw dust is a wonderful soil improver and weed suppressor as it conserves soil moisture, decreases run-off, increases infiltration and percolation, decreases evaporation, etc. and weed growth can be substantial under clear mulch. Ossom et al. (2001) [15] also observed significant differences in weed control between mulched and unmulched plots of eggplant, cowpea and sweet potato and concluded the same as above.

Pest control: The main benefit of transparent polyethylene mulch is that; reduced whitefly populations, aphids also caught in yellow traps and reduced viral diseases incidence, in comparison to bare soil. The reflective plastic mulches can also reduces the incidence of aphid-borne viruses by confusing aphids and possibility of excluding some species of insect-pest. Here are the main properties of transparent polyethylene mulch having a repellent effect on pest and vector insects, such as aphids, whiteflies, and thrips. The mode of action of the transparent mulch is probably the high reflectance of UV light. A beneficial effect of clear mulch on reduction of aphid population was recorded by Farias-Larios and Orozco-Santos 1997b [16]. The success of living mulches is the suppression of pests and weeds population.

Maintain soil temperature: By reducing the temperature during the summers and maintaining the optimum temperature during winters is the main beneficial effect of the mulches by reflecting and transmitting the solar energy. The main purpose of the white mulch is reduction of temperature while clear plastic mulch increases the temperature.

The plastic mulching increased soil temperature by 0.9 to 4.3°C at the seedling stage, 1.6 to 2.3°C at the bud initiation stage and 0.8 to 1.9°C at the flowering stage (Chen and Katan (1980) [17]. According to Sarolia and Bhardwaj 2012, wheat straw mulch raised the soil temperature by 2-3°C in peak winter season. At night, condensation on the underside of the mulch absorbs the long wave radiation emitted by the soil thereby slowing cooling of the soil (Lamont, 2005) [19].

Reduced Fertilizer leaching: In sandy soils, excessive rainfall is shed drained to the root zone, and thus fertilizer loss due to leaching is reduced which allows the grower to place more pre plant fertilizer prior to planting the crop. Hundal et al. (2000) [20-24] revealed that the uptake of nutrients is significantly higher in mulched plots over unmulched plots in tomato. According to Worthington (2001) [21-25], an increase in available nitrogen contents stimulates protein production, in cabbage following serradella and vetch mulches. Muhammad et al. (2009) [11,22-26] observed that mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than unmulched ones.

Add organic matter: Organic mulches improve the physical, chemical and biological properties of the soil after decomposition thus return organic matter and plant nutrients to the soil and which in turn increases crop yield. Soil under
the mulch remains loose, friable and leading to suitable environment for root penetration. The organic mulches not only conserve the soil moisture, but they also increase the soil nutrients through organic matter addition. Saroa and Lal (2003) [23-27] and Khurshid et al. (2006) [10] concluded that organic matter was significantly higher when more mulch was applied. Higher organic carbon content of soil was recorded with sunhemp mulch (0.71%) followed by silkworm bed waste (0.68%), paddy straw (0.66%) mulched plots and least organic carbon content (0.48%) in non-mulched plot (Shashidhar et al., 2009) [29].

Stimulate soil micro-flora: Mulching stimulates the soil micro-flora such as algae, mosses, fungi, bacteria, actinomycetes and also other organisms like earth worms etc., owing to loose the soil, well aerated soil conditions, maintain uniform moisture and temperatures thus helps in resulting the more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth. According to Brown et al. (2001) [30] mulching practices gave positive effect on the soil biota. Soil biota increase under mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years. Sugiyarto (2009) [31] showed that application of maize residue as mulch enhanced diversity index of surface and deep soil macroinvertebrate, i.e: 0.215 and 0.214 (by 44% and 73% respectively as compared to no mulching). Shashidhar et al. (2009) [29] reported more number of bacterial, fungal and actinomycetes colonies found in Cassia sericea (32 CFU x 105/g), paddy straw (53 CFU x 104/g) and sunhemp (53 CFU x 103/g) mulched plots over other treatments respectively.

Plant growth and development: Reduced evaporation is the major cause for the plant growth and development. Mulching provides the better environment for the plant growth. Therefore, both the above said factors in combination results in vigorous and healthy plant which becomes resistant to the plant growth, also ensures the early plant growth than the unmulched plants. Mulching regulates the soil moisture and temperature which helps to stimulate the faster root growth and thus stimulates the better plant growth. Lourduraj et al. (1996) [32] obtained highest plant height (81.5 cm) and number of laterals (8.6 per plant) in tomato cv. “CO-3” with the application of black LLDPE mulch as compared to organic mulch and no mulch. According to Gao et al. (2001) [33] the nutrient paper mulch (NPM) advanced the plant growth as compared to plastic mulch and no mulch in tomato.

Improved quality and yield: Mulch helps keep fruits such as tomato from contacting the ground and avoids the attack from several diseases. This reduces the problem created by soil rot and helps to keep the produce clean. Fruit cracking, buck eye rot and blossom end rot are reduced in many cases. Properly installed plastic mulch helps keep soil from splashing onto the plants during rainfall, which also reduce grading time. The yield and chemical composition to tomatoes, cucumbers, muskmelons, eggplant, etc. were found to be improved. The yield and keeping quality of early potatoes, cabbage and other vegetables may be improved by straw mulch. Hassan et al. (1994) reported that organic mulch gave highest fruit yield of bell pepper over control. Gao et al. (2001) [33] reported that the nutrient paper mulching (NPM) promoted flower bud differentiation, enhanced yield and improved fruit quality in tomato as compared to the plastic mulch or no mulching.

Promotes Earlier Harvest: Black mulch when applied to the planting bed (prior to planting) will warm the soil and promote faster growth in early season, which generally leads to earlier harvest. Whereas, clear mulch also warm the soil more rapidly than black mulch and usually provides even earlier harvest. Warm season vegetable, such as cucumbers, muskmelons, watermelons, eggplant, peppers, usually respond well to mulching in terms of early maturity and more yields. The main reason for earlier maturity is probably due to maintenance of favourable soil temperatures during the particular growing season. Beneficial effect of polyethylene mulch on the increase of the early yield was also found for watermelon (Romic et al. 2003) [2], tomato (Brown et al. 2001; Hutton et al. 2007) [30, 34] and pepper (Hutton et al. 2007) [34].

References