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Mulching: A sustainable solution for soil and water conservation

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ABSTRACT: The necessity to increase food production while also improving the quality of our environment has prompted a search for materials to reduce wind and water erosion. This study offers a review of research and development related to the application, techniques, and volumes of several forms of mulch-crop residues, chemical soil stabilizers, and feedlot wastes (manure) that are needed to reduce wind erosion. A wind erosion control treatment that can withstand a 38.0 m/s wind measured at 15.2 m is successful. Mulching has become a common technique in modern agriculture. Mulch paper lowers the need of chemical fertilizers and herbicides, as well as weed control and maintaining the temperature of the ground. Over-mulching can generate an anaerobic environment in which fungal infections can grow in plant stems and roots (some are toxic to humans). When mulch is placed too thickly in the fall, rats may find a place to live and begin feeding on plant stems and trunks all winter. In some circumstances, the danger of pests as well as some soil-borne illnesses can be decreased by using plastic mulch. Organic mulches can break down in the soil and enhance the amount of organic matter and microbial activity there. These mulch coverings must be replaced over time since they decompose quickly. They enrich the soil with nutrients, reduce the pH, and are short-lived on the soil's surface. This article covers the published research on mulches and considers how they may be used to tackle the problem in agriculture.

Keywords: Mulching, plastic mulch, water conservation, soil properties, weeds.

INTRODUCTION

In the areas of agriculture and food security, India has achieved significant progress. It all started with the choice to use higher-yielding, disease-resistant wheat varieties, as well as greater agricultural expertise, to boost output. Irrigation projects, the increased use of fertilizers and pesticides, and the adoption of high-yielding cultivars all contributed to the Green Revolution. Mulch is said to be originated from the German term "mulch", which means "soft to decay" and refers to gardeners spreading straw and leaves over the ground as mulch. Mulches are employed in agriculture for a variety of reasons, but the most essential goals are water saving and erosion control, especially in dry and semi-arid areas. Mulching is the method or practice of covering the soil/ground to improve plant growth, development, and crop production efficiency. Mulch is a technical word for soil covering. While natural mulches such as leaf, straw, dead leaves, and compost have been utilized for generations, synthetic materials have changed the techniques and advantages of mulching in the last 60 years. Straw mulching is very successful practice for weed management to deny toxic hazards of pesticides (Morya *et al.*, 2016).

The amount of study and field data available on the effects of synthetic mulches has resulted in a large body of valuable literature. Plastic mulches are entirely impermeable to water when compared to other mulches; this avoids direct evaporation of moisture from the soil, limiting water losses and soil erosion over the surface. As a result, it contributes to water conservation in a favorable way. Evaporation control has a secondary benefit in that it reduces the increase of salty water, which is significant in nations with high salt content water supplies. As a result, it improves the physical, chemical, and biological qualities of soil, as well since the development and yield of crops. It also improves the physical, chemical, and biological aspects of soil, as it provides nutrients to the soil (Dilipkumar *et al.*, 1990).

A. Mulching in improving soil health

To obtain maximum production for each soil/climatic environment, understanding the physical attributes of soil is vital for defining and or enhancing soil health.

This assumes that to increase agricultural yield, soil must be kept in a physical state that allows for appropriate crop development. Even if all other conditions are met, a crop's genetic yield potential cannot be reached unless the soil physical environment is maintained at its optimal level. Without a doubt, if these soils are appropriately maintained for physical health, the production potential of many crops may be greatly boosted. Mulching is a technique for improving soil health by retaining moisture, regulating temperature, suppressing weeds, preventing erosion, improving fertility and plant nutrition, and preventing pests and diseases. Mulching reduces surface water flow and transport capacity by increasing the hydraulic roughness of soil surfaces, as well as trapping water and soil. Compost, plant and animal residues, and groundcovers are examples of common organic mulch materials that have been shown to be effective in arable systems. Organic mulch improves soil health by increasing soil fertility and moisture and optimising soil temperature, resulting in less surface evaporation and nutrient loss (Ngosong *et al*., 2019). The study provides a brief background to the idea of current scenario of Indian agriculture, as well as a critical evaluation of the concept in terms of difficulties and possibilities for overall sustainability (Balkrishna *et al.*, 2021).

B. Soil temperature

The temperature of the soil under plastic film is generally high, and the colour of the plastic mulches influences this. The soil temperature in the black plastic-film mulched plots was substantially lower (1 to 2.8°C) than in the clear plastic-film mulched plots. Because a significant amount of the solar energy absorbed by black plastic-film mulch is lost to the environment as a result of radiation and induced convection (Schales, 1963). When compared to plastic film mulched plots. It has been found that the unmulched plots had the lowest soil temperature (approximately 1-3.8°C lower) at various dates since planting. Plastic film mulching, among the several mulching procedures, raises soil surface temperature by changing the heat balance, hence increasing soil temperature, and positively impacting crop emergence (Aniekwe *et al.*, 2004).

C. Soil water content

In comparison to the control (no mulch) and bare soil treatments, the black polyethylene mulch maintained high soil water content. In semiarid locations, improving water usage efficiency by better using soil water looks to be the greatest strategy to boost grain output (Zhao *et al.*, 1995). The major approaches for enhancing water usage efficiency are reducing soil water evaporation, utilizing deep soil water to enhance shoot biomass accumulation, and optimizing dry matter allocation by selectively enhancing reproduction. The plastic film mulch encourages root development and increases root distribution in the mid and deep soil, allowing the plant to absorb more water from the deep soil and enhance grain output

D. Nutrient availability

The breakdown of organic leftovers beneath plastic mulch releases organic acids into the soil, lowering the pH and perhaps increasing micronutrient bioavailability (Mn, Zn, Cu, and Fe). The increasing Fe and Zn content in soil beneath plastic mulch was also evidence of this. Due to the mineralization of organic nitrogen over time, the mineral N concentration (NO_3 and NH_4^+) in soil is high, increasing the availability of soil nitrogen. Under plastic mulch, the breakdown of organic material releases soluble nutrients such as NO_3, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, and fulvic acid into the soil, increasing soil nutrient availability.

E. Effect of mulching on Crop growth parameters

Plastic mulch promotes early crop emergence, resulting in enhanced biomass output during the early phases of crop development. Plastic film mulching, according to Li *et al.* (1999), causes quicker seedling emergence and spike differentiation, which aids in the development of more spikelet and grains per spike in wheat. In wheat, an increase in soil moisture and topsoil temperature caused by plastic mulch accelerated seedling emergence by 8 days on average. Plants in mulching treatments reached maturity earlier and had a longer maturation time. This alteration favours partitioning assimilate that is stored in vegetative organs, allowing wheat plants to grow their reproductive organs more quickly. It lengthens the reproductive period to maximize the yield (Li, *et al.*, 2004).

F. Effect of mulching on weed control

Mulching's main goal is to prevent weeds from getting light and thereby suppressing their development. Because all types of mulch cover the soil and exert physical pressure on weeds. Non-living mulches have a number of advantages. These include soil moisture retention, leaching prevention, improved soil structure, disease and pest control, crop quality improvement, and, in many crops, an extended growing season, which reaps financial benefits. The primary benefits, however, are associated with weed control. Weed suppression with particle and sheet mulches can result in significant long-term labour and herbicide savings. It is critical to select the appropriate mulch for the situation. The effectiveness of the mulch will vary depending on the prevailing weed problems and the surrounding environment (Grundy and Bond 2007).

G. Biodegradable mulches

Carrubba and Militello (2013) provided various ecologically friendly weed control approaches that were effective in increasing coriander, fennel, and *Psyllium* seed production. Even though the biodegradable films employed in the experiment had a favorable effect on yields, they were unable to reduce weeds. Organic farming also makes use of degradable inorganic elements like gravel, which has been employed as

mulch for over four decades. Aside from the mulch's thickness, the gravel's distinct grain sizes are also analyzed (Qiu *et al*, 2014). Wang *et al.* (2014) looked at the use of gravel-sand mulches in watermelon production and how they affect soil temperature. Many additional organic mulches, such as composted pine bark in *Allium flatulence* and pine bark mulch in *Salvia splendens*, have been reported. For acid-loving plants like *Calla* (Wright and Burge 2010) or blueberries, sawdust has been proposed as excellent mulch (Haynes and Swift 1986). Like composting, straw, and other organic mulches decay over time through the mineralization process, resulting in humus. Compost, in addition to its primary function as an organic fertilizer, aids in the improvement of soil structure and is widely used to create various substrates and mulches.

H. Non-biodegradable film mulches

The effectiveness of several polypropylene (PP) black films in weed management was examined, and the findings revealed a considerable rise in plant height (Fontana *et al.,* 2006). Strawberry and watermelon production typically uses black and other film colors because they require higher soil temperatures to achieve optimal sweetness. Despite the fact that conventional Polyethylene (PE) films are considered to be hazardous to the environment, watermelon cultivated on silver black PE film had greater yield and quality features (Parmar *et al.,* 2013). The effectiveness of PE film to five biodegradable films and found no significant changes in strawberry yield and quality (Costa *et al*., 2014).

I. Advantages and disadvantages of Mulching

Because of their weed suppressing effect, different mulch kinds may have a favorable or negative impact on crop output. Mulching has been shown in different studies to have a positive impact on crop development as well as the number and quality of yields obtained (Ramakrishna *et al*., 2005). Mulches made of nonbiodegradable PP and PE films, irrespective of colour, were the most effective in preventing weed seed germination and subsequent growth, however they are also useful in reducing moisture loss from the soil and moderating its temperature. Their use typically results in a variety of other advantages, including reduced run-offs, increased rain water penetration, erosion management, soil chemical balance correction, and insect and disease damage reduction. They do, however, have certain environmental drawbacks because of the removal, and handling of their waste (Briassoulis, 2006).

J. Mulches and insect pest and disease management

Polyethylene mulches have been utilized to reduce insect and disease problems in the past (Lament, 1993). Mulches affect plant microclimate and energy balance by varying solar radiation transmittance, absorbance, and reflectance (Lamont, 1999). By adding UV reflectivity, thrips' host-seeking behavior can be interrupted, resulting in a reduction in thrips populations on and near host plants (Brown and Brown, 1992; Kring and Schuster, 1992; Scott *et al.,* 1989; Stavisky *et al.,* 2002). This reflectivity is provided by using highly ultraviolet-reflective aluminized mulch as a bed covering to interrupt thrips' initial flights into a field (Brown and Brown, 1992; Kring and Schuster, 1992; Scott *et al*., 1989).

K. Soil preparation and preplant fertilization

At least one month before bed preparation, the soil should be deep ploughed or disked. Crop residues should be well-integrated. Remove any garbage, pebbles, or clods that may obstruct the application of the plastic from the field. Fertilizers for preplanting can be dispersed and integrated into the beds as they develop. To build solid, smooth beds, good soil moisture (60 to 80 percent of field capacity) is required (Granberry, 1994). It is critical that the bed be firm for the soil not to settle.

L. Mulch application

When used in combination with drip watering, plastic mulch is most effective. A drip tube can be buried two to three inches beneath the soil surface or put on the soil surface under the mulch. Burial decreases the chances of the tube moving or being damaged, which might lead to leaks. The tube must be put before the mulch in any case. Mulch should be put at least seven days before planting in the spring to give time for soil warming. Soil fumigation can also be done during the mulching process. Fumigation is a highly skilled procedure. Make sure to prepare ahead of time to account for equipment readiness and any necessary time between treatment and planting. To get the most bang for your buck, make sure you apply the mulch correctly. The plastic should be in constant contact with the soil, *i.e*., there should be no dish shapes in the bed to keep the mulch from sticking to the soil. Heat transfer is hampered by the space between the soil and the mulch, which prevents the soil from warming as rapidly and thoroughly as it might.

A considerable amount of earth should be used to fix the mulch's edges. However, do not put more dirt than necessary since this will make removing the mulch more difficult (Stavisky *et al.,* 2002).

M. Planting

Planting the crop in the Centre of the bed is recommended. Transplants or direct-seeded veggies can be planted using a machine or by hand straight through the plastic. To stimulate early development, starter fertilizer solutions are usually administered to transplants. Fertilize plants in the middle of the season using soluble fertilizers injected through the drip line.

N. Culture and management

The use of plastic mulch does not negate the need of excellent agricultural practices. On the contrary, more rigorous management is required to guarantee that the mulch is used to its full potential. Insect buildup under the plastic surrounding plant holes should be checked

on a regular basis. Apply a shovel of dirt during the plastic at regular intervals down the row to anchor the mulch if it loosens after installation and flaps in the wind. This will keep the mulch from blowing off the row and causing damage to the transplants. Establish and adhere to a strong integrated pest management programme for the crop in question. Use your best judgement to determine the nutritional condition of the plants and take appropriate action. The use of plastic mulch does not negate the need of excellent agricultural practices. On the contrary, more rigorous management is required to guarantee that the mulch is used to its full potential. Insect buildup under the plastic surrounding plant holes should be checked on a regular basis. Apply a shovel of dirt during the plastic at regular intervals down the row to anchor the mulch if it loosens after installation and flaps in the wind. This will keep the mulch from blowing off the row and causing damage to the transplants. Establish and adhere to a strong integrated pest management programme for the crop in question. Use your best judgement to determine the nutritional condition of the plants and take appropriate action.

O. Removal

The plastic must be removed from the field once it has fulfilled its function, which is to produce at least one and preferably two or more harvests. After usage, the plastic should be removed as quickly as possible. Allowing the plastic to become overrun with weeds before removing it is not a good idea. After the growth season, the plastic must be removed. Underneath do not place any plastic discs. Plastic removal machines are commercially available; however, they can be costly. The plastic must be removed by hand and disposed of at a landfill in most cases.

CONCLUSION

The demand for horticulture crops has expanded globally because of globalization and rising health consciousness. Soil parameters such as temperature, moisture content, bulk density, aggregate stability, and nutrient availability increased when plastic mulch was used. Because of the altered soil microclimate, the plastic mulch has a favorable impact on plant development and yield. Even though it offers numerous advantages, farmers face challenges such as high startup costs and the removal and disposal of plastic components. To address these restrictions, photo and biodegradable plastic mulches can be utilized efficiently to maintain productivity while also reducing pollution caused by the usage of plastics.

FUTURE ASPECT

Mulches protects soil moisture, improve the soil's nutritional status, reduce erosion losses, inhibit weed growth in agricultural plants, and eliminate pesticide, fertilizer, and heavy metal residues. Mulches raise the aesthetic and financial value of agricultural landscapes. Regarding mulching materials, there are inconsistencies since some researchers support mulches while others have expressed some reservations. Regarding the type of crop, management techniques, and climatic circumstances, the choice of mulching material is crucial. The agro-ecological systems might gain the aforementioned advantages from the proper mulching strategy. Therefore, future research should focus on the effects and economic feasibility of low-cost, environmentally friendly, and biodegradable mulching materials on soil microorganisms, nutrient balance, plant development, and soil erosion.

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