

Mulching Techniques to Conserve the Soil Water and Advance the Crop Production - A Review

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Abstract

The necessity to increase the production of food grains and enhances the quality of surrounding environment has led to find the materials to control or regulate the water and wind erosion. Mulching has become now a days an essential and decisive exercise in agricultural production. It lessens the application of herbicides and various chemical fertilizers, control the weeds and maintains the soil moisture and soil temperature. This article consists of the detail reviews of different research conducted on mulches and elaborate the opportunities that they resolving the problem in agriculture. The resources of water for agricultural operations have been inadequate over the years as a result of global warming and uneven or uncertain rainfall in the low rainfall zones of India. To alleviate the water scarcity in agriculture, mulching has a vital impact as a water conserving technique in rain-fed cropping. It is very important primarily for preserving the soil moisture, preventing evaporation of soil and governing the soil temperature, which affects the food production. India being an agricultural country should have a better admiration towards water conservation tactics. By now we are fighting from a great stress of water insufficiency. Each and every drop of water is important for us but inappropriately because of inattentiveness, we repeatedly waste gigantic



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volume of water in which 70 to 80 % is passed down for irrigation purpose. Mulching and micro-irrigation techniques can play a vital role in controlling the over and excessive irrigation. This practice assistance to prevent weed growth, increment soil moisture, reduce soil erosion, maintain soil temperature, augments soil structure, improves soil fertility and improvise soil biological regime. There are several categories of mulching which are organic mulching, inorganic mulching, natural mulching, synthetic mulching, surface mulching, upright mulching or vertical mulching, plastic mulching, rubber mulching, pebble or stone mulching, dust mulching, straw mulching, landscape fabric, live vegetative barriers etc. Mulching also shows some limitations beyond many advantages as it may harbor some insects, pests and diseases and also create some weed problems sometimes. The current analysis deals with argument of every single feature of mulching and its beneficiary effects.

Introduction

It is becoming increasingly clear that the challenge of feeding tomorrow's population is to an outsized extent about improving productivity of water within present land use, as new arable land is relatively limited (Prem *et al.*, 2017). Agriculture sector consumes the highest quantity of water in the world around 70% of total usage (Qin *et al.*, 2018). In which, 80% of global cropland is covered by non-irrigated (rain-fed) that contributes 60–70% of the world's food production (Chen *et al.*, 2018). Bearing in mind the rising water scarcity, rain-fed cultivation plays a vital role in the global food supply (Sun *et al.*, 2012; Li *et al.*, 2017). Contrarily, global warming and asymmetrical rainfall outlines are answerable for the lack of water resources which bound agricultural production in arid and semi-arid areas (Qin *et al.*, 2015; Li *et al.*, 2017). Thus, to save water in cultivated land, agriculture water management is a key concern. Also, in dryland farming rain-fed cultivation is being stressed which needed more effective consumption of water resources by using water-saving technologies (Qin *et al.*, 2013). Therefore, in arid and semi-arid regions of the world, conservative and efficient water-use has been functioned for many years with huge success. Maximizing yield with minimizing water usage is the leading target of every water conservation systems. The effective usage of water is decisive aspect during crop growth stages which can significantly advance yield (Kader *et al.*, 2019). Insufficiency of water is the major concern for the country now a days because the water resources are contaminated with pollutants day by day and usable water is declining. Also, the health of soil is

declining vigorously. Therefore, what are the options to break out from these situations? What should have to do to save the moisture content of soil body? What can we do to reestablish the soil's healthiness? What should have to do to stop the weed growth and restrict its germination in the soil? What can we do to feature nutrients to soil body? What can we do to take care of a decent micro-flora and maintain a well steadiness of soil's micro-organisms? The reply is simple, to implement the exercise of mulching in agricultural fields. Therefore, mulching could be an effective choice for saving water along with increasing production in rain-fed or dryland farming. The word mulch has been originated from the German word "*molsch*" means soft to decay, which seemingly denoted to the use of straw and leaves by gardeners as a spread over the ground as mulch (Jack *et al.*, 1955). Therefore, mulch is frequently defined as any material applied as cover to the soil surface. Mulch is defined as a coating material spread over the soil surface (Kasirajan and Ngouajio, 2012). Mulching is an important cultural practice that can lessen the quantity of work essential in gardening, helping to produce healthier plants and potentially growing vegetable produces. Mulching is the exercise of protective covering of the soil surface around the plants with a living or non-living mulch to make promising conditions for the plant growth and efficient crop production (Chakraborty *et al.*, 2008; Kader *et al.*, 2017a). It shields soil to protect organisms and plant roots from diverse meteorological conditions. Mulching optimizes water use and helps to advance crop development along with yield (Yu *et al.*, 2018). The principal objectives

of mulching are controlling erosion and saving water in low rainfall regions. While natural mulches such as leaves, straw, tree waste, grass clippings, bark clippings and compost have been used for centuries, during the last 60 years the arrival of synthetic materials has changed the means and profits of mulching. There is so much resources available on effect of synthetic mulches make a huge volume of valuable works. Comparatively plastic mulches are fully impermeable to water. Therefore, it confines the losses of water and erosion of soil through-out the soil surface by preventing rapid evaporation from the surface of soil and the upsurge of water comprising salt, which is important in countries which has high salt content water resources. In this way it plays a productive part in conserving water (Sharma and Bhardwaj, 2017). Thus, it enables more withholding of soil moisture and assistances in control of temperature variations, advances physical, chemical and biological properties of soil, because it can augment nutrients to the soil and eventually augments the advance and harvest of various crops (Dilip *et al.*, 1990). In addition, mulch can excellently diminish water vapour loss, weed problems soil erosion, and nutrient loss (Van Derwerken and Wilcox, 1988). Mulching can be divided generally into two groups—organic and inorganic. Also, natural and synthetic mulching is other types. Organic mulches like tree barks are generally a descendent of various timber industries, which decay willingly on time. Inorganic mulches like plastic films do not decay rapidly and may essentially persist in the atmosphere to an unspecified period of time. Most categories of mulches are accessible by the container. It's best to spread on organic mulch just after buying or distribution. If it is no convenient to do so, cover the mulch with a tarp or plastic to keep the material dry. The assortment of mulches hangs on accessibility, rate, appearance, quality, and resilience. Understanding the features of various mulching materials and their proper usages may assistance you to hand-picked the correct mulch as per requirements.

Benefits of Mulching

Mulching improvises soil productivity, soil ventilation around the plant, aggregates the soil particles and drainage of excess water (Kader *et al.*, 2017a). There is a lot of benefit of mulching in crop fields

like reduction in loss of soil water, soil erosion, growth of weeds, kinetic energy of water droplets and competition between the surrounding fields for nutrients and water (Tarara, 2000; Yang *et al.*, 2015; Kader *et al.*, 2017a). Mulch can be helpful in improvising soil structure and steering of nutrients due to movement of earthworm into the soil (Qin *et al.*, 2015). It also let down the soil pH which augments availability of nutrients. Organic mulch adds nutrients in the soil after break down and increases the availability of nutrients for long time within soil (Larentzaki *et al.*, 2008). Plastic mulch entertains as impermeable to the gassy movement which act as a greater wall for the process of solarization and fumigants. It can also show an astonishing role in increasing soil health and control of pests (Chalker-Scott, 2007). Consequently, it supports in keeping the nutrient around the root of plant for effective use of nutrient and also helps in reduction of leaching of fertilizer. The uniformity in look all over the mulched landscape are more appealingly (Li *et al.*, 2013; Chen *et al.*, 2018). Furthermore, in the different stages of growth of crops there is a viable changing in the appropriateness of soil moisture and temperature. After decomposition of organic mulch in the soil, the organic material of soil enhances rapidly and consequently increases the water holding capacity of the soil (Kader *et al.*, 2017c). Some other benefits are described below:

Moisture Retaliation in the Root Zone

Due to slow down in evaporation done by mulches, more moisture is being available nearby the plant roots and also more time available for plants to take the water. So, area covered with mulch requires less application of water (Ranjan *et al.*, 2017).

Soil Structure Improvement

Organic mulches as well as bio-degradable plastic mulches ultimately collapse and augment nutrients to the soil surface, improvement in moisture retention capacity and increment in the humus layer.

Soil Temperature Stabilization

The fluctuation in temperature is governed by mulches in the plant's root zone, which resulted in the cooler soil in summer and warmer soil in winter season.

Weed Management

Mulch reduces the germination of seed by preventing sun light to reach the top layer of soil. Weeds are also prevented to germinate by plastic films and landscape fabrics after forming a protective layer on the soil (Sharma and Bhardwaj, 2017).

Reduction in Reflectivity

The heat and light are reflected by sand and clay soils beneath the leaves of plant. Less reflection of light is observed in organic mulches due to its multifaced and darker faces. Thus, rate of evaporation is reduced by organic mulches. But reflectivity is increased by inorganic mulches specially rocks, which is suitable for some plants but harmful for more sensitive plants (Kader *et al.*, 2019).

Erosion Control

Mulch reduces the kinetic energy of rain and slow down the movement of rain water, which averts runoff and giving the soil more time to absorb the rain water. The supplementary moisture cheers growth of plant roots, which further results into the stabilization of soil. Mulch also protect soil from wind erosion (Ranjan *et al.*, 2017).

Reduction in Maintenance

Less intercultural operation required in the mulched area due to less weed growth.

Drawbacks of Mulching

There are also some negative impacts of mulching such as more labor requirement, higher transportation charge, removal and disposal problems etc. The plastic mulch has close contact with the soil which results into the production of fragment and contamination of soil (Steinmetz *et al.*, 2016). Growth of weeds and release of acid into the soil is also main problem of some organic mulching material such as straw and grass (Chalker-scott, 2007; Patil *et al.*, 2013). Mulched soil consisting better aeration of soil, higher temperature and constant moisture content tend to favor the higher microbial activity in the soil which refers to more complete nitrification in the soil which is treated with mulching (Huang *et al.*, 2008). The plastic film wreckages disposed and buried by farmers in cultivable sheet of the soil through on-site burning and landfilling which leads to severe soil contamination and reduced crop growth (Gonzalez *et al.*, 2014).

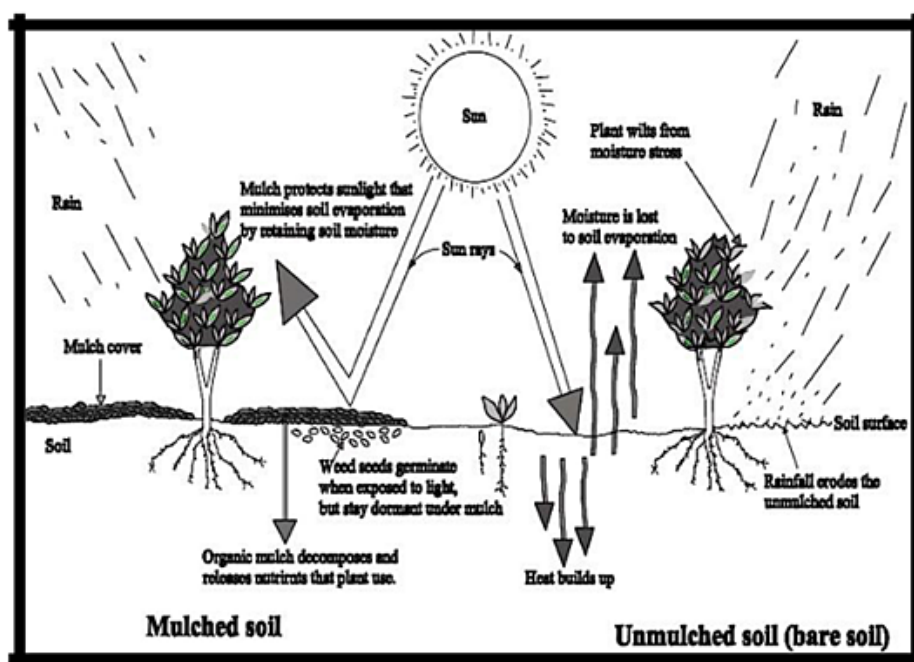


Fig 1: Advantage of mulched and un-mulched soil interactions with plant and environments (Kader *et al.*, 2017a)

Application Criteria for Mulches

The crops you grow and the location of your field will determine the time of application of mulching. Some important guidelines are described below:

Crop Growing Season

The crops grow in cool season, like peas and spinach, can be mulched early but crop grows in summer season, like corn and tomatoes, cannot be mulched until the soil gains higher temperature unless black plastic film is used in mulching. In spring season mulching is done after little dry up of soil.

Cold Season Protection

A common misapprehension is that mulching is done to prevent freezing of soil. Water temperature should not be permitted to go far below fir acceptable biochemical oxidation of organic (Ranjan and prem, 2018). Mulch permits soil to heat up progressively in spring and useful for the early germinated plants which germinates early before soil temperature is warm sufficient to tolerate them. In the spring season when new growth of plant is observed at the base of protected plant, then winter mulch should be removed.

Trees and Shrubs

To avoid compaction of soil and root suffocation nearby the foot of shrubs and trees, not more than 2-3 inches layer of mulch should be applied. Avoid supporting mulch against stems and trunks of plants. Over mulching resulting in constant moisture availability may also lead to promote the growth of bio-organisms or various pathogens and build a home for unwanted and dangerous insects and pests (Ranjan *et al.*, 2017).

Vegetable Production

Mulching the vegetable garden guards fruits and vegetables from being streaked by soil, conserves moisture, lessens rivalry from weeds and also reduces the spread of hazardous pathogens. Mulch must be applied subsequently soil has warmed. In vegetable gardens, mulch might be applied to make alleyways between plant rows for easy inter-culture operation and harvesting.

Recently Seeded Lawns

In newly seeded lawns, mulching is used to save seeds from washing away, protects from birds and rodents and keeps moisture for better germination.

Clean barley, oat or wheat straw is suggested as an alternative because it is generally free from seeds instead of hay because it often comprises of weed seeds.

Weed Management

Mulching should be done before weeds start rising to control the weeds. Hoeing or pulling should be done before mulching when weed starts growing. The thickness of mulch layer should be enough to control weeds but not thicker that it become harmful for plants. The density of mulch material, aeration of soil and type of plant decides the proper thickness of the mulch. Commence with a mulch layer around 2 inches thick and top up with more mulch as it collapses. Mulch should be at least 4 inches away from the stems of plant (David, 2002).

Classification of Mulches**On the Basis of Organic Matter****Organic Mulches**

Organic mulches can be made of naturally occurring various substances which contains organic matter in it. Common examples of organic mulching are bark clippings, grass clippings, compost, dry leaves etc.

Inorganic Mulches

Inorganic mulches made up of inorganic substances which does not contains organic matter in it. Inorganic mulches include stones and gravels, polyethylene films, landscape materials and rubbers.

On the Basis of Living Matter**Natural Mulches**

Natural mulches are generally made up of naturally occurring materials. Organic mulches are also known as natural mulches. No prerequisite for replacement of natural mulches because it decomposes readily.

Synthetic Mulches

Synthetic mulches are made of artificial non-living substances. Various types of synthetic mulch materials are available in market for use in crop fields such as plastic films, plain and oiled paper, spun materials etc.

On the Basis of Method of Application

Surface Mulching

When mulches are spread on the soil surface in order to lessens the evaporation rate and increase the moisture holding capacity of soil, then it is called as surface mulching. In rain-fed farming, surface mulching is broadly used as water conserving practice (Chakraborty *et al.*, 2008; Zribi *et al.*, 2015).

Vertical Mulching

It is the soil treatment which is conducted near the root system of tree's in order to improve the root function and health of tree by ventilating the compressed soil, increasing water retaining power of soil, advancing infiltration capacity of soil and adding nutrients to the soil. Vertical mulching commonly known as composting. It is conducted by digging of 30 cm deep and 15 cm wide trenches across the slope at interval of 2 to 4 m and adding some organic materials like grasses, straws, stubbles etc. (Telkar *et al.*, 2017).

Growing Vegetative Barriers

Subabul and Glyricidia plants are planted on the contour lines as vegetable barriers in order to serve as a mulch, which can improve the moisture holding capacity of soil (Patil *et al.*, 2013).

Organic Mulches

Organic mulches comprise of materials like animal compost, grass clippings, straw of various crops, dried leaves, tree bark clippings and saw dust. It has easily degradable capacity because nature of appealing slugs, insects and worms that eat them and help them in rapid degradation, which results in addition of some quantity of nutrient and organic material in the soil. Organic mulch has a large number of helpful features. Some of them are: soil moisture conservation by reducing the rate of evaporation, moderates soil temperature, lessens soil erosion, hinders growth of weed, cheers the growth of beneficial soil bio-organisms, and diminishes the blowout of soil-borne pathogens. Organic mulches after decomposition over time improve soil structure and increase nutrient content of the soil (Telkar *et al.*, 2017). The illustration of different organic mulches and their usages are given below:



Fig. 2: Bark clipping mulching (Source : <https://media.spokesman.com>)

Bark Clippings

Bark clippings (shown in Fig 2) are long lasting materials and permit appropriate aeration to the soil. It can be used properly in dry as well as wet

regions and having more water holding capacity. In wet region, if rain is too much the wood bark will reduce waterlogging condition after absorbing the excess water and if rain is too little, the wood bark

will release the holding water, providing water to the plants in dry times also.

Bark (hardwood)

Hardwood bark clipping is the derivative of paper and timber industries and differs in sizes ranging from chips to bigger nuggets. It is mostly used nearby the shrubs and trees. Both coloured and natural varieties of bark is obtainable. Colored varieties are generally a mixture of recycled wood waste comprising non-natural peroxides. Hardwood bark clippings having more nutrients than soft wood but bark clippings are not effortlessly and plentifully available (Ranjan *et al.*,

2017) and also phytotoxicity is caused by some bark products (Telkar *et al.*, 2017). These barks are slightly alkaline in nature (Ranjan *et al.*, 2017).

Bark (softwood)

It is similarly a derivative of wood and paper industries. The common example is pine bark and it is commonly used under large shrubs and trees. It is somewhat acidic in behavior, takes more time to decay. These barks are obtainable in several sizes and generally applied to 2 to 4 inches of depth (Ranjan *et al.*, 2017).



Fig. 3: Tree wastes (Source: <https://wikimedia.org/wikipedia/>)

Tree waste

Generally, this mulch (shown in Fig 3) outcomes from larger lumps of timbers. At the time of decomposition, the fresh tree chunks will utilize

larger sums of nitrogen inside the soil. This type of mulch is specifically useful for making pathways (Telkar *et al.*, 2017).



Fig. 4: Leaf Mulching (Source : <https://www.greenmylife.in/>)

Leaf Mulch

Leaves are decent for mulching which is easily and profusely available (Ranjan *et al.*, 2017). However, leaves are good for shielding inactive plants during winter season by keeping them warm and it helps in starting germination throughout winter season but they may be blown away even by little speed of wind due to its light weight. Bark, stone or any other material which are useful in reducing wind

speed, should be used to lessen these problems (Patil *et al.*, 2013). It can be made at home by composting shredded leaves. Leaf mulch (shown in Fig 4) can be used in all types of gardens. Leaves infected with disease should be disposed instead of composting (Telkar *et al.*, 2017). Proper thickness of the leaf mulching is about 3 to 4 inches (Ranjan *et al.*, 2017).



Fig. 5: Grass clippings (Source: <https://www.onegreenplanet.org/lifestyle/how-to-use-your-grass-clippings/>)

Grass Clippings

Grass clippings (shown in Fig 5) are effortlessly and profusely available mulch materials in agriculture. It provides some quantity of nitrogen and organic material into the soil if freshly incorporated in the soil. If green grass clippings added in the soil, it can develop its root system it can create damage to growth and development of crops. So, use of dry grass is more favorable as mulch material (Telkar *et al.*, 2017, Patil *et al.*, 2013). Grass clippings

should be spread in thin layers for better result across perennial and vegetable beds and concave at the end of the growing season. Before adding extra layers let every layer to dry. Grass clippings will mat if thick layer of clipping is applied instead of thin layers. Grass clippings taken from lawns which is treated with insecticides or herbicides never be used. It should apply at a depth of 2 to 3 inches (Ranjan *et al.*, 2017)



Fig. 6: Composted animal manure (Source: <https://en.wikipedia.org/wiki/Manure>)

Composted Animal Manure

The composted animal manure (shown in Fig 6) is an excellent choice for mulching material which advances the soil health, increases the population of microbes or bio-organisms and adds nutrients to the soil. Compost is slightly acidic in nature. Compost does not have better capability of weed suppression which is one noticeable drawback of composted animal manure (Telkar *et al.*, 2017). Use of fresh manure in crop field sometimes results

into burning of plant roots. Before using as a mulch manure should be well decomposed at temperatures between 54°C to 60°C for minimum one week and 4 to 6 months composting to eradicate potential disease micro-organisms. The manure of pigs, cats and dogs should never be added to vegetable crop. It is too used as a mulching material in various nutrient consuming florae alike roses. 3-4 inches of depth is favorable for compost using as a mulch (Ranjan *et al.*, 2017).



Fig. 7: Newspaper mulching (Source: <https://www.waldeneffect.org/>)

Newspaper

Newspaper mulching (shown in Fig 7) is helpful in adding some organic matter into soil and controlling weeds. Thickness of 1 to 2 cm of newspaper sheet is required for mulching and the edge of paper should be fastened with stones, gravels, pebbles etc. Suppression of weed is done by the layers of white

and black newspapers (Patil *et al.*, 2013). Apply 2 to 3 layers of newspaper at a time and cover it with leaf mulch or grass clippings or any other organic materials so that it cannot blow away by the winds. Newsprint will ultimately decay and can be merged into the soil.



Fig. 8: Straw mulching (Source : <http://agritech.tnau.ac.in/agriculture/>)

Straw Mulches

Some examples of straw mulches are groundnut shells, cotton shells, Straws of paddy and wheat, crop stubbles etc. which are used as mulches for moisture conservation on soil surface. Even nutrient

content is less in straw but soil converts more productive after decomposition of straw mulches. Straw mulches (shown in Fig 8) reduce amount and rate of evaporation and lessen the amount of energy captivated by the soil (Telkar *et al.*, 2017).

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Fig. 9: Sawdust mulching (Source : <https://www.denbow.com/>)

Sawdust

Sawdust (shown in Fig 9) is obtained from wood and furniture making industry and very deprived in nutritive value. It is slowly decomposable. It is acidic in nature so it should not be used in acidic soils.

Benefits of Organic Mulching

A vital role is played by organic mulch in reflecting solar radiation. It reduces rate of evaporation and keeps soil cooler. Prevent germination and growth of weeds, lessens erosion of soil, reduces runoff, increase moisture retaining power of soil, improves infiltration and percolation of water, advances the soil condition, make soil porous and augments better growth of roots. It can also maintain the soil temperature.

Drawbacks of Organic Mulching

Mulches restricts oxygen supply nearby the root region of poorly drained soil because more moisture retains due to mulching. Surrounded moisture in stem of the plant can create habitat for various microorganisms, pests and diseases, if mulching is done close to the stem. Mulches like grass clipping, straw, hay etc. having seed can encourage germination of weeds.

Inorganic Mulches

Inorganic mulches are commonly used to create obstruction in germination of weeds and also used for decoration. Inorganic mulches like stones, gravels and rocks does not decomposes voluntarily, so they do not participate in improving soil condition but biodegradable and photo-degradable plastic mulches are readily decomposable and improve the soil condition as well after decomposition, because they are made from plant sugar or starches. Heat can be absorbed and reflected by rocks which are useful in dry and hot environmental condition.

Advantages of Inorganic Mulching

Inorganic mulches are cost efficient because they cannot replace frequently, more durable compared to organic mulches because they do not decompose early, conserving soil moisture, save the time, control weeds, maintain the soil temperature, prevents attack of insects and diseases and solarize the soil.

Drawbacks of Inorganic Mulching

Inorganic mulches, except in biodegradable plastic mulches, do not augment any nutrient to the soil because they do not decompose. In several cases inorganic mulch will get damaged by sun in several

cases and starts looking damaged with time. It can increase temperature of soil if established in large areas. Inorganic mulches like rubber may create harm to plants as it is toxic in nature.

Inorganic Mulches Material

The illustration of different inorganic mulches and their usages are given below:

Landscape Fabric

Landscape fabric is a better option to overpower weeds for a long time because it permits water

and air to pass through it. It can also crumble more quickly than most of the other inorganic mulches when it is used in combination with organic mulches. Landscape fabric is generally made up of polypropylene web of high strength and it acts as a stretchy open-weave textile. It can also control the soil erosion and protect the soil from wind and water erosion, when it is used beneath a layer of mulch. It allows drainage of rain water through it into the soil, which is not possible in plastic films. Landscape fabric is more preferable than plastic films most of the time.



Fig. 10: Landscape fabric (Source : <https://www.lawnstarter.com/>)

Stones and Gravels

Stones and gravels are used successfully in dryland fruit cropping. It can lessen evaporation rate, rise infiltration rate and prevent germination of weeds.

solar radiation is echoed by stones, that can create very hot soil atmosphere during hot season. So, it should be used away from trees and other plants.



Fig. 11: Stone mulching (Source: <https://nearsay.com/>)

Rubber

Rubber mulch is made from recycled rubber or tires. It has toxic substance in combination, having

more risk of flammability and can remain in the soil for indefinite period. It is not suggested to use in home gardens. Rubber mulch does not absorb

nutrients or water, effective in controlling weeds, does not decompose or misplace by wind, extremely

cost effective and discourages insects and pests development.



Fig. 12: Rubber mulching (Source: <https://www.rymarrubber.ca/rubber-mulch>)

Plastic Mulch

Plastic mulches are very useful and effective in controlling rate of evaporation. Water and nutrient cannot pass through plastic film because it is impervious in nature. Plastic mulch is best suited for vegetable gardens to increase the temperature of soil in spring season. It is not advisable to use for long period and generally used for only one season because it deteriorates with exposure to

sunlight. In plastic mulching, both types of colored and clear or transparent films are used. Plastic mulches like biodegradable and photodegradable mulches comprises of optical properties which is used for definite crop in a specified location (Steinmetz *et al.*, 2016). It should be used for specific crop after understanding the optimum environment around the ground.



Fig. 13: Plastic mulching (Source: <http://agritech.tnau.ac.in/agriculture/>)

Types of Plastic Mulches: -

Colored Mulches

With the appropriate assortment of plastic mulch composition, thickness and color, soil environment can be accomplished exactly. Many color mulch films are available including red, white, black, silver, clear or transparent etc. But the selection of the color hinge

on definite targets. Different types of colored mulches are described below:

Single Colored Mulch Films:

- White: Cools the soil better than all available colors.
- Red: Increases vegetative production of many

crops.

- Black: It is very helpful in soil moisture conservation, reducing weed growth due to lack of photosynthesis beneath the film, economical in use and does not permit the entry of sunlight through it.

Double Colored Mulch Films:

- Yellow/ Black: Work as ambush for various insects and pests.
- White/ Black: Cool off the soil.
- Silver/ Black: Cool off the soil but not more than white/black film and prevent attack of some aphids and thrips.
- Red/ Black: Partially translucent in nature allowing some solar rays to lead through it to warm up the soil and reflect some

radiation back to plant canopy, which results in vegetative growth, better development of flowers and change in metabolism to increase the production and reduce the time of fruiting in some vegetable and fruit crops.

- Blue/ Black: Restricts reflections of radiation.

Clear or Transparent Mulches

It is used to solarize and increase the temperature of soil.

Reflective Silver Film

It usually keeps cool the temperature of root zone.

Metalized Mulch Film

It delivers extra light to the plant and reflect a range of light which can partially discourage the white flies and aphids to spread disease.



Fig.14: Colored mulch film (Source: <http://agritech.tnau.ac.in/>)

Infra-Red Transmitting Mulch Film

IRT (Infra-Red transmitting) plastic mulch films are available in different colors from green to brown hues. The light is permitted to pass through the

soil bed after getting filtered from the colored films. These films are effective in controlling of weeds and increasing the temperature of soil.



Fig. 15 Biodegradable plastic mulch (Source: <https://www.growingproduce.com/fruits/>)

Degradable Mulches

- Photo-degradable plastic mulch: It gets easily disintegrated by sun during mulching period (Divya and Sarkar, 2019).
- Bio-degradable plastic mulch: It is primarily made from polyester fibers, plant sugars, starches or firewood resources which can come from maize and wheat plants. It gets easily decomposed under natural environmental conditions and gets mixed in soil after mulching period (Divya and Sarkar, 2019). The biodegradable mulches were prominently thinner than the photodegradable mulches (Hannan, 2012).

Advantages of Plastic Mulching

It is totally impervious to water. Plastic mulching reduces rate of evaporation, increases moisture holding capacity, stops the rise of water containing salts, lessens the leaching of plant nutrients, prevent germination of weeds, repel insects and pests,

increases the germination speed, maintains soil structure and reduces soil erosion.

Disadvantages of Plastic Mulching

They are less economical as compared to organic mulches. Black mulch film can develop the risk of scorching of early plants because of increased temperature. Movement of agricultural machinery in mulched field is difficult. Plastic mulching is toxic for animals (Srinidhi and Nazareth, 2018). It can hinder development of roots of the succeeding crop (Schonbeck, 1995). If plastic mulching in soil continues for 5 to 20 successive years it can result into 122 to 146% increase in salt content of top soil (Liu *et al.*, 2014).

Selection of Plastic Mulches

The assortment of plastic mulches be subject to environmental conditions and main characteristics of mulching.

Table 1: Selection of appropriate plastic mulch

Rainy season	Perforated mulch
Orchard and plantation	Thicker mulch
Early germination	Thinner film
Soil solarisation	Thin transparent film
Weed control through solarisation	Transparent film
Weed control in cropped land	Black film
Sandy soil	Black film
Saline water use	Black film
Summer cropped land	White film
Insect repellent	Silver colour film

Source: (Sharma and Bhardwaj, 2017)

Aspects of Plastic Mulching

Application of plastic mulching material in modernize agriculture is termed as plasticulture, which is being used progressively for the production of fruits and vegetables (Kader *et al.*, 2017b, Ibarra-Jiménez *et al.*, 2011; Kasirajan and Ngouajio, 2012). Approximately 10 lakh ton of plastic is used as plastic mulch in agriculture across the globe every year (Yu *et al.*, 2018). China is the biggest user of plastic mulch, around 40% of the world, in the country followed by Japan and South Korea (Daryanto *et al.*, 2017; Ihuoma and Madramootoo, 2017). Plastic mulching has boosted the production

of maize and wheat with the amount of nearly 33.6% and 33.1% respectively in China (Chen *et al.*, 2014).

Effect of Mulching on Soil Water Conservation

Mulching is very helpful in conserving soil moisture in dryland areas after reducing the rate of evaporation (Yang *et al.*, 2015; Kader *et al.*, 2017a; Chakraborty *et al.*, 2008; Zribi *et al.*, 2015). Plastic mulch having moisture barricade properties does not allow escape of soil moisture, because the moisture evaporates beneath the mulch film, after condensing, gone back into the soil as water droplets. Thus, moisture is conserved for many days, that's why increases the

irrigation period and lessens the irrigation demand during period of crop cultivation (Kader *et al.*, 2017b). Plastic mulching is much effective as compared to straw mulching for soil water conservation (Li *et al.*, 2013). Reducing rate of surface evaporation for soil moisture conservation and diminishing soil erosion is the foremost asset of mulching techniques (Qin *et al.*, 2016). Mechanism of transferring heat and water is very important for effective use of mulching material (Li *et al.*, 2018; Kader *et al.*, 2019). Selection of suitable mulching material is very

important to lessen the irrigation frequency in crop cultivation (Chalker-Scott, 2007). Mulches have the ability to retain moisture in the root zone of plants (Smith *et al.*, 1997; Koski and Jocobi, 2004; Duryea *et al.*, 1999), consequently, water may be accessible for an extended period for the plants (Pakdel, 2010). Soil covered with mulches has lesser rate of evaporation in comparison to the bare soil (Singer and Martin, 2008; Steward *et al.*, 2003; lies and Dosmann, 1999; Duryea *et al.*, 1999).

Effect of Mulching on Control of Weeds

In summer season, weeds available in bare soil not covered with mulches can increase the rate of evapotranspiration by 25% (Chalker-Scott, 2007). Organic mulches conquer weeds and burry the seeds of weeds to stop its germination (Koshki and Jocobi, 2004; Duryea *et al.*, 1999; Pakdel, 2010), and if any weeds grow by mistake due to its loose texture, then pulling out of weed is an easy task.

Effect of Mulching on Soil Temperature

Organic and inorganic mulches both are very useful in regulating temperature in root zone of the plants (Singer and Martin, 2008; Koshki and Jocobi, 2004; Steward *et al.*, 2003). In nonliving inorganic mulches the temperature of soil below it at a depth of 10 cm is around 2.5°C higher than the soil at a depth of 10 cm beneath organic mulches. Organic mulches restrict the diffusion of heat energy into the soil which results in decreasing soil temperature (Singer and Martin, 2008). While using plastic mulches, the temperature of soil upsurges approximately 6°C and 4°C at depths of 5 cm and 10 cm respectively, while wheat straw mulch upsurges temperature of soil by approximately 2.3°C (Ramakrishna *et al.*, 2006).

Effect of Mulching on Soil Properties

Compaction of soil is very much common in municipal areas. In this esteem, compression by rainfall, which is due to absence of shield of the soil, is not much understandable (Chalker-Scott, 2007). Mulches are capable to advance the condition of soil for a long period. After using bark mulch obtained from forest tress during 8 years amplified porosity and lessened bulk density of the soil (Oliveira and Merwin, 2001).

Effect of Mulching on Plant's Growth

Mulches can enhance germination and growth of plants in the soil (Smith *et al.*, 1997; Koshki and Jocobi, 2004; Skroch *et al.*, 1992). Mulches can improve establishment of roots, germination of plants and survival of transplanted plants. In organic mulching, there is better growth and density of the plant root system as compared to naked soil and plastic mulching (Chalker-Scott, 2007).

Discussions

It is proved that more favorable soil environment can be obtained by use of mulching to upsurge the harvest of fruits and vegetables (Kumar *et al.*, 2018). Among all the mulches, soil moisture conservation is higher in rice straw mulch and black plastic mulch as compared to soil without mulch. Drop in competition of weeds with the crop and its environment in soil organic carbon were resulted in better growth and yield of vegetables. Based on benefit cost ratio, Soil treatment with rice straw mulches were most economical, followed by black much films (Kumar *et al.*, 2018). Black plastic mulch playing very precious role in the production of various fruits and vegetables. It also increases the habit of early maturity in fruits and vegetables by increasing the temperature of soil, conserving the soil moisture and reducing the use of pesticides. Also, it can protect the soil from leaching of nutrients to root zone in the season of heavy precipitation. Earlier plastic mulches do not comprised of degradation ability but now a days so many degradable plastic mulches such as biodegradable plastic mulches, photodegradable plastic mulches etc., have been developed and they have better ability to deteriorate itself into the soil after the life span of mulches, without adding any negative impact to the soil and that leads to

eliminate the purpose of removal of waste mulches that are designed to be fused into the soil profile (Hannan *et al.*, 2012). For the purpose of control of soil sodicity and salinity, organic and inorganic both mulches are more effective than the unembellished soil. (Ramon *et al.*, 2014). It has seen that, use of plastic mulching expressively increased the yield of crop and water use efficiency by 24.32% and 27.63% respectively (Gao *et al.*, 2018). Plastic mulching had also increased the yield and water using capacity of potato crop noticeably by 30.62%

and 30.34% respectively (Li *et al.*, 2018). Yield of crops and water use efficiency are greatly influenced by method of mulching, type of crop and color of mulch film. Black mulches are more favorable to increase the production and water use efficiency of crop in low rainfall regions (Gao *et al.*, 2018). The yield of tomato reported was highest under plastic mulches followed by newspaper mulching, rice-straw mulches and biodegradable plastic mulches (Divya and Sarkar, 2019).

Table 2: List of crops showing high yield after using plastic mulch

Vegetable crop	Orchard crop
Cabbage	Pomegranate
Cauliflower	Lemon
Capsicum	orange
Tomato	Banana
Brinjal	Peach
Chilli	Guava
Okra	Papaya
Potato	Apricot
	Grapes

(Source: <https://agricultureguruji.com/mulching/>)

Table 3: Increase in Yield of Fruit Crops through Plastic Mulching

Crop	Yield (T/ha)		Increase in yield (%)
	Un-mulched	Mulched	
Banana	53.99	73.32	33.95
Papaya	73.24	120.29	64.24
Ber	7.02	8.92	27.06
Mango	4.93	7.16	45.23
Guava	18.36	23.12	25.93
Litchi	111.0	125.0	12.61
Pineapple	10.25	11.75	14.63

(Source: NCPAH, New Delhi (National Committee on Plasticulture Applications in Horticulture))

Table. 4: Increase in Yield of Vegetable Crops through Plastic Mulching

Crop	Yield (T/ha)		Increase in yield (%)
	Un-mulched	Mulched	
Bitter Gourd	20.12	25.63	27.39
Tomato	69.10	94.85	37.26
Brinjal	36.73	47.06	28.12
Chilli	16.79	19.71	17.39
Okra	6.91	8.56	23.88
Cabbage	14.3	19.9	39.16
Broccoli	15.64	25.14	60.74
Cauliflower	18.58	25.02	34.66

(Source: NCPAH, New Delhi (National Committee on Plasticulture Applications in Horticulture))



Fig. 16: Straw mulching in vegetable (Source : <https://horticulture.ucdavis.edu/>)



Fig. 17: Plastic mulching in tomato (Source : <http://www.tomatonews.com/en/>)



Fig. 17: Plastic mulching in tomato (Source : <http://www.tomatonews.com/en/>)

Conclusions

Mulching, now a days, has become a very useful practice to conserve the soil water and increase the production of various agricultural commodities generally in low rainfall regions. Mulching can increase the moisture holding capacity of soil, lessen the evapotranspiration, reduce the weed growth and moderate the soil temperature. Mulching can increase the water use efficiency of soil, reduce the leaching of nutrients, diminish the soil erosion and increase the infiltration capacity of soil. Mulching can also be useful in beautification of landscape, farmlands and gardens. The selection of mulch materials basically depends on durability, availability and cost-effectiveness. Yields of crops may not essentially increased directly by application of mulching, but more land can be cultivated with the available amount of water and thus overall cultivation of crops can be increased. Organic and inorganic mulches both are very useful in regulating temperature in root zone of the plants. Plastic mulching can readily improve the various soil properties like soil moisture, soil temperature, soil nutrients, bulk density and cumulative stability. There are also various types of plastic mulches are available in market such as black, red, blue, white brown colored mulches, transparent mulches, reflective silver mulches, metallized mulches and infra-red transmitting mulches, which all have different benefits. Yield and growth of plant are also certainly influenced by the use of plastic mulches due to the amendment of soil

microclimate. In spite of many advantages, plastic mulching has also some disadvantages such as high initial cost, more moisture accumulation, soil salinity and disposal of plastic materials but these drawbacks are resolved after the introduction of biodegradable and photodegradable mulches, which can efficiently increase the productivity and control the pollution of soil atmosphere. So, it can be concluded that the use of both organic and inorganic mulches is very useful for increasing the agricultural production with least usage of irrigation water, providing additional nutrients to soil and protecting the soil health from various limiting factors.

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Conflict of Interest

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