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Mulches: Their impact on the crop production

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Abstract

Mulch is an organic or inorganic protective layer that covers the soil and modifies some of the soil properties for the better performance of the crop. Mulching is one of the important techniques that are used in crops to increase crop yield. Even though mulching is commonly done in the horticultural crops, in recent years it is also being used in the field crops. Mulches regulate the soil temperature and reduce the leaching of fertilizer and help in weed suppression and help to increase the crop yield. Nowadays, the usage of water in agriculture has become a concerning issue. So, mulching can be followed as a quick solution to reduce the water loss to a certain extent. This paper reviews the research information published on organic and inorganic mulches. Mulching is done with organic material like straw, cover crops, etc. and plastics are used as inorganic material. The mulches used for the crops are varied depending on the different agricultural environments. The organic mulch adds organic matter to the soil which improves soil health and the black plastic mulch is highly effective than other mulches.

Keywords: Mulches, soil temperature, weed suppression, crop yield

Introduction

Agriculture is an occupation that depends on the natural resources for its progress and among these natural resources water is one of the important limiting factors that play a major role in increasing agriculture production. Farmers in recent years have adopted various techniques to overcome the problem of water usage in crop production. Mulching is one such technique being practiced not only to conserve the water but also to improve the soil's physical characteristics and improve plant growth and increase productivity. 'Molsch'-A German word is the source for the term mulch which means an organic or inorganic material used to spread over the upper surface of the soil (Kaisrajan and Ngouajio., 2012) [25]. Mulching is a technique according to which straw, hay, organic manure or polythene mulch can be used as a protective layer over the soil surface around the plants which helps to create a favorable environment for the plant growth (Chakraborty *et al.*, 2008 and Kader *et al.*, 2017, Yu *et al.*, 2018) [7, 23, 55].

Mulches act as a barrier against soil pathogens and repel certain insects and also suppress the growth of the weeds. The usage of mulch has a negative impact on weed growth and it is considered to be a great alternative to chemical herbicides. Mulches act as a protective barrier and avoid the direct contact of sunlight with the soil which helps to regulate the temperature further accelerates the germination of the seeds and helps in the increase of yield.

Different types of mulches can be used for mulching such as organic mulches or biodegradable mulches and inorganic or synthetic mulches. Organic mulches include crop residue mulch and living mulch. Inorganic mulches include plastic sheet mulches. Plastic mulches are of different types based on the polymers used like High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), etc.

A. Organic mulches

Among different agronomic measures taken to improve the soil health and also to conserve water organic mulches are proven to be effective (Li, *et al.*, 2020) [33]. The application of organic mulches to the crops has been in practice since ancient times though the material used for organic mulch has been varied from present-day agriculture. In the past pebbles, gravel and volcano ash were used whereas now hay, straw (crop residue mulch) and living mulch or cover crop are used in present agriculture.

Cover crop referred to as living mulch is a crop grown till the maturity stage and is cut down and are allowed to act as mulch for the soil. Living mulch can not only reduce the velocity of surface runoff and reduce topsoil erosion by greatly increasing surface coverage but it can also enhance the anti-disturbance effect of soil due to the consolidation of soil roots (Donjatee and

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Tingsanchali., 2016) [11]. Crop residue mulch is a technique where material like straw, stubble of previous crops and leafy organic material brought from other places is used to cover the soil surface (Erenstein., 2002) [13]. Stalks of matured grains after harvest are considered as straw. The most frequently used straw mulches are rice straw mulch, wheat straw mulch and legume straw mulch. Vertical mulch is also considered as the organic mulch. This is a process of making trenches all across the crop lines in a crop and filling them with the stubbles so that they prevent the water from silting and also reduce runoff. Organic mulches tend to provide nutrients to the soil unlike plastic mulches (Sri Lakshmi *et al.*, 2012) [51]. Straw has a higher C:N ratio and releases potassium and nitrogen slowly into the soil which helps to increase the soil enzyme activity and also helps the growth of microorganisms in the soil. Organic mulches maintain low soil temperature by reflecting solar radiation. They also help to improve the water holding capacity of the soil.

1. Organic mulching-effect on soil and plant properties

A seven-year organic mulch study in India has shown that the organic mulch improved soil water and temperature conditions which resulted in improved flowering and pod production and yield of groundnut which is better than that of black mulch (Ghosh *et al.*, 2006) [16]. For the better usage of the organic mulch, the mulch should be applied immediately after the germination of the crop (Bhardwaj., 2013) [5]. Organic mulches have shown their impact on crop production as they are very efficient in reduction of nitrate leaching, improving the soil's physical properties, preventing the soil erosion and the organic matter supply, regulating the temperature and taking part in the nutrient cycle and also increasing the biological activity (Hooks and Johnson., 2003 and Bharadwaj., 2012) [20].

1.1 Effect on soil properties

Mulching helps to regulate the soil temperature by preventing the extremes of the temperature by reducing the soil temperature during the summer and increasing it during the winter. An increase in soil temperature by 2-3 °C can be observed in the peak winter season by the usage of wheat straw mulch (Sarolia and Bhardwaj., 2012) [46]. At night, to increase the soil temperature condensation on the underside of the mulch absorbs the longwave radiation emitted by the soil thereby slowing the cooling of soil (Lamont., 2005) [30]. Mulching reduces evaporation from the soil surface, so more water is available for transpiration, which is of great benefit in the dry areas and plant water status is sustained (Chakraborty *et al.*, 2008) [7]. Nutrient loss happening due to the run-off and leaching can be reduced by the use of organic mulches. Organic mulches act as a vapor barrier and do not allow the

moisture loss and take part in water conservation which leads to increased availability of water to the plants and increases the crop production. The presence of organic mulch at the soil-atmosphere interface has an effect on the infiltration of rainwater and evaporation and helps to reduce surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil (Khurshid *et al.*, 2006) [26]. Trials conducted in higher potential areas of Zimbabwe have shown that mulching appreciably reduced the surface run-off and infiltration rate (Erenstein., 2002) [13].

Mulch protects the surface of the soil against unfavorable factors, reduces nutrient leaching and improves growing conditions for vegetables (Baumann *et al.*, 2000; Kolota and Adamczewska-Sowińska., 2004) [3, 27]. According to (Bharadwaj., 2013) [5] some authors noticed that the treatments with mulches have shown higher uptake of nitrogen, phosphorus and potassium when compared to the non-mulched ones and also it is observed that rice straw mulch increased K-content and decreased P-concentration in some crops.

1.2 Effect on plant properties

An increase in soil temperature and moisture content stimulates root growth which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformly than non-mulched plants (Bhardwaj *et al.*, 2011; Sarolia and Bhardwaj., 2012) [4, 46]. Organic mulches (straw or bark) help to reduce the weeds by avoiding the germination of the weeds by acting as a physical barrier and also by not providing nourishment for the weeds. In the cereal crops, the living organic mulches suppress the weeds without competing with the growth of cereal crops (Ronald, 2018) [42]. Organic mulches help to restore the organic matter and increase the plant nutrient availability to the plants. The soil under the mulch remains loose and friable and leads to a suitable environment for root penetration (Ray, 2016) [41]. Saroa and Lal (2003) [45] and Khurshid *et al.* (2006) [26] reported that organic matter was higher when mulch is applied in more quantity. The higher organic carbon content of the soil was shown in sunhemp mulch (0.71%) and paddy straw (0.66%) mulched plots and the least organic carbon content (0.48%) in the non-mulched plot (Shashidhar *et al.*, 2009). Organic mulches help to induce the early flowering in the plants. This helps to early fruit set and results in early harvesting. Early maturity is obtained due to the maintenance of favourable temperature during the growing period. Mulching helps to keep the fruits/pods clean from contacting the ground and avoid the soil rot and blossom end rot. Marketable fruit or pod yield from the mulched plot was significantly higher than those produced on bare soil as they have differences in soil temperature and mineral uptake.

Table 1.1: Organic mulches effect on crops

	Crop	Best treatment	Result	Reference
1.	Cotton	Wheat straw mulch @10 tonnes ha ⁻¹	Increase the soil moisture availability and increase the nutrient uptake by plants which increases plant growth	Singh <i>et al.</i> , 2021 [49]
2.	Mustard	Paddy straw mulch	Increase in growth (plant height, dry weight) and yield characters (grain yield, straw yield)	Jat <i>et al.</i> , 2017
3.	Sesame	Sesame straw mulch, Sudan straw mulch	Sesame straw mulch has conserved the highest soil moisture content. Sudan straw mulch has given the highest yield.	Goitom <i>et al.</i> , 2017 [17]
4.	Chickpea	Kranj leaf mulch	Increase in plant height and no. of branches and high yield due to optimum availability of nutrients and moisture.	Rajak and Prasad., 2017 [17]
5.	Wheat	Wheat straw mulch	Conserve soil moisture and increase crop productivity.	Depar <i>et al.</i> , 2014 [9]
6.	Black gram	Leaf mulch of <i>Saccharum</i>	Better growth and seed yield of the crop and also improve moisture	Mitra, S., 2011 [35]

	sp. and <i>Gliricidia maculata</i>	storage.	
7. Sorghum	Sugarcane trash mulch	Soil moisture conservation and increase in grain yield.	Chavan <i>et al.</i> , 2010
8. Green gram	Dust mulch	Increase in growth and yield attributing characters (grain yield, straw yield)	Verma <i>et al.</i> , 2008 ^[52]

As mentioned in table 1.1 among the straw mulches paddy straw mulch is more effective than other straw mulches like wheat straw mulch and legume straw mulch. In the crop sesame when different organic mulches like sudan grass, sesame and sorghum mulches are applied they have given better yield over control as these mulches had higher moisture content at different stages which resulted in better growth and yield of sesame. And the sesame straw mulch, sudan grass mulch and sorghum straw mulches are more effective than paddy straw mulch when applied to the sesame crop. In green gram when different treatments like dust mulching and paddy straw mulching are applied dust mulch has given better results in an increase of growth parameters and the lowest density and dry weight of weeds and increased uptake of N, P, K by crops and. Dust mulch is more efficient than the paddy straw mulch in green gram.

In cereal crops like wheat when different organic mulches like wheat straw, mungbean straw, rice husk and farmyard manure

and poultry manure are applied. Wheat straw mulch has retained the soil moisture of 27% followed by farmyard manure and rice husk and the highest grain yield was obtained with wheat straw mulch followed by poultry manure. Wheat straw was found to be more effective when compared to other mulches in increasing crop productivity. Straw mulches are found superior to leaf mulch in the soil water conservation and water use efficiency.

Whereas in a crop like chickpea leaf mulch was found effective compared to straw mulch and dust mulch. In this crop when treatments like kranz leaf mulch, straw mulch, dust mulch are applied where kranz mulch has given the highest plant height and has shown an increase in grain yield. The increase in growth parameters and yield parameters was observed in the kranz leaf mulch treatment as it has retained the high soil moisture content when compared to straw mulch and dust mulch.

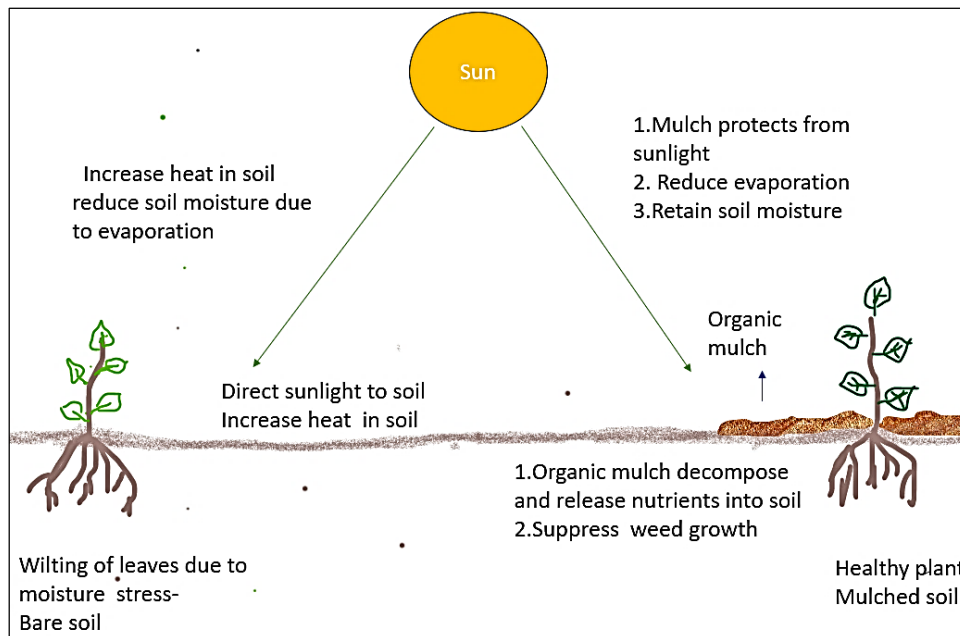


Fig 1.1: Organic mulches-Effect on soil and plant properties

B. Inorganic mulches

The most used plastic mulch is Linear Low-Density Polyethylene (LLDPE) because of its economic use (Bharadwaj., 2013) ^[51]. Poly-ethylene or plastic is the most commonly used material as mulch in agriculture because of its high flexibility, durability and chemical resistance. The plastic mulches act as efficient barriers as they are completely impermeable to the water and prevent the direct evaporation of the moisture is useful for soil solarization. The thickness and color of the plastic mulches may affect the soil. The thickness of the mulch may cause an effect on the soil solarization hence a thin film of 15 microns of plastic mulch is used nowadays. There are different colored mulches used like white film, transparent film, black film, silver color film as the color of the plastic mulch may affect the soil salinity and the soil temperature and the air temperature. The salts remain on the upper surface of the soil when a transparent

film is used and when the black film is used the water movement is restricted and the salts do not move upwards. The black plastic mulch has become popular and has given very good results in arid and semi-arid regions (Bharadwaj *et al.*, 2011) ^[41]. Rubber mulch can also be considered as inorganic mulch. Rubber mulch is made from recycled and pulverized old tyres but it is not preferable as the toxins present in the rubber may cause harm to the soil.

2. Inorganic mulching-effects on soil and plant properties

Even though the plastic mulches were restricted to the colder region in the earlier times their usage has become widely common in the present days as they can be used in all types of soils and all seasons. The usage of plastic mulch in field crops like corn (*Zea mays L.*), cotton (*Gossypium hirsutum*), rice (*Oryza sativa*) and sugarcane (*Saccharum officinarum*) and groundnut (*Arachis hypogaea*) has given great results in many

countries. It was reported by Chen and Katan that the plastic mulching increased soil temperature at the seedling stage by 0.9 to 4.3 °C, 1.6 to 2.3 °C at the bud initiation stage and 0.8 to 1.9 °C at the flowering stage. The findings of the other scientist have shown that there is an increase of 2.9-3.3 °C in soil temperatures with transparent, photodegradable polythene film mulching (Ray and Biswasi., 2016) [41].

2.1 Plastic mulches: Effect on soil properties

Soil temperature is one of the major soil properties that have an impact on crop production as systems and processes involved inside a soil mainly nutrient uptake, absorption of water root growth, and life of soil microorganisms depend on the level of soil temperature (Sabri *et al.*, 2018) [44]. Gordon *et al.*, 2010 [18] have expressed that there is a difference in soil temperature by plastic mulches and row cover as the highest temperature (31.2 °C) was recorded by black plastic mulch with row cover and the lowest was recorded from bare soil. Covering the land with black and white plastic mulch during the growing period of the plant helps to increase the soil temperature as they tend to increase the temperature up to 60 °C by trapping the solar radiation. Whereas an increase in the canopy of a plant results in the increase of shading on plastic mulch and causes the restriction of direct interception of solar radiation and heat transfer from surrounding air and soil which results in the reduction of rootzone temperature and reduction of soil temperature (Diaz *et al.*, 2010 and Lee *et al.*, 2020) [31]. The temperature of the soil can be enhanced by the plastic mulches when compared to no mulch. But, the decision on selecting the type of colours depends on the climate, soil type, crop type and intended purpose (Amare. and Desta., 2021) [1].

2.2 Plastic mulches: Effect on water use efficiency

Water plays a major role in the plant's life by playing a crucial role in processes like transpiration and photosynthesis. Mini. Mizing the water loss and increasing the optimum water availability level for the crop helps to enhance the plant growth, development, and yield hence there were many technologies that were introduced to enhance the availability

of water for plants and to protect against water loss. Mulches help to enhance the availability of water for plants by their impact on reducing erosion, evaporation, surface temperature, wind impact and weed infestation (Döring *et al.*, 2005; Bucki *et al.*, 2019 and Niziolomski., 2020) [12, 6, [37]. Plastic mulches have a better effect on the yield and water use efficiency of plants when compared to conventional tillage patterns because of their impact in the reduction of evapotranspiration from the soil surface. (Amare and Desta., 2021) [1]. It is reported that there is an increase in the water use efficiency of wheat and maize by using plastic mulch (Qin *et al.*, 2014) [38]. Plastic mulches show the impact as they can decrease the soil bulk density, increase soil porosity and enhance the nutrient contents (Hou *et al.*, 2015) [21].

2.3 Plastic mulches: Effect on plants

Plastic mulches play an important role in crop growth and development, for example black and silver plastics are significantly more effective in an increase of leaf area than bare land. These black and silver plastic mulches help in enhancing leaf area which would increase the rate of photosynthesis and plant yield (Arancibia., 2008 and Ruíz-Machuca., 2015) [2, 43]. Plastic mulches help to improve the micro-climate around plants by maintaining the optimum growth environment like adequate moisture and root zone temperature which results in increased cell expansion and elongation which can increase the growth and development of plants (Li *et al.*, 2004; Franquera *et al.*, 2015) [32, 14].

The changes in the temperature at the root zone caused by the plastic mulches may affect the yield. In wheat and maize plants plastic mulches have visibly increased the yield of the plants by 20% and 60% respectively (Qin *et al.*, 2014) [38]. Weed suppression is reported as one of the positive impacts of plastic mulching because of its effect on shading which can reduce the germination and seedling growth of weeds (Rajablarajini., 2014). Some other reports have informed that plastic mulch reduced the dry matter of weeds by 63.8% compared with an un-mulched land (Mahajan *et al.*, 2007) [34]. Plastic mulches are also effective in reducing the incidence of viral diseases, whitefly population, and aphid population.

Table 2.1: Inorganic mulches effect on crops

S. No.	Crop	Best treatment	Result	Reference
1.	Chickpea	Black Plastic mulch	Increased the growth (plant height, no. of primary branches/plant) and yield attributes (no. of pods/plant, seed weight/plant at harvest.	Garhwal <i>et al.</i> , 2020
2.	Red gram	Black Plastic mulch	More effective in reducing the soil moisture loss.	Solanki <i>et al.</i> , 2019 [50]
3.	Maize	Plastic mulch	High N uptake and increase in grain yield.	Wang <i>et al.</i> , 2018 [53]
4.	Chickpea	Polypropylene woven mulch	Increase in plant height and no. of branches per plant.	Komal <i>et al.</i> , 2018 [28]
5.	Blackgram	Plastic mulch	Has a significant effect on plant height, no. of branches per plant, pods per plant.	Mahale <i>et al.</i> , 2018
6.	Mustard	Polythene mulch	Conserve more moisture and increase yield.	Mondal <i>et al.</i> , 2008 [36]
8.	Mustard	Black plastic mulch	The treatment was weed-free and resulted in increased no. of siliqua per plant and seed yield.	Kumar and Premi., 2003 [29]

As per the findings of many researchers, we observe that plastic mulches just like organic mulches help to retain the soil moisture and increase the plant growth and result in higher grain yield. Among the plastic mulches used Polypropylene woven mulch is more effective than the plastic mulch when applied to chickpea crop. And when organic and plastic mulches are given as treatments to the crop it was observed by most of the researchers that plastic mulches have given a higher yield when compared to organic mulches. Polythene mulch application has resulted in the lowest weed

biomass and application of this mulch can reduce the growth of certain species of mono and dicotyledonous weeds which helps them to increase crop productivity. Mulches increase the plant height and number of branches/plant (Awal *et al.*, 2016). Black plastic mulch has given higher results in growth parameters like plant height and the number of branches/plant and seed yield when compared to that of straw mulch. When observed in some crops like red gram organic mulches like sugarcane trash mulch has given a higher yield when compared to plastic mulches.

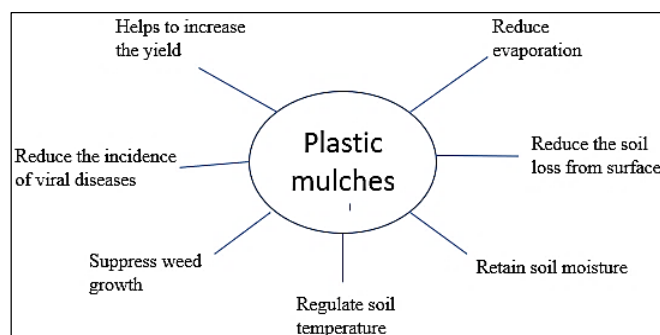


Fig 2.1: Inorganic mulches-Effect on soil and plant

Conclusion

As per the opinion of many researchers mulching with the use of both organic and synthetic mulches have an impressive effect on crop production because of their properties like regulating the soil temperature and also reducing the surface runoff and reducing the moisture loss. In the coming future where there are visible signs of water scarcity mulching is an effective method to follow for conserving water. And different plastic mulches are helpful based on their characteristics like repelling the pests like aphids. Black plastic mulches have higher results than any other mulches but the increase in pollution by the use of plastic can be a problem. As many new methods and new types of mulches are being introduced, the biodegradable film can be used in place of plastic mulch, organic mulch helps to add organic matter to the soil and increase the soil properties. In this way, both the organic and inorganic mulches are helpful and useful to the farmers for increasing their crop production.

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