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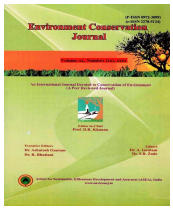

Reflective mulch films a boon for enhancing crop production: A review

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ABSTRACT

Mulches are materials that are put to the surface of the soil for a variety of reasons. Plastic mulches of various colours have been developed and employed in a variety of agricultural production methods. Colored plastic mulches are used to modify the radiation budget and prevent soil water loss. It also helps with weed and insect infestation, as well as soil temperature regulation, water efficiency, plant development, yield, and quality. This paper reviews and discusses the understanding and prospective application of coloured plastic mulches to improve soil physical attributes growth, yield, and crop quality. Colored plastic mulches' effectiveness in minimising the detrimental impacts of environmental stress on crops is also explored. The impact of coloured plastic mulches on soil temperature has been documented by several researchers to vary from area to area and crop to crop. Various physicochemical mechanisms have also described that result in increased crop productivity when coloured plastic mulches are employed. Colored plastic mulches have a significant impact on soil temperature, moisture, and water holding capacity, according to the study. Clear and white plastics lower the temperature of the soil, but black and blue plastics raise it. A higher number of fruits, roots, tubers, and bulbs were produced when coloured plastic mulches were used. TSS, Vitamin C, and the proportion of liquid in diverse plants all improved significantly. Infestation of weeds and viral diseases has also been found to be significantly reduced. Reduced plant growth and yield, increased pest infestation, microplastic pollution, soil puddling, soil structural loss, and reduced soil-microorganism activity are some of the disadvantages of coloured plastic mulches. As a result, using coloured plastic mulches demands a detailed investigation of interactions with factors such as cropping season, root zone temperature, crop type, insect pest infestation, and water use efficiency.

Introduction

Farmers all around the world are using various types of including, both organic and inorganic, which are used not only to conserve water but also to reap other benefits such as reducing weed and pest infestations. Inorganic mulches, such as plastic mulch films, have become more popular among farmers due to their ease of transport and installation. The research work done on several types of reflective plastic mulch films is examined in this paper, and distinct case studies based on the colour of the mulch films used in their studies are described.

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Black coloured plastic mulch film

In India, black colour reflective plastic mulch films are the most widely available and used films. The black colour mulches, like other plastic films, inhibit weed development and decrease soil temperature during hard winters. UV (ultraviolet), visible, and infrared wavelengths of solar light are all efficiently absorbed by it. By absorbing a large amount of radiation, it had a considerable impact on increasing soil heat. Black plastic mulches recorded greater temperatures than olive, silver, white, and blue colour films, according to a study (Shah *et al.,* 2018). According to reports, black plastic mulch films are more effective than white, aluminum/black plastic mulch films in boosting minimum, maximum, and mean soil temperature (Claudio *et al*., 2017). Many crops yielded more under black-colored mulch films than in bare fields (Rashidi *et al*., 2010; Berihun 2011; Bhatt *et al.,* 2011; Hatami *et al*., 2012; Kumar and Lal 2012). The effects of black polyethylene plastic mulch on okra and squash growth and yield under rain-fed conditions revealed that plants with polyethylene mulch produce larger fruits and higher fruit yield per plant. This is due to better plant growth caused by a favourable hydro-thermal regime of soil and a completely weed-free environment (Mahadeen, 2014). In comparison to control, the study found that extended moisture retention and availability resulted in higher nutrient uptake for optimum plant growth and development. The goal of the study (Mohammad *et al.,* 2018) was to create ways for reducing salt impact in maize crops using three different coloured plastic mulches (blue, black, and white), rice straw mulch, and a non-mulch control (bare soil). In 2016 and 2017, the black plastic mulch had 0.2 and 1.0 °C lower temperatures than the control, whereas the rice straw mulch had 2.0 and 1.5 °C lower temperatures than the control. At 5 and 10 cm depth, (Deshmukh *et al*., 2013) discovered the highest soil temperature under black plastic mulch, followed by no mulch and paddy straw mulch. They discovered a strong correlation between soil temperature and 1000-grain weight in the experiment. Studies on influence of mulch film removal date on potato indicated that the water use efficiency (WUE) was highest under black plastic mulch that was removed on the 60th day (50 kg tuber/ha mm) after sowing, over no mulch condition (34 kg tuber/ha mm) (Gangwar *et al.,* 2017) (Fig 1). The treatment of black mulch film removed on the 60th day after sowing produced the maximum yield (30.2 t/ha), followed by silver mulch removed on the same day (29.3 t/ha), and no mulch (20.8 t/ha).

Figure 1: Black coloured plastic mulch film

Silver coloured plastic mulch film

In comparison to black and white plastic mulches, silver plastic mulches reflect more radiation. The root zone temperature and water loss are reduced as a result of the increased refection of radiations (Rylander *et al*., 2020). This plastic mulch's fundamental qualities make it effective at conserving water and preventing water loss (Díaz-Pérez 2010; Rylander *et al*., 2020). The mean soil temperature has influence on plant growth characteristics such as stem diameter, plant height, leaf length, leaf dry weight, stem dry weight, and plant dry weight. In the hot season, silver plastic film mulching produced better yields than black plastic film mulching, but in the cold season, the opposite is true. Under silver plastic mulch, the maximum weight of fruit per plant (1 kilogram) was reported by Sarkar *et al*., 2019. Total soluble solids, reducing sugar, non-reducing sugar, vitamin C, and pyruvates were all higher in onion crops cultivated beneath silver polyethylene film. The explanation for this is that the reflective aspect of the film increases microbial activity in photosynthesis by increasing S and K activity (Helaly *et al*., 2017; Sarkar *et al*., 2019). Aphids (and the viral illnesses they carry), whiteflies, cucumber beetles, and other pests are deterred by the reflective aspect of film (Rao *et al*., 2018; Saxena 2018). Crops grown under silver plastic films had a higher leaf area than those grown on bare soil (Fig 2). Experiments on a Chickpea crop

in the winter season showed that silver plastic mulch films (17.21 kg/ha mm) provided superior water use efficiency than a crop without mulch (Rao *et al*., 2021). A study on the effect of different mulching materials and mulch colour on watermelon growth and yield found similar trends. The efficiency of water and fertilizer consumption in a crop grown under a silver-colored mulch film was found to be 60% greater than in a crop grown without one (Rao *et al*., 2017).

Figure 2: Silver coloured plastic mulch film

White coloured plastic mulch film

White mulches are generally used for reflecting incident solar radiation so as to moderate micro climate near the vicinity of plant environment. When white plastic mulch films are placed on the soil top, they chill the soil and are commonly employed in crops that do not require much heat (Lament, 2017; Agrawal, 2010). According to the findings, crops farmed beneath plastic mulch films have earlier branching and are lower in height than crops cultivated using traditional methods. White and clear plastic mulches are more successful in reducing the incidence of viral illnesses, whitefly population, and aphid population, according to studies (Brown *et al*., 2019). White plastic films keep the soil cool longer than black, dark, or transparent plastic films (Snyder *et al*., 2015) (Fig 3). The warming effects of mulch films are advantageous in the spring when soil temperatures are below ideal, but they could be detrimental to plant growth later in the season (Snyder *et al*., 2015).

Red coloured plastic mulch film

Red plastic mulch is more efficient than black, blue, green, and yellow plastic mulches at absorbing global sun radiation. According to some studies, the energy balance is described in the following order: red>transparent>green>blue> yellow>black (Díaz-Pérez, 2010; Deshmukh *et al*., 2013; Claudio *et al*., 2017). When compared to other coloured films, certain crops perform better when planted in red mulch. Tomatoes, for example, produce 20% more fruit; basil leaves have a higher surface area, succulence, and fresh weight; and strawberries smell better, taste sweeter, and produce a larger harvest. Researchers discovered that red mulch increased tomato and eggplant yields when compared to black mulch. Tomatoes grown in red mulch produced more mature fruit and set fruit earlier than those cultivated in black plastic (Fig 4). Phytochromes are pigments found in tomato plants that contain color-sensitive proteins and react differently to different light spectra. When far-red light wavelengths from the plastic reflect back up to tomato plants, phytochromes help the fruit grow quicker (Rao *et al*., 2016; Trivedi and Nandeha, 2020). Plants planted in red mulch are taller than those cultivated in other coloured mulch treatments in red bell pepper. The lettuce (Lactuca sativa) with the most leaves was planted on red mulch.

Figure 3: White coloured plastic mulch film

Fig 4: Red coloured plastic mulch film

Other colour mulches

Other coloured mulch films have been studied in other crops; however, the results are very subjective to a specific crop or disease. When crops were covered with yellow mulch films, they did not perform well when aphids attacked because the colour of the film attracts them. Blue mulch is used in the Cantaloupe crop. This resulted in a 35% increase in yield over black plastic films. Under blue mulch films, there was a 30% rise in cucumber and a 20% increase in summer squash when compared to black mulch films. However, because the blue colour attracts thrips, it's best to avoid using it in thrips-prone crops like bell peppers and tomatoes. Brown Infrared Transmitting (IRT) plastic mulch films are a relatively new crop protection technology. IRT is a technology that combines the weed-suppressing features of black plastic with the heat-absorbing qualities of clear plastic. It warms garden soil better than black plastic early in the growth season and reduces weeds. Brown mulch can help naturally repel insects like termites, cockroaches and crickets. Brown mulch is beneficial to soil because it adds nutrients and moisture. Various mulches are depicted in Fig.5.

Figure 5: Other colour mulch films

The crop specific recommendations of colour of the mulch film to based on the studies conducted across the country in different seasons are presented in Table1.Plastic mulches alter plant microclimate by adjusting the reflectivity and absorptivity of the topsoil around the plant, according to research. The table below shows the impact of different polymers on soil temperature, radiation, and weed control (Maughanand and Drost, 2016) (Table 2).

Table 1: Crop specific recommendations of colour of the mulch film

Name of the crop	Colour of the mulch film recommended	Season	Reported by
Watermelon	Silver	Summer	Parmar *et al*. (2013); Rao *et al*. (2017); Dadheech *et al*. (2018)
Tomato	Red	Winter	Agrawal *et al*. (2010); Rao *et al*. (2016)
Potato	Black	Winter	Karam *et al*. (2016); Gangwar *et al*. (2017); Li *et al*. (2018); Qiang *et al*. (2018); Kader *et al*. (2021)
Chickpea	Silver	Winter	Rao *et al*. (2021)
Capsicum	Black	Winter	Ashrafuzzaman *et al*. (2011); Claudio *et al*. (2017)
Pea	Black	Winter	Awal *et al*. (2016); Khan *et al*. (2018)
Cauliflower	Black	Winter	Mintu *et al*. (2018); Kumar *et al*. (2020); Tawfeeq and Abdulrhman (2021)
Strawberry	Black	Winter	Bakshi *et al*. (2014); Adnan *et al*. (2017); Sharma and Goel (2017); Rannu *et al*. (2018)
	Red		Posada *et al*. (2011)

Table 2: Effect of various plastic colours on light and weed control (Reddy *et al*. 2020)

Plastic color	Soil Temp. (2-4" depth)	Light Reflectivity	Light Absorptivity	Weed Suppression
Black	Increases (3 to 5 ℉)	Low	High	Excellent
Clear	Increases (6 to 14 ℉)	Low	Low	Poor
White/silver	Decreases(-2 to 0.7 ℉)	High	Low	Excellent

Conclusion

These findings could have a lot of implications for farmers. Mulch films may provide improved flexibility and the ability to develop with better assurance due to the numerous types of microclimate management that can be achieved. These investigations found that these films give insulation against temperature extremes, and that choosing different colours of films can result in effects ranging from higher to lower average temperatures. Mulch films also reduced the need for irrigation and other methods of water management by covering the soil bed with these films, which prevented both extreme wet and dry conditions. Root zone temperature, microbial life, soil properties, and moisture levels have all been proven to be influenced by coloured plastic sheets. By improving the plant microenvironment, these mulch films boosted plant growth, fruit quality, and yield. Black and silver-colored plastic mulches were found to benefit the majority of the crops. However, choosing the right film colour for a specific crop in a specific season of the year will assist farmers boost their economic returns by increasing agricultural yield.

Conflict of interest

The authors declare that they have no conflict of interest.

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