



AGRONOMIC IMPORTANCE OF MULCHING IN CROP PRODUCTION: A REVIEW

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ABSTRACT

As the population of Nigeria is continuously increasing, we have to adopt some means of sustaining our agricultural growth and it can be done through conservation farming. The best way out is the adoptions of the age long practice of mulching in our agricultural fields. Mulching has become an important practice in modern field production due to benefits such as increase in soil temperature, reduced weed pressure, moisture conservation, reduction of certain insect pests, higher crop yields, and more efficient use of soil nutrients. Plastics are the most widespread mulching materials, and especially black polyethylene is used almost everywhere due to its low price and has proved positive results in production, also in the fields the use of biodegradable films is increasing because they can be left safely in the field after harvesting, but they are not very durable and are much more expensive than plastics. This article reviews the published research on mulches. Different mulching materials have been used for different agricultural and horticultural species in different climatic environments, and results vary according to the chosen approach, growing practices, conditions and species, thus generalizations are hard to make.

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INTRODUCTION

The word mulch is most likely originated from the German word "molsch," which means "soft to decay." It seems that this word referred to the mulch that gardeners lay on the ground by using straw and leaves. Mulching reduces weed infestation, controls water evaporation, and prevents runoff and soil loss, all of which contribute to the reduction of soil deterioration that can lead to degraded soils. As a result, it increases soil moisture retention, aids in temperature regulation, boosts the physical, chemical, and biological qualities of the soil, adds nutrients to the soil, and eventually promotes crop development and production [1]. Additionally, it has been observed that mulching increases yield by 50–60 % compared to none mulched soils. By applying various materials to the soil's surface, farmers and horticulturists can improve the quality of agricultural soils through a process called mulching. Enhancing the physical environment of the soil can lead to increased crop yield [2, 3].

Mulching can be done with a variety of materials in contemporary crop production such as crop leftovers, different plastics, biodegradable films, and various types of paper mulches—either coated or uncoated with plastic or biodegradable film—are options available to farmers and horticulturists.

Depending on the crop species, growing conditions, and production methods, different types of mulch may have varying effects on crop growth.

Organic mulching

Natural mulch made of organic materials offers several advantages. It minimizes soil erosion, lowers soil temperatures, prevents weed growth, promotes the growth of beneficial and healthy soil microorganisms, and stops soil from splashing onto plants during rainstorms and irrigation, all of which help to conserve soil moisture and prevent the spread of soil-borne pathogens. Mulch can also stop trees and plants from needing to be mowed around them, protecting the trunks from mechanical harm. Mulch acts as winter protection by preventing plant roots from being forced upward out of the soil during freeze-thaw cycles. Additionally, it can be applied to stabilize regions that have been eroded by wind and water. As organic mulches break down over time, the soil's structure and quality are improved and nutrients are replenished [4].

The process of covering the soil surface with the organic residue left over from the previous crop, such as straw, maize stalks, palm fronds, or a stubble of leafy organic material that may have been brought in from somewhere else, is known as "organic mulching" or "crop residue mulching" [5]. Woody materials like

bark or sawdust are examples of organic mulches. Compost, which is becoming more readily available in areas where municipalities have green waste recycling programs, is another type of organic mulch [6]. Reduced maximum soil temperature in warmer climates has been linked to better production and higher growth, according to some researchers. A seven-year study on the benefits of organic mulching over black or transparent polythene mulch or bare ground revealed that this benefit was partially attributable to better soil temperature and water conditions, which enhanced groundnut flowering, pod production, and yield [7].

Types of organic mulch

Bark (hardwood)

Shredded hardwood comes in a variety of sizes, from chips to bigger nuggets, and is a byproduct of the paper and timber industries. This kind of mulch is typically utilized in perennial beds and surrounding trees and plants. There are two types of shred bark: natural and coloured. Artificial dyes are added to a mixture of hardwood or recovered wood waste to create dyed variants.

Bark (softwood)

Another byproduct of the paper and lumber industries is softwood bark. One such example is pine bark, which is commonly placed beneath big trees and bushes. Compared to other forms of organic mulch, pine bark does not need to be replaced as frequently because it is naturally somewhat acidic and takes longer to break down.

Leaf mulch

Shredded healthy leaves can be composted at home to make leaf mulch. You can use leaf mulch in every garden bed. Leaves with possible scab, leaf spot, or anthracnose infections should not be composted for mulch; instead, they should be disposed of.

Grass clippings

Grass clippings can be added to vegetable and perennial beds in thin layers and then removed at the end of the growing season. Prior to applying more layers, let each layer dry. Apply in thin layers to avoid matting of the clippings. Grass clippings from lawns treated with pesticides or herbicides should not be used. Moreover, avoid using grass clippings that have germinated to stop unwanted turf grass from sprouting in garden beds.

Composted animal manure

Animal dung that has been properly composted can be added to soil or used as mulch. Since composted animal dung adds nutrients and enhances soil quality, it is a great option for newly constructed planting beds. Since fresh manure can burn plant roots, it should not be applied to garden beds. Also, avoid the use of farm yard

manure that have not been composted to reduce introduction of weeds and spread.

Municipal tree waste

Mulch is frequently provided to residents at no cost by utility companies and arborists from the city or town. Usually, this mulch is composed of bigger wood fragments. When it breaks down, the fresh material will use more of the nitrogen in the soil. Pathway construction is a great usage for this kind of mulch.

Benefits of organic mulching

i. Soil moisture conservation

Mulching preserves plant water status and decreases ineffective evaporation from the soil surface, increasing the amount of water available for transpiration in water-limited situations [8]. By shielding the soil's surface, organic mulch also reduces erosion and minimizes nutrient loss from runoff and leaching [9]. When compared to the control (without mulch), straw mulch was able to retain 55% more soil moisture. When comparing bare soil to mulched wheat residue at a rate of 6730 kg/ha, the average amount of accessible soil moisture stored down to a depth of 1.5 m in the soil rose significantly. Under straw mulch, okra production was noticeably higher than under dust mulch.

ii. Reduction of infiltration rate

Mulch cover slows down surface runoff and retains precipitation at the soil's surface, allowing it to seep into the ground over time [10]. When the soil's surface was covered, the amount of irrigation water needed for the crops of peppers and onions was reduced by around 14 to 29 and 70%, respectively. Mulching dramatically decreased surface runoff and infiltration, according to trials carried out in Zimbabwe's higher potential areas [11].

iii. Maintenance of soil temperature

Mulching prevents temperature extremes by raising soil temperature in the winter and lowering it in the summer. During the height of winter, the soil temperature was increased by 2–30°C by using mulch made of wheat straw [12]. When bare soil is replaced with clear mulch, the temperature of the soil was raised by as much as 7°C; an increase of 0.8°C under black film and 2.4°C on average for the soil temperature at a depth of 15 cm under transparent film. The long wave radiation that the soil emits at night is absorbed by condensation on the mulch's underside, which slows the soil's cooling process [13].

iv. Reduction of fertilizer leaching

Fertilizer loss from leaching is minimized while the root zone is flushed by severe rainfall. This is especially valid for soils that are sandy. This enables the grower to fertilize the row with extra pre-plant fertilizer before the

crop is planted. The N, P, and K content of chili leaves were boosted by mulching with coconut fronds and quicker plant growth, earlier fruiting, and higher concentrations of N and P in leaves and fruits were achieved [14]. Additionally, they found that when compared to bell pepper leaves without mulch, rice straw mulch enhanced the K-content and lowered the P concentration. According to Hundal *et al.* [15], tomato mulched plots had considerably greater concentrations of nitrogen and phosphorus as well as higher nutrient uptake than un-mulched plots. Worthington [16] states that increased nitrogen contents that are available to the plant enhance the development of proteins in cabbage. Additional sources of available nitrogen include vetch and serradella mulches, which coexist in symbiosis with nitrogen-fixing bacteria and provide additional nitrogen. Mulch minimizes nutrient loss, shields the soil's surface from adverse elements, and enhances vegetable growth conditions. Compared to similar un-mulched treatments, mulched treatments exhibit considerably higher overall uptake of potassium, phosphate, and nitrogen [17].

v. Reduction of weed infestation and growth

Mulching inhibits weed germination and nutrition by establishing a physical barrier. The process of mulching helps to suppress weed growth and seed germination while maintaining weed control. The surface of the soil can be covered or mulched to physically suppress seedlings emergence or stop weed seeds from germinating. Effective weed control can be achieved with loose materials like straw, bark, and municipal green waste that has been composted. Because sawdust retains soil moisture, reduces runoff, boosts infiltration and percolation, lowers evaporation, and inhibits weed growth significantly under clear mulch, thus, it serves as a soil amendment and weed suppressor. While brown, black, blue, or white on black (double colour) films inhibited weed growth, white, clear, or mulch and green covering had no effect on weeds [18]. Significant variations in weed control were also noted by Ossom *et al.* [19] between eggplant plots that were mulched and those that were not.

vi. Addition of organic matter

After decomposition, organic mulches improve the physical, chemical, and biological qualities of the soil and replenish it with organic matter and macro and micro nutrients, all of which boost crop output. Beneath the mulch, the soil is still loose and friable, creating an ideal condition for root penetration and water percolation. By adding organic matter, organic mulches improve soil nutrients in addition to preserving soil moisture. Bulk density is lower under straw mulch (1.42 g cm⁻³) as against bare soil (1.50 g cm⁻³). According to Khurshid *et al.* [20], applying additional mulch resulted in a much higher amount of organic matter. Sun hemp

mulch had the highest organic carbon content of the soil (0.71%), followed by paddy straw (0.66%), silkworm bed waste (0.68 %), and non-mulched plots with the lowest organic carbon content (0.48%). It shortens the harvesting season, promotes earlier maturity and higher yield when warm-season crops like cucumbers, muskmelons, watermelons, eggplant, and peppers are mulched [21].

vii. Improvement of quality and yield of crops

Mulch, in many circumstances, prevents soil rot, fruit cracking, and blossom end rot while keeping fruits away from the ground. Fruits typically have fewer scars and are smoother. Grading time can be shortened by using properly installed plastic mulch to prevent soil from splashing onto the plants during rainy seasons. It was discovered that the yield and chemical makeup of eggplant, muskmelons, cucumbers, and tomatoes had improved. Straw mulch may increase the output and quality of storage for potatoes, cabbage, and other vegetables. Tomato and okra yields were enhanced by 100% and 200%, respectively, over control when straw mulch was applied at a rate of 6 tonnes/hectare. The amount of marketable fruit produced in a mulched plot was noticeably more than that of a bare soil plot. This difference can be ascribed to improved root temperatures in the mulched plot, improved moisture conservation, weed control, and higher soil temperature. Yield of 2.5 t ha⁻¹ of dried chili fruits were generated by applying 40 t ha⁻¹ of organic mulch. Compared to the control, bell pepper fruit output increased with organic mulch. Paddy straw mulch was superior to un-mulched in terms of potato yield (27.9%) and starch content (18.18%).

Inorganic mulching

Weed barriers are typically created with inorganic mulches. In addition, they serve as decorations. Rocks and gravel are examples of inorganic mulch that does not break down easily. In hot, dry weather, rocks can be harmful because they both absorb and reflect heat. Inorganic mulches do not increase soil quality because they rarely break down.

Types of inorganic mulch

i. Plastic film (polyethylene): Plastic film is impermeable, preventing the passage of nutrients and water. For optimal results, place plastic along vegetable rows to warm the soil in the spring. It's not the ideal option for continuous use. Plastic film is typically only used for one season because it deteriorates when exposed to sunshine.

ii. Landscape fabric: Because it lets air and water through, landscape cloth is a superior option for long-term weed suppression. It may be used in conjunction

with organic mulches and breaks down faster than most other artificial mulches.

iii. Stone: Crushed gravel, marble chips, and volcanic rock are a few examples. Stones should be utilized away from trees, shrubs, and other plants because they don't hold moisture and can induce heat stress on plants through reflection and ground heating, which can burn roots.

iv. Rubber: Ground or recycled tires make up rubber mulch. Although study on this product is still ongoing, preliminary findings point to potential flammability and toxicity levels. Rubber mulch can also be left in the ground for an endless amount of time. Using it in your home's landscaping is not advised.

Plastic mulch

The primary purpose of plastic during its early use in cold climates was to provide warmth. Due to its many advantages, including higher soil temperatures, plastic is now utilized in a variety of climates, soil types, and seasons. Production of peanuts (*Arachis hypogaea*) has increased dramatically as a result of plastic mulch. Similarly, many nations have found success with using plastic mulch in field crops like rice (*Oryza sativa*), corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), and sugarcane (*Saccharum officinarum*). Nowadays, the majority of producers globally produce fresh market veggies in raised beds that are drip irrigated and coated with plastic mulch. At the seedling stage, the plastic

mulching raised the soil temperature by 0.9 to 4.3°C, or 1.6 to 2.3°C.

i. Plastic mulch and yield quality

Vegetable farming has shown notable yield gains over the past few decades in various parts of the world. The use of drip irrigation in conjunction with plastic mulch has been a significant factor in yield increment of several vegetables, including cucumber, squash, muskmelon, eggplant, tomato, and pepper. However, there aren't many reports on using plastic mulches in broccoli. Reflective mulch was found to increase the level of soluble solids, total phenolics (aromatic chemicals that provide anti-microbial protection), flavanols, and anthocyanins (water-soluble pigments linked to flavonoids properties) in wine grapes grown in Ontario [22]. Plum soluble solids were also shown to rise with reflective mulch [23]. Modifying the hue of the plastic mulch may change the amount of anthocyanins in butterbeans. The usage of yellow and black mulches led to increased concentrations of phenolics in carrots, and strawberries that ripened over red plastic mulch had much higher scent and flavor components. Additionally, as compared to other coloured mulches and bare soil treatments, the application of yellow and white mulches increased the quantity of ascorbic acid—a water-soluble sugar acid with antioxidant properties—and α -carotene—organic molecules with orange hues in plants—in carrots [24]. For further illustrations, data on Tables 1 & 2 below showed the yield increments per hectare of fruit and vegetable crops, respectively as influenced by plastic mulch.

Table 1: Increase in yield of fruit crops through plastic mulching

Crop	Crop Yield (T/Ha.)		Increase in yield (%)
	Un-mulched	Mulched	
Guava	4.93	7.16	7.16
Mango	73.24	120.29	120.29
Papaya	7.02	8.92	8.92
Ber	10.25	11.75	11.75
Pineapple	53.99	73.32	73.32
Banana	111.0	125.0	125.0

Table 2: Increase in yield of vegetable crops through plastic mulching

Crop	Yield (T/ha)		Increase in yield (%)
	Un-mulched	Mulched	
Broccoli	15.64	25.14	60.74
Cauliflower	18.54	25.02	34.66
Tomato	69.10	94.85	37.26
Okra	6.91	8.56	23.88
Bitter gourd	20.12	25.63	37.39
Chili	16.79	19.71	17.39
Gabbage	14.3	19.9	19.9

Source: Kasperbauer and Antonious [24].

ii. Plastic mulch and pest management

The degree of weed control offered by plastic mulches varies based on how much light passes through them. During the growth season, plastic mulch decreased weed emergence by 64 % to 98 %. Although they usually don't warm the soil as much as clear mulch, black mulches are better in controlling weeds [25]. A hectare of hand weeding in non-mulched plots requires more man-hours than in areas covered with plastic mulch. At a premium price, wavelength selective or infrared transmission mulches combine the weed-controlling properties of black mulch with the soil-warming properties of clear mulch [26]. Reflected energy not only affects plant growth and development but reportedly influences the behaviour of insects surrounding the plants. Mulches may also protect the crop from insect pests or diseases [27]. Silver leaf whitefly populations that are comparable to those obtained from imidacloprid treatment can be controlled with reflective plastic mulch [27].

Interference with visual cues can increase attraction or repulsion to plastic mulched fields and, consequently, crops enclosed within them, as many insects rely on these cues to locate host plants. Additionally, aphids exhibit repulsion against certain colours, like silver, and attraction to others, like yellow, green, and bare soil. The application of coloured plastic mulches to prevent or postpone the start of certain insect-vectored diseases has garnered more attention in recent years. By using reflective mulch such as silver or aluminum material, the transmission of the cucumber mosaic virus and bean yellow mosaic virus was slowed down and the number of aphid vectors was significantly decreased [28].

iii. Photodegradable plastic mulch

Creating biodegradable or photodegradable mulches is an alternate strategy to reduce waste from polyethylene mulches. Scientists began looking into the prospect of employing bio photo degradation as a self-destructive method of disposing of plastic film in the 1960s and 1970s [29]. Polymers that break down by chemical processes triggered by light are known as photodegradable polymers. Starch-containing photo-biodegradable polyethylene films have been created and applied to agriculture. Compared to standard polyethylene films, they are more effective at raising temperature, preserving moisture, and increasing yield. Additionally, the soil-buried photo-biodegradable polyethylene sheets have good degradability [30]. Using biodegradable films composed of corn starch and other biodegradable polymers could serve as an alternative to photodegradable plastics since they entirely decompose into CO₂ and water due to the action of humidity and bacteria [31].

iv. Biodegradable plastic mulch

Using biodegradable materials is one of the appropriate substitute techniques for getting rid of plastic films. Biodegradable materials can be incorporated straight into the soil at the end of their life, where microflora converts them into water, biomass, and carbon dioxide or methane. Low-density polyethylene films may have a viable ecological substitute in the form of biodegradable materials, which do not generate wastes that need to be disposed of Kapanen *et al.* [32].

CONCLUSION

Many researchers have examined the advantages of both synthetic and organic mulches for crop yield. Mulch offers numerous advantages to crop production, according to research findings. These include shielding plant roots from extreme heat and cold, regulating temperature to foster favorable plant growth conditions, lowering salinity, controlling weeds, and enhancing crop yield and quality. Farmers will thus employ this cutting-edge method in the coming days since it greatly enhances soil health, helps them prevent weeds, and conserves moisture while increasing production. This will also play a significant role in the world's sustainable achievement of food security.

RECOMMENDATIONS

- i. I hereby advise farmers particularly in the humid tropics and subtropics to apply mulch materials as an agronomic routine during rainy seasons to break rain water into droplets and hence checkmate erosion and leaching which adversely influence nutrient availability to crop plants and finally resulting in poor yield.
- ii. It also recommendable to practice during dry seasons as it helps to improve soil moisture content through which water can be made available for photosynthesis.
- iii. This mulching practice can assist farmers cultivate crops all year round with the help of little irrigation.
- iv. It is also seen as an indirect approach with organic mulch to soil amendment which simultaneously improves both soil health and crop productivity of the farm.

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