



WANT TO ASSIST SOILS – JUST MULCH

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Abstract: According to FAO, “Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs.” Organic farming had a modest pick-up but was gradually adopted world over. The practice which excludes the use of chemicals, provides consumers with healthier and safer food. However, the system often does not match conventional agriculture in yield and price of the product; the prices being mostly out of reach of a common consumer. For such reasons, there has been a need to bring innovation in organic farming which is now talked about as sustainable organic agriculture. This involves integrated system of agriculture aiming at maximizing production through optimal use of local resources while improving soil health. Two major problems faced in agriculture are the occurrence of weeds and need to conserve water. Mulch provides a second line of defense against weeds and has become an integral part of sustainable farming and directly relates to the key goals of sustainable agriculture. Mulching with inorganic and especially the organic materials can do more than just enrich the soil, as it promotes soil health and biodiversity, conserves water, reduces the needs of pesticides and fertilizers, and lowers input costs. However, the use of inorganic mulches such as plastic films is now discouraged, as these mulches are not sustainable. The market is now flooded with new biopolymers from renewable sources being sold as eco-sustainable alternatives to petroleum based plastic films. Some of the products such as thermo-extruded Mater-Bi and sprayable water-borne polysaccharide based coatings are new entrants in organic farming.

Index terms: Biodegradable films, landscape fabrics, moisture, mulch, organic farming, weeds

I. INTRODUCTION

Mulch is often defined as any material (organic or inorganic) applied to the soil surface as cover around and under plants to protect and improve the soil for plant growth. The term “mulch” originally was simply referred to the action of spreading manure over fields. The word mulch is believed to have been derived from the English counterpart “molsh” meaning strawy dung. Though mulching is an age-old technique but it has given new dimensions to the idea of organic farming. Towards the end of the 18th century, Parisian market gardeners practiced cultivating strawberries (*Fragaria* × *Ananassa*), by covering the soil between their plants with straw which kept weeds down. It also reduced fruit rot, a common problem when strawberries touched the soil directly while also reducing populations of slugs, snails and insect pests. They called this technique “paillis” (strawing) which is derived from the word “paille” (straw), and it is still the term used in French for mulch [1]. Since it was first used about 250 years ago, the practice has grown enormously and has spread all over the world, especially towards the end of the 20th century, when it has undergone expansion in terms of material used as mulch. Straw is no longer the main mulching material, wood-based products are the most common mulch while inorganic sources are also being used quite frequently.

Traditionally, mulch is any organic material such as leaves, straw or common plant remains. Mulching is an essential cultural technique that can reduce the amount of work inherent in gardening, helping to produce healthier plants and potentially increasing vegetable yields. It can discourage weed growth [2] and can be carried out for commercial purposes or for home gardens (Fig. 1). Mulching can be done throughout the year but in winters the mulch layer needs to be held loosely while in summers the mulch should be spread on moist soil.

II. TYPES OF MULCH

Mulch can be divided into two general groups – organic and inorganic (Fig. 2) [3, 4]. While organic mulches such as bark are usually byproducts of industries using organic sources and decompose readily over time, inorganic mulches such as plastic sheeting do not decompose quickly. Such materials are not eco-friendly as they remain in the environment for an indefinite period of time. Organic mulches tend to keep the soils relatively cool in the spring and these work best for raising cool season crops such as beets, broccoli, cabbage, carrots, cauliflower, kohlrabi, lettuce, onions, peas, potatoes and spinach. On the other hand, synthetic mulches tend to retain the warm condition of the soil. Therefore, they are best used with warm-season crops like tomato, pepper, squash, okra, pumpkin and eggplant. Both types have been used to create a good soil for plants; however, the benefits provided by organic mulch may outweigh those of inorganic types as they are materials which can be recycled.

2.1 Some common organic mulch

Bark (hardwood/softwood) or Shredded wood is a by-product of the lumber and paper industries and varies in size from shredded chips to larger nuggets. This type of mulch is generally used around trees and shrubs as well as in perennial beds [5] and is known to ward off pathogens, weeds and fungi. It may be due to the chemicals present in bark with allelopathic effect [6]. Shredded bark is available in natural or dyed varieties. The dyed varieties are often a mix of hardwood or recycled wood waste containing artificial dyes. Bark is relatively easy to use, but some types of barks have a tendency to float away in heavy rains. Pine bark is slightly acidic in nature [7], takes time to decompose, and does not need replacing as for other types of organic mulch (Fig. 3A). Pine bark is a common example of softwood and is frequently used under large trees and shrubs. The bark of Cypress and redwood are also popular. Cypress resists floating and is termite resistant [8]. Municipal tree waste and utility companies often make mulch available to home owners at no charge. However, it is made up of larger chunks of wood which has not aged and utilizes larger amounts of nitrogen for its decomposition (Fig. 3B). This type of mulch does not ameliorate soil status and is especially useful for creating pathways.

Cocoa bean hulls/cocoa bean mulch which are a by-product of the chocolate industry, are lightweight, easy to handle, appropriate for all planting areas, and smell pleasant. Hulls should be applied no more than 1 inch deep and should be lightly watered to hold them in place. They decompose quickly and therefore need to be replenished annually. Leaf mulch can be created at home by composting shredded leaves and can be used in all garden beds. Grass clippings may be spread in thin layers across vegetable and perennial beds and turned in at the end of the growing season. Each layer should be allowed to dry before adding additional layers and thick layering should be avoided as clippings will form slimy mat. One needs to be careful not to use clippings from lawns that have been treated with herbicides or insecticides. The grass clippings that have turned to seed should also be avoided to prevent undesirable turf grass from growing in garden beds. Composted animal manure is an excellent choice as mulch or soil amendment for new planting beds as it improves soil quality and adds nutrients. Fresh manure should not be used in garden beds because it can burn plant roots due to the heat it produces because of high nitrogen content [9]. It is best to let manure age for a month at least before use. Layers of black and white newspaper can be used to suppress weeds and two to three layers can be applied at a time. These layers can then be covered with some organic material such as leaf mulch or grass clippings to hold it in place. Newspaper will eventually decompose and get incorporated into the soil. Two or three types of organic materials can be mixed also and used as a mulch e.g., chipper debris which is a mixture of shredded bark, wood chips and leaves from tree-trimming operations is a common choice, however, chipper debris is non-uniform so it's not as attractive as many other types. It may be used for a rustic effect for outlying areas of the yard where fine texture may not be important. It may under certain conditions, create nitrogen deficiency as it breaks down unless first aged [10]. Partially decomposed compost, sea weeds and mushrooms are also excellent materials for making mulch. However, compost may also contain some weed seeds that can germinate and interfere with the crop plants. Leaves which

are readily available and inexpensive, work best if shredded before applying as a mulch. Large, unshredded leaves tend to form an undesirable “mat” which repels water.

2.2 Some common Inorganic mulch

Inorganic mulches are generally referred to as synthetic mulch and are used to create barriers to weeds and for decorative purposes. Plastic film or the polyethylene film is impermeable – water and nutrients cannot pass through it. Such mulch may increase yields of heat-loving crops like peppers, tomatoes and melons [11]. Plastic which is best used along rows of vegetables to warm the soil in spring, is not the best choice for long-term use (Fig. 3C). One disadvantage of plastic mulch is regulation of soil moisture. If a plastic mulch film is laid down on either wet or dry soil, this unfavorable soil moisture condition may stay for a long period and eventually slow down plant growth. In addition, plastic films have been criticized as potentially suffocates plant root systems, particularly of shallow-rooted woody plants like azalea and other rhododendron. The plastic films traps air and water not allowing roots to breathe [12]. As a result, plastic mulches may create anaerobic conditions which produce gasses like methane from rotting plant debris buried in the soil. Plastic film deteriorates with exposure to sunlight and is usually used for one season only and should be removed at the end of the growing season. This may be difficult because the films often partially decompose due to UV light from the sun, making them brittle and easily torn.

On the other hand, landscape fabric is a better choice for long-term use to suppress weeds because it allows air and water to pass through. However, it blocks light so that most broadleaf weeds are suppressed with the exception of very aggressive grasses and nuts edge. Landscape fabrics can be used around perennial plantings because they allow more air exchange in and out of the soil [13]. It can be used in conjunction with organic mulches and will decompose more quickly than most other inorganic mulches. In contrast to plastic films, landscape fabrics are easier to manage since fertilizers can still be applied by traditional methods and they can move through the fabric without difficulty. However, they generally cost more than plastic films. Mulching film has become popular as a very comfortable instrument, especially for professional gardeners, or people who have big extensions. It is sold as refolded sheets or more frequently as rolls. Film rolls are easily available in different widths and give a tidy look to the field. The film can be easily laid down and the operation can be mechanized with specific agricultural machines.

2.3 Miscellaneous Inorganic Mulches

Classified in this category of mulches are stones, gravels, marble chips and other rock materials which can be used for the same purpose as organic and synthetic mulches. A layer of gravel or pebbles is often applied in areas where the most durable mulch is required. Rocks or gravel, do not readily decompose and cannot improve soil fertility making the mulch therefore of limited use. Further, rocks absorb and reflect heat which can be detrimental during hot, dry weather. They are poor at weed control. On the other hand, it is relatively inexpensive and should be considered a permanent mulch for woody planting beds. As stones do not retain moisture and can cause heat stress on plants through reflection and ground heating they can burn roots and are therefore not very popular.

III. ADVANTAGES OF MULCHING

Organic mulch has a number of positive attributes.

- The main advantage of mulching is that it reduces soil’s exposure to wind and thus checks soil moisture loss through evaporation [14].
- If the type of mulch is selected mindfully, the insulating quality of mulch helps to keep the soil cooler in the summer and warmer in the winter months.
- By maintaining more even soil moisture and temperature, mulch promotes better root growth and improves plant health.
- Organic mulches sequester carbon and make soil fertile.
- Mulch helps to reduce rain splash and runoff, which in some cases will also help prevent the spread of pathogenic spores and propagules, besides checking soil erosion.
- It also suppresses the growth of many weeds by preventing sunlight from reaching the soil. Any weed seedlings that do manage to germinate and break through the layer of mulch can be easily pulled out manually. A mix of coarse and fine mulch help to reduce weed seed germination.
- Mulch improves soil microflora.

- Though generally in small amounts, most mulches will add some essential elements back into the soil and if it is of organic origin, it may finally add humus to soil.
- Mulches also improve soil tilth, particularly the organic mulch on decomposing improves the physical properties of soil such as increase air spaces, which thereby improves moisture retention and nutrient holding capacity.
- Mulches reduce heaving of soils from frost [15]. At freezing temperature, the water in soil turns into ice resulting in increase in pressure which tears plant crowns and roots. Addition of mulch results in loosening the soil structure and lessen the tension between water molecules that form ice in the subsurface.
- Mulches insulate against soil compaction [16]. A cushion of organic materials on the soil surface reduce the compaction of subsurface soil layers by absorbing the pressure due of irrigation and erosion [17].
- Mulches can improve the appearance of any planting site specially if landscape mulching is done with rocks and pebbles.
- Mulch has aesthetic value. There is a range of colors and textures offered by various mulching materials. The uniform quality of most mulches when added to the garden floor serves much the same aesthetic purpose as a carpet at home.

IV. LIMITATIONS OF MULCH

- Allelopathy- Allelopathy is defined as a common biological phenomenon by which one organism produces biochemicals that influence the growth, survival, development, and reproduction of other organisms. Allelopathic effect is elevated by some mulches resulting in injury to newly planted or shallow rooted plants [18]. A short period of composting and correct application of woody mulch will prevent damage to the plant.
- Acidification- Though mulch of Pine origin is presumably responsible for acidification of soil but the in-depth studies are wanting in this direction.
- Disease- Many mulches made from diseased plant materials can transmit the disease to healthy plants. Therefore, in order to prevent this, mulch can be composted or treated at temperatures that kill pathogens that can be transmitted to healthy plants.
- Flammability- In general, carelessness in management of wood based mulches may cause damage due to fire. Though mulches are not flammable if handled carefully but rare incidences of spontaneous combustion of yard wastes have been seen.
- Nitrogen deficiency- It is a common that some mulch sources are rich in nitrogen and may cause damage to the roots and underground parts of the plant.
- Pests- Many organic mulches, especially wood-based mulches, have the reputation as being “pest magnets”. On the contrary, many are not attractive to pest insects but are actually insect repellent.
- Weed contamination- Improperly treated crop residues and composts as well as bark mulches are often carriers of weed seed. Mulch must be deep enough to suppress weeds and promote healthy soils and plants. Hence, weed control and enhanced plant performance are directly linked to mulch depth.

V. DO'S AND DON'TS OF MULCHING

- Before selecting mulch several points need to be considered e.g., availability, cost, appearance, quality, and durability of the mulching material.
- It is best to apply organic mulch shortly after purchase or delivery. If it is not convenient to do so, the mulch should be covered with a tarp or plastic to keep the material dry.
- Coco mulch should not be used if pets visit the area as it is toxic to them.
- Leaves that may be infected should be disposed of instead of composted for mulch.
- Manure should be well composted prior to using as mulch at high temperatures for at least one week and composted for four to six months to eliminate most potential disease organisms.
- Dog, cat, and pig manure should never be added to vegetable gardens as they are more likely to contain parasites that infect humans.
- One should also understand the characteristics of different mulches and their appropriate uses so that one does not end up making gardening less eco-friendly.

- The mulch should be applied to planting beds and around the root zone of plants in mid-spring after garden soil has warmed.
- Mulching around newly planted seeds is particularly beneficial, especially for fall plantings as it protects roots over the winter. It is not necessary to replace mulch each year and new mulch should be added only when the previous layer has either decomposed or has become too thin to be effective.
- Aged mulch can be recycled and plowed into the garden later to amend the soil.
- Mulch allows soil to warm up gradually in spring, preventing damage to plants that emerge early before temperatures are warm enough to sustain them.
- Roses and tender perennials in particular benefit from an application of winter mulch which should be removed from the base of protected plants in the spring when new growth is observed.
- For trees and shrubs no more than a 2 – 3” layer of mulch around the base of trees and shrubs should be applied. This is done to avoid soil compaction and root suffocation that lead to early decline. Avoid piling mulch against trunks and stems.
- Over-mulching is also not good for plant health because it creates constantly moist conditions which may also promote growth of pathogens and provide a habitat for insects and animal pests.
- Mulch gives good results when used for raising annuals.
- Mulch can also be used in the vegetable garden to create pathways between rows for easy cultivating and harvesting.
- Lightly mulching newly seeded lawns keeps seeds from washing away, deters feeding birds and rodents, and conserves moisture needed for good germination.
- While, clean wheat, barley, or oat straw is recommended as it is usually free from seeds, hay is not recommended as it often contains weed seeds.
- Commercially available mulches made from recycled paper, work very well in protecting spot renovations.
- While using organic mulch one should be careful not to use any source which has been subjected to pesticides or weedicides as these synthetic chemicals will prove hazardous for any crop being raised on such soil covers.
- It should also be remembered that field hygiene is extremely important. Though mulch does not attract pests, however, more decomposing insects may be observed if mulch is kept too wet.
- Mulch may also provide habitat for unwanted small animals such as voles, so it is important to keep it from touching plant trunks and stems as well as foundations of homes and other buildings. Occasionally some mulch may develop mold or an odd looking fungus during periods of wet weather or if irrigation systems run too frequently. Such mulch should be turned to promote drying and to improve air circulation.

VI. NEW TRENDS IN MULCH

Film mulching has remained for long an important agronomic practice to improve grain productivity and control weeds [21]. It was estimated that around 700,000 tons of plastic are used annually for agriculture [22]. In 2018, the usage of polyethylene plastic sheet reached to 1.4 million tons, which covered more than 17.8 million hectares accounting for 15% of the total cropland in China [23].

Despite the favourable results of plastic film mulching in terms of crop yield, extensive application and poor management of plastic film in agro ecosystems have thrown daunting environmental challenges [24]. Plastic mulch films are frequently incorrectly disposed of by either being dumped in marginal land or by burning. The microplastics residues which are added in agriculture soil after their use, threaten soil health and productivity [25] and are not the sustainable option agriculture. The research has come out with a more viable solution, the biodegradable mulch film which consists of polysaccharides such as cellulose [26], starch [27] and chitin/chitosan [28] or polyesters including polylactic acid, polyhydroxyalkanoate [29], (polybutylene adipate-co-terephthalate (PBAT) [30], polybutylene succinate (PBS), and polybutylene succinate-co-adipate (PBSA). In contrast to traditional plastic mulch films, biodegradable mulch (BDMs) films can be plowed into soil directly after crop harvest [31]. After the fragmentation of biodegradable mulch films, soil microorganisms catabolize them into carbon dioxide, methane and water, less harmful to the environment [32].

Biodegradable mulches possess similar mechanical properties as polyethylene (PE) (e.g. good tensile strength and elongation), but are composed of biodegradable polymers. The latter polymers may be blended with

thermoplastic starch, polylactic acid [PLA], polyhydroxyalkanoates [PHA], plasticizers, or other additives to improve mechanical properties, durability or biodegradability.

Specifically, in this unstable climate and global warming condition [33] mulch is utilized to help plants adapt to climate change by modifying microclimate around the growing plants [34-36]. Organic mulch sheet made from natural fiber, cellulose can be processed from plant source such as kenaf, pineapple leaf fiber, banana fiber, coir, paddy straw, sugarcane, water hyacinth, corn cobs, and many more [37-40]. The use of organic fiber waste such as banana pseudostem and water hyacinth for the organic mulch sheet improve soil properties [41, 42]. Made from simple technology, the organic mulch sheet is cheaper in price, more practical and effective in usage, helps recycle nutrients after use, environmentally friendly, and in long-term increases soil fertility.

The Australian Research Organization CSIRO, has developed a sprayable biodegradable polymer membrane named Transpirational that can help farmers increase the yield of their crop yet use less water. It is said to work better than plastic mulch and is eco-friendly.

VII. CONCLUDING REMARKS

It is estimated that by 2030, when the population around globe is estimated to cross 8.5 billion, demand for food and energy will jump by 50% and for fresh water by 30%. Issues of climate change will exacerbate matters in unpredictable ways. With these warnings, stakeholders need to act now before things collapse. A major concern is in the field of agriculture, where the farming has to adopt ways which help increase yield and are also eco-friendly. A balance has to be worked between farmer and the planet. Sustainable agri-practices have raised hope and new innovations are being worked out. Traditional practice of mulching is quite promising especially when mulch used is of organic source. Plastic films have also helped increase yield but have raised concern as potential health hazard. CSIRO estimates 10 million tonnes of plastic mulch film is used globally in agriculture each year. China, the United States and Australia account for more than half of this. And usage is growing, with the global market predicted to reach USD 14.31 billion by 2026.

But the downside effects of the plastic films are significant – to the farmer and the planet. Application is specialized, costly and typically one-size-fits-all. The plastic mulch if not retrieved and disposed of at the end of the growing season, will be an environmental concern. Biodegradable films and sprays are new innovations in a bid to improve soil and water management

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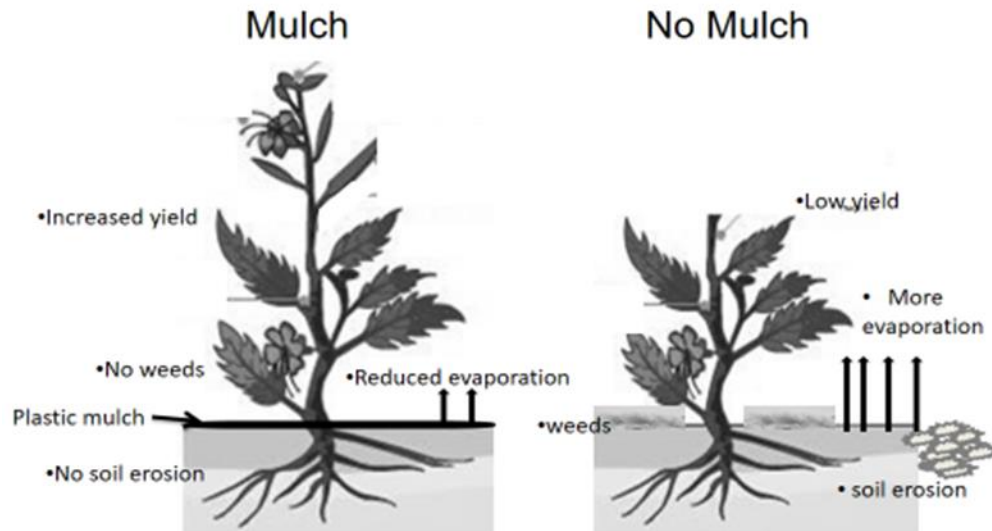


Figure 1: The selective advantage of using mulch.

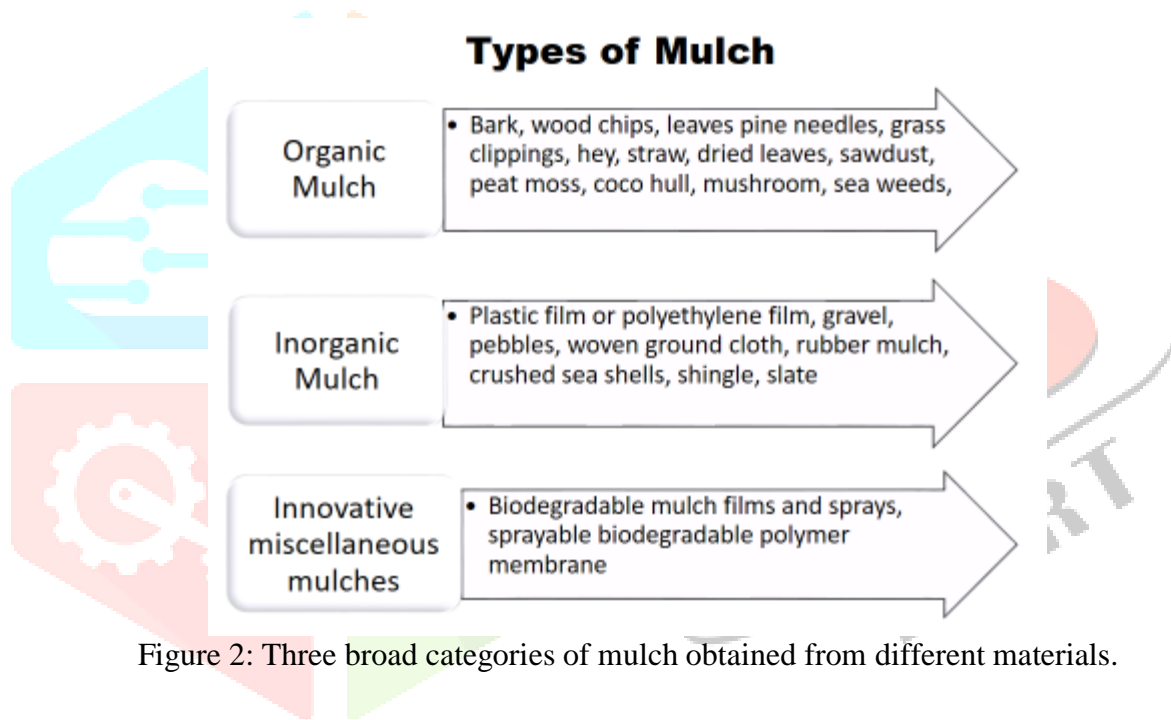


Figure 2: Three broad categories of mulch obtained from different materials.

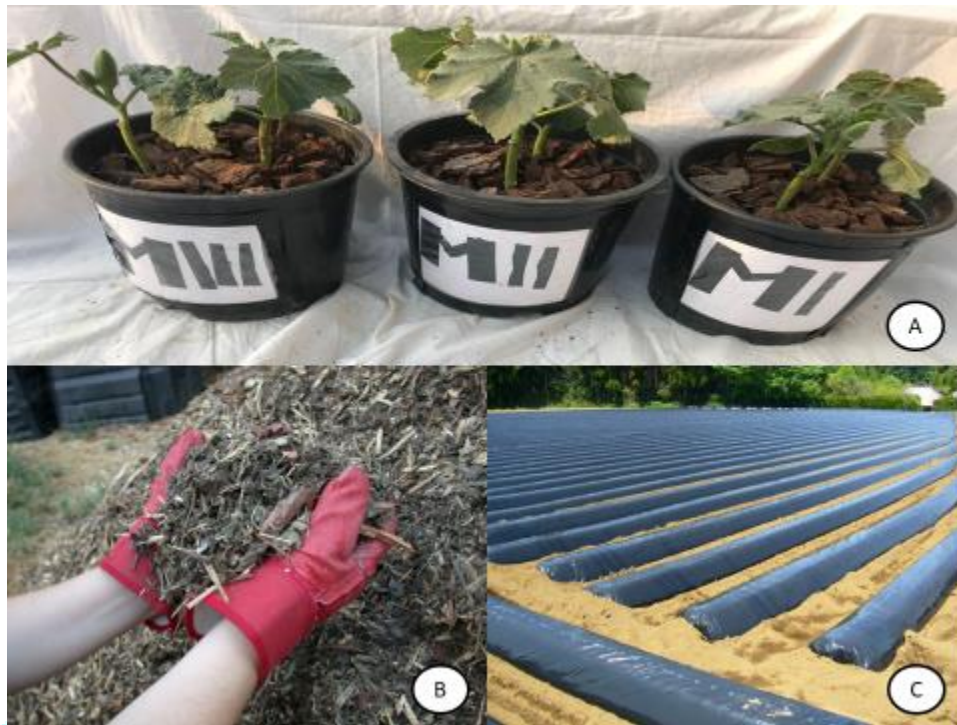


Figure 3A-C: Different types of mulch.

A. Okra raised on Pine bark mulch. B. Mulch made from shredded yard waste in a municipal recycling program, showing compost bins in the background and gloves in the foreground. C. Plastic mulch, sweet potato field, katori-city, Japan

