International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(4): 646-652
www.biochemjournal.com
Received: 23-01-2025
Accepted: 25-02-2025

Ashif Iqbal Biswas
M.Sc. Scholar, Department of Horticulture, Fruit Science, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Dr. Rupinder Singh
Assistant Professor, Department of Horticulture, Fruit Science, Lovely Professional University, Phagwara, Punjab, India

Nirmal Patil
M.Sc. Scholar, Department of Horticulture, Fruit Science, Lovely Professional University, Phagwara, Punjab, India

Anant R Betkekar
M.Sc. Scholar, Department of Floriculture, Lovely Professional University, Phagwara, Punjab, India

Souhardya Adhikari
M.Sc. Scholar, Department of Agronomy, Lovely Professional University, Phagwara, Punjab, India

Arnab Sinha
M.Sc. Scholar, Department of Horticulture, Fruit Science, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Ashif Iqbal Biswas
M.Sc. Scholar, Department of Horticulture, Fruit Science, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Mulching interventions in strawberry: Influence on soil temperature, moisture conservation and pest dynamics

Ashif Iqbal Biswas, Rupinder Singh, Nirmal Patil, Anant R Betkekar, Souhardya Adhikari and Arnab Sinha

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i4h.4169

Abstract
One of India's most significant soft fruits is the strawberry. Mulching is regarded as the most important strawberry production technique since it helps maintain the delicate fruit clean, reduce weeds, control soil temperature, and preserve soil moisture. Mulching has been promoted as a successful strategy for retaining soil moisture. It functions as an insulating layer that prevents evaporation from the soil's surface and the strawberry's exposure to sunlight. Mulching is a horticultural and agricultural technique that involves the use of synthetic materials (paper, polyethylene, wax-coated papers, aluminium and steel foils, etc.) and organic materials (plant residues—straw, hay, groundnut hulls, leaves, compost, peat, wood products—sawdust, and animal manures) with or without shallow tillage in order to increase soil productivity. Organic mulches increase soil nitrogen, recycle nutrients, decrease erosion, and function as slow-release fertilisers as they break down, all of which benefit the environment. Mulches made of polyethylene plastic are also essential for strawberries because they control soil temperature, prevent evaporation, keep fruits clean, and prevent weeds and pests. Utilising organic and plastic mulches improves soil hydrothermal conditions, moisture availability, fruit quality, and growth duration while preventing crop damage, which ultimately results in increased strawberry yield. This literature review examines the benefits of using organic and polyethylene plastic mulches in strawberry cultivation.

Keywords: Strawberry, mulch, moisture, mulching, conservation, sustainability

1. Introduction
Mulching is a technique used to enhance soil conditions and promote plant growth by covering the soil with either organic or inorganic material. Mulch is any substance that is applied to the soil's surface or positioned vertically inside it to promote soil productivity and water and soil conservation. A layer of material called mulch is spread over a section of soil. According to Hutton and Handley (2007) [19], the word mulch is most likely derived from the German word "molsch," which means "soft to decay." This term seems to refer to the usage of straw and leaves by garderners as mulch strewn over the ground. Mulch lessens the impact of water droplets by preventing rain from striking the soil directly.

Strawberry (*Fragaria vesca*) is an important fruit crop of India and its commercial production is possible in temperate and sub-tropical areas of the country (Sharma and Sharma, 2004) [40]. Strawberries are valued for their sweet flavour, scent, and nutritional content; they are high in protein, essential minerals including calcium, iron, potassium, and phosphorus, as well as vitamins C and B (Joolka, 1983) [22]. With an average yield of 4.5 tonnes per hectare, strawberries are grown on 3 million hectares of land in India, yielding 13.52 million metric tonnes year. Himachal Pradesh, Uttar Pradesh, Maharashtra, West Bengal, Delhi, Haryana, Punjab, and Rajasthan are among the states that grow strawberries.

In strawberry cultivation, mulching interventions entail applying materials to the soil surrounding plants. These treatments have several advantages, including better soil moisture and temperature, weed control, and cleaner fruit. Both synthetic and organic mulches are used; whereas synthetic mulches, such as plastic films, provide effective weed control, organic mulches, such as wood chips and straw, improve soil qualities. Mulching is necessary for the strawberry crop in order to prevent direct fruit-soil contact and improve

disease and pest control. Better-quality fruits can be harvested in this manner. Furthermore, mulching boosts fruit production and encourages the management of invasive plants (Kaur & Kaur, 2017) [26]. Strawberry farming uses mulching to reduce soil erosion, minimise freezing harm, inhibit weed growth, and boost yield. To shield the roots from cold damage, the soil in cold climates is covered with mulch during the winter. In milder areas, the mulch shields flowers from frost, prevents fruit deterioration, preserves soil moisture, keeps fruits free of soil, and shields plants from freezing damage in colder climes. Straw mulch is the most widely used type of mulch, though there are other types as well. This fact is the basis of the name strawberry.

2. Types of Mulching

According to Kader *et al.,* (2017) [23], mulching materials fall into three categories: organic, inorganic, and special. Organic mulching materials can be made from agricultural waste, wood waste, leftover processed foods, and animal dung. Kader *et al*. (2017) [23] state that synthetic and polyethylene sheet-based plastics are examples of inorganic mulching materials. Comparably, Adhikari *et al.,* (2016) [2] have developed eco-friendly, multipurpose, and easy-to-use goods such surface coatings, biodegradable polymer films, and compostable and photodegradable plastic films that are crucial for agricultural applications.

2.1 Organic mulches

The top layer of soil in gardens, landscapes, and agricultural fields is covered with organic mulches, which are made from living or recently deceased plants and animals. Applying organic mulch, which is derived from plant or animal materials, is best done immediately following crop germination. Organic mulches have many advantages, such as lowering nitrate leaching, enhancing the physical characteristics of the soil, encouraging microbial activity, balancing the nutrient cycle, enriching the soil with nutrients, controlling temperature, enhancing the soil's ability to absorb water, and halting erosion (Goodman, 2020) [16]. However, using organic resources for crop production is challenging and requires a significant amount of work. As a result, due to economic and logistical restrictions, the use of organic mulch in horticulture production has been limited (Zhao *et al.,* 2014) [54].

2.1.1 Wood chips

Wood chips made from chipped or shredded wood are used in horticulture, landscaping, and gardening. Because pesticides block the light and prevent weed seeds from sprouting, we won't need to use them as frequently or weed by hand (Bantle *et al.,* 2014) [6]. Its barrier effect reduces soil moisture retention and evaporation in addition to provide insulation. Long-term advantages of wood chips include enhanced microbial activity, less soil erosion, and improved soil structure (Zheng *et al.,* 2022) [55].

2.1.2 Straw mulch

Straw mulch, which is created from the stalks of cereal crops, is a good option for protection in the garden and on the farm. It keeps the soil moist, inhibits the growth of weeds, and shields the soil from abrupt temperature fluctuations. It prevents soil erosion by preserving soil particles and reducing the impact of wind and rain (Ma *et al.,* 2024) [32]. When allowed to break down, straw mulch enriches the soil with organic matter, enhancing its structure, nutrient availability, and beneficial soil organism populations (Goodman, 2020) [16].

2.1.3 Sawdust mulch

In landscaping and gardening, sawdust mulch formed from finely ground or chipped wood debris is used to restrict weed growth by obscuring sunlight. However, if sprayed sparingly, it can still allow weeds to grow (Davis and Strik, 2022) [10]. Although sawdust retains and absorbs rainfall, its high carbon content may cause the soil's nitrogen levels to drop. Sawdust from some woods, such as pine or cedar, may become acidic, changing the pH of the soil. Sawdust not only takes longer to break down than other organic mulch materials, but it may also hinder plant growth (Tan *et al.,* 2016) [48].

2.1.4 Bark mulch

Because of its practical benefits and visual attractiveness, bark mulches—organic mulches made from tree bark—are used in gardening and landscaping (Łukasiewicz, 2013) [31]. They produce a dense layer that inhibits the growth of weeds, reduces evaporation, and retains moisture in the soil. Additionally, they act as a barrier, lowering soil erosion and offering insulation. Bark mulches are a long-lasting mulching substitute since they decompose gradually and can last for many years. Each type of bark has its own characteristics (Kosterna, 2014) [28].

2.1.5 Newspaper mulch

For weed control and soil moisture retention in gardens and landscapes, newspaper mulch is a cost-effective, environmentally acceptable, and sustainable alternative (Puka-Beals and Gramig, 2021) [35]. It acts as a physical barrier to smother existing weeds, blocks sunlight, and prevents weed seeds from growing. Newspaper mulch is beneficial in arid climates because it reduces evaporation and preserves soil moisture. Newspapers' decomposed wood pulp adds organic materials to the soil, improving its fertility and structure (Puka-Beals and Gramig, 2021) [35]. It provides protection in cold weather, modifies soil temperature, and acts as insulation. Newspaper is a sustainable substitute for other mulch materials since it is widely available and frequently thrown away as trash (Haapala *et al.,* 2014) [18].

2.1.6 Compost mulch

According to Mallory and Smagula (2014) [33], compost mulch is a nutrient-rich mulch made from decomposed organic waste that improves soil health and promotes plant growth. It increases soil structure and microbial activity by distributing essential minerals like potassium, phosphorus, and nitrogen into the soil. By burying weeds and inhibiting seed germination, compost mulch also improves soil drainage, aeration, and moisture-holding capacity while reducing weed growth (Paradelo *et al.,* 2012) [34]. In addition, it provides insulation, regulates soil temperature, and protects against frost in the winter. According to Mallory and Smagula (2014) [33], compost mulch is an excellent and nutrient-rich option for plant health.

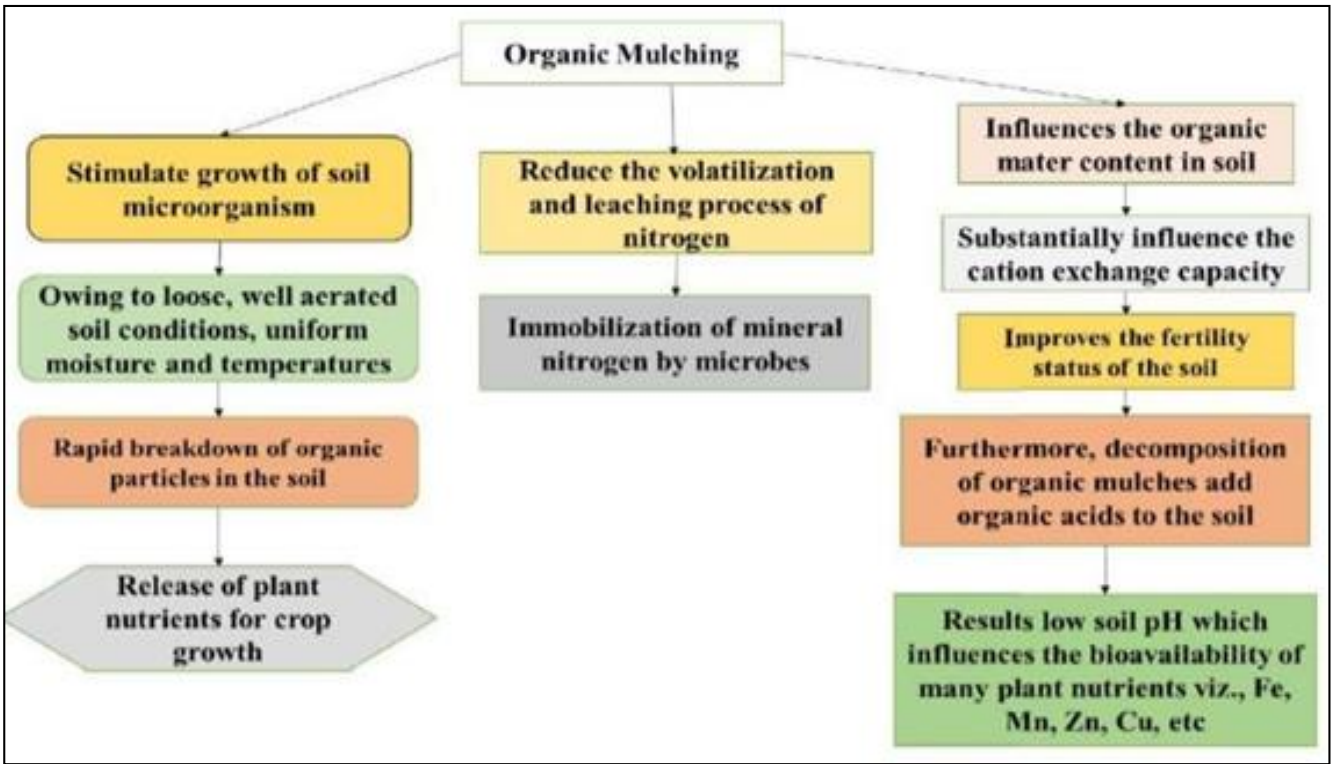

Fig 1: Significance of Organic Mulching (Ullah *et al.*, (2021)) [50]

2.2 Inorganic mulches

Plastic mulch is widely utilized in industrial crop cultivation, the most popular forms being polyvinyl chloride and polyethylene films. Because these plastic coatings are more permeable to long-wave radiation, they can raise the temperature around the crop during winter nights. As a result, Gosar and Baričevič (2011) [17] propose that polyethylene mulch is the best material for horticultural crop development. In another study by Gao *et al.*, (2019) [15] many plastic films produced from various polymers, including polyvinyl chloride (PVC), high-density polyester (HDPE), and low-density polyethylene (LDPE), were studied for mulching applications in the 1960s. Because of its convenience, LLDPE is the most often used plastic mulching material. Because of their great results, black plastic mulch films have become increasingly popular, particularly in dry and semi-arid locations. Black polyethylene mulch improved crop yield and quality, raised soil water content, and changed the soil microbial community, all of which increased farmers' profits. Fresh vegetables are increasingly being produced using the "plastic culture" farming method, which uses plastic as mulch. Furthermore, reported that around one million tonnes of synthetic mulch material are used annually throughout the world.

3. Influence of mulching on strawberry cultivation

In addition to keeping the fragile fruit tidy and clean, mulching is regarded as the most significant cultural practice among the several strawberry production techniques since it is crucial for weed control, soil moisture conservation, and soil-hydrothermal regime regulation (Cook *et al.*, 2006) [9]. When Johnson and Fennimore (2005) [21] looked into how different coloured plastic mulch affected berry crop productivity, they found that black mulch produced the most marketable berries. Furthermore, strawberry plant growth, berry weight, fruit yield, and quality are all enhanced by mulching (Singh *et al.*, 2007) [42]. Mulching of the soil surface is an excellent soil conservation strategy (Doring *et al.*, 2005; Smets *et al.*, 2008) [11, 44].

Mulching is a viable strategy for successful crop production, particularly in areas with limited irrigation infrastructure, according to (Solaiman *et al.*, 2008) [45]. Mulches significantly slow down the soil moisture loss, maintaining a higher and more consistent soil moisture regime and lowering the need for frequent irrigation (Ramakrishna *et al.*, 2006) [36]. Mulch has the potential to significantly decrease the amount of water that evaporates from the soil's surface. This implies that plants will use water more effectively.

Additionally, mulch can be used to mitigate the adverse impacts of a persistent drought (Frąc *et al.*, 2009) [13]. Mulching increases soil moisture by 1.7 times (Shumova, 2002) [41]. Additionally, surface-covered plots exhibit increased water intake and slower evaporation (Kumar and Dey 2011) [29], and the soil moisture in mulched plots is not only higher but also more stable throughout the entire vegetation period (Sinkeviciene *et al.*, 2009) [43]. Black polyethylene is the most commonly used mulching material in various parts of the world, and it is commonly used in raised-bed cultures of strawberries to conserve water, control weeds with fewer herbicides, and maintain clean fruit (Kasperbauer, 2000) [24].

4. Influence of mulching interventions on soil temperature

Mulching progressively increases permeability, soil fertility, air circulation around plants, and soil particle aggregation (Kader *et al.*, 2017) [23]. Mulch protects the soil from extremes of temperature by acting as an insulator. Mulch treatments benefit agricultural fields in a variety of ways, such as reduced soil erosion, water loss, weed growth, raindrop influence on the soil surface, and competition for

moisture and nutrients from neighbouring fields (Yang *et al.*, 2015; Kader *et al.*, 2017) [53, 23]. Mulches are particularly helpful in the summer because they stop soil moisture loss from evaporation, as noted by Qin *et al.*, (2015) [56]. By increasing earthworm mobility in soil pores, mulch may help improve soil structure and nutrient circulation. Additionally, mulching promotes nutrient accessibility by lowering the pH of the soil (Larentzaki *et al.*, 2008) [8]. Organic mulch breaks down over time, resupplying the soil with nutrients and enhancing the soil's ability to retain long-term access to nutrients, according to Larentzaki *et al.*, (2008) [8].

Mulching layers reduce soil water evaporation and protect the soil from direct sunlight, which regulates temperature (Bakshi *et al.*, 2015) [5]. Research conducted in hotter regions or throughout the summer has shown that mulching with organic matter can reduce soil temperatures by more than 10 °C when compared to bare soil (Chalker-Scott, 2007) [7]. In particular, throughout the seedling, bud initiation, and flowering stages, the soil temperature rose by 0.9 to 4.3 °C, 1.6 to 2.3 °C, and 0.8 to 1.9 °C, respectively (Xie *et al.*, 2005) [51].

According to an additional investigation by Subrahmaniyan and Zhou (2008) [46], the soil temperature increased by 2.9 to 3.30 °C when covered with transparent, photodegradable polythene films. For transparent film and black film, the temperature differential between mulched and bare soil in early May was 7 °C and 5 °C, respectively. Rajablariani *et al.*, (2012) [34] found that the average soil temperature increased by 3 to 6 °C beneath various coloured plastic mulches when compared to bare soil.

By maintaining a uniform appearance, mulch also makes the surroundings more appealing. Crop type, water retention, crop water loss and topsoil, and rainfall penetration all influence the amount of water in soil, which is a complex ecosystem (Li *et al.*, 2013; Ma *et al.*, 2024) [38, 32]. At different phases of growth, plants require different soil temperatures and levels of moisture. Organic mulching increases the soil's ability to hold water, encourages the growth of organic matter, and reduces soil degradation (Kader *et al.*, 2017) [23]. By keeping nutrients in the area where the crop roots are located, mulch improves soil health by increasing the efficiency of fertiliser use and reducing nutrient leaching.

5. Influence of mulching interventions on moisture conservation

Mulching is a widespread agricultural practice that helps improve soil quality and crop production by spreading various materials over a field either before or after planting. Sand, pebbles, plastic, animal manure, and agricultural waste can all be used as mulching materials (Gan *et al.*, 2013) [14]. The primary goals of mulching are to reduce water evaporation, enhance moisture retention, boost soil warming, and restrict weed growth (Gan *et al.*, 2013) [14]. Mulching can increase crop yields, growth, and water consumption, according to studies (Chaudhary *et al.*, 2003; Abdrabbo *et al.*, 2017; Ali Mozaffari, 2022) [8, 1, 4].

According to Qin *et al.*, (2015) [56], mulching's key benefit is its capacity to preserve soil moisture by reducing soil loss and surface water loss. By controlling the soil's temperature and reducing evaporation, mulching aids in soil water conservation in agricultural activities (Kader *et al.*, 2017) [23]. Improving system accessibility for effective mulching requires an understanding of the water transport and soil temperature dynamics beneath the mulch layer (Kader *et al.*, 2017; Li *et al.*, 2018) [23].

Mulch is a crucial component for plants to retain moisture in their roots because it prevents evaporation from the soil, which lowers evaporation by protecting plants from wind and sunlight (Tang *et al.*, 2022) [49]. This helps to maintain moisture levels around plant roots and increases the time available for plants to utilise water. Consequently, the use of mulch may minimise the demand for irrigation in covered regions (Ranjan *et al.*, 2017) [37].

It functions as an insulating layer that regulates soil temperature, lessens heat stress, and keeps soil moisture levels steady. Mulch lowers runoff by slowing the flow of water across the soil's surface, allowing more water to reach the root zone (Suburika *et al.*, 2018) [47]. Because it stops weeds from sprouting, the roots have less access to water and require less watering. As organic mulches break down, they improve soil structure, which raises the soil's capacity to retain water and gives plant roots more moisture (Fonteyne *et al.*, 2020) [12].

6. Influence of mulching on weed management

Mulch can physically control seedling emergence, act as a material barrier to prevent weed growth, or cover the soil's surface (Khan *et al.*, 2022; Kaur *et al.*, 2024) [27, 25]. Plots with polyethylene and straw mulch had the least amount of weeds compared to those without mulch and those with chemical mulch. Plots of different crops have shown significant differences in weed control with and without mulch (Yadav *et al.*, 2018) [52]. Mulch is a straightforward method for controlling weed populations in both the field and nursery. But as of yet, nothing is known about the phenomenon of weed reduction (Iqbal *et al.*, 2020) [20]. Applying mulch to the soil surface reduces the germination of small-seeded weeds by acting as a barrier to light transmission. The research findings showed that there was no variance among all forms of coatings, but that there were significant variations in weed reduction when treating bare soil. Fifteen various types of coatings were used, as opposed to no coating (Kader *et al.*, 2017) [23].

According to Ahmad *et al.*, (2015) [3] mulch prevents the growth of weeds; nevertheless, when organic mulches decompose, weeds quickly emerge to the surface of the ground. In addition to producing poisonous substances that are effective at controlling weeds, some natural mulches also have an allergic reaction. Furthermore, mulch creates a great environment for helpful bacteria that consume weed species or weed seed (Chalker-Scott, 2007) [7]. Similarly, by competing with weeds for basic resources like light, moisture, nutrients, and oxygen, living mulch effectively suppresses weeds. They are beneficial to weeds as well. Mulches and a variety of crops for cover also help to reduce the establishment and germination of weed seeds (Iqbal *et al.*, 2020) [20].

7. Influence of mulching interventions on pest dynamics

Transparent polyethylene mulch reduced whitefly populations, aphids caught in yellow traps and virus diseases incidence, in comparison to bare soil. The reflective plastic mulches can reduce the incidence of aphid borne viruses and exclude some species of pest (Saroa and Lal, 2003) [39].

Transparent mulch reduced the incidence of virus disease, and delayed by 2 weeks the onset of virus symptoms compared with the bare soil. Transparent mulch has a reflective effect and reduces the incidence of virus diseases by confusing aphids, which vector the virus. The mode of action of the transparent mulch is probably the result of high reflectance of UV light. The success of living mulches is the suppression of pests and weeds population

Plastic mulch is a reliable fumigant barrier and sun protection material due to its impermeability to gas passage. On the other hand, it may have unexpected effects on pest management and soil health (Chalker-Scott, 2007) [7].

8. Benefits of mulching in strawberry cultivation

8.1 Mulching helps prevent soil erosion

Mulch prevents rain from hitting the soil directly, reducing the impact of the water drops. Water soaks into the soil gradually instead washing the soil away

8.2 Mulching adds organic matter to the soil

Soil that is high in organic matter is very much alive. In just one pinch of soil, there are about a billion individual living organisms, perhaps ten thousand distinct species of microbes. As these microbes decompose organic matter, it supplies nutrients needed by growing plants. The beauty of this natural nutrient cycle is that nutrients are released in harmony with the needs of the plants. When environmental conditions are favorable for rapid plant growth, the same conditions favor a rapid release of nutrients from the organic matter

8.3 Mulching feeds soil life and improves soil structure

When a mulch of organic matter is added to the surface of the soil, it decays producing slimes and gums that help to form and stabilize soil structure. The extra organic matter is food for soil creatures. These burrow their way through the soil, mixing the organic matter in and creating passage ways within the soil through which air and water can infiltrate. In this way, mulching can help loosen up heavy clay soils, making it easier for the farmer to work, and making it easier for plant roots and shoots to push their way through. Some people call earthworms “a farmer’s best friends”. As earthworms multiply, the soil becomes looser and more porous-a better place for plant roots to grow. Mulching also prevents the soil from getting a hard crust. When raindrops hit bare soil in a heavy rainstorm, it breaks into smaller pieces. These pieces stick together and form a hard crust when the soil dries. This crust makes it difficult for water to soak into the ground. It also makes it hard for young plants to push through the soil crust. Mulch is a protective cover for the soil, sheltering the soil from hard-hitting rain

8.4 Mulching adds nutrients to the soil

Mulch around crop plants mimics the litter layer of a forest floor. The nutrients in the mulch are gradually released and taken up by the crops. Mulching is cheaper than chemical fertilizers, and because it also improves soil structure, the nutrients will not be washed away or leached from the soil by heavy rain

8.5 Mulch decreases water loss due to evaporation

Mulch reflects a lot of the sun that otherwise beats down on the soil. This keeps the soil cooler and helps prevent evaporation. This is especially important in hot, dry climates. Also, by slowing down rain water run-off, mulch increases the amount of water that soaks into the soil. The loose soil structure, created by the soil life fed by the mulch, helps hold water in the soil. Since mulch reduces effective precipitation, irrigation is required to restore lost water when growing strawberries. The most popular technique for this production system is drip irrigation (Kasperbauer, 2000) [24]

9. Conclusion

Mulching has been promoted as a successful strategy for retaining soil moisture. It functions as an insulating layer that prevents evaporation from the soil's surface and mitigates the effects of sunlight on strawberries. There are many different varieties and colours to choose from, but in order to ensure the crop's longevity, the right width and thickness must be selected. Depending on the type and season, applying polythene mulches (apart from white) causes the soil to warm. By lowering evaporation from the soil surface, all varieties will preserve soil moisture. With the exception of clear and white varieties, all types inhibit the growth of weeds, negating the need for herbicides and any related growth checks. Polythene mulches offer a practical method of preserving distinct plants because runners cannot grow through plastic.

The industry's resilience, sustainability, and adaptation are all part of the strategic vision for strawberry cultivation's future objectives and prospects. The strawberry industry is working to create varieties that are not just climate-resilient but also have improved disease resistance and superior flavour profiles in response to issues including disease pressure, climate change, and changing customer preferences. Strawberries are being grown using a more sustainable paradigm that embraces precision agriculture, eco-friendly methods, and less chemical use. A crucial component of future objectives is consumer-centric cultivation, which is defined by an emphasis on satisfying the changing desires of health-conscious consumers. Furthermore, the future of strawberry farming is significantly shaped by the incorporation of state-of-the-art technologies and developments in genetic research. The strawberry business hopes to establish itself as a prosperous and inventive segment of the agricultural landscape by encouraging international cooperation, investigating specialised cultivars, and advocating for sustainable farming methods.

Mulching, an elementary but incredibly advantageous cultural practice in strawberry farming, has been shown to improve fruit quality and production. Numerous potential advantages for horticultural crop development have been demonstrated while using different mulching materials. According to studies, mulching can promote crop growth and quality, control soil temperatures, boost soil microbial activity and health, inhibit weed development, lessen pest infestations, and increase water use efficiency. Furthermore, mulching can improve the visual and financial worth of agricultural land while shielding plants from abiotic pressures. According to earlier research, mulching and other sustainable farming techniques can successfully offset crop water requirements in situations where there is a shortage of water. Despite environmental stressors, mulching improves strawberry growth, yield, and quality by maximising soil moisture availability. In conclusion, studies show that mulching is a useful tactic for increasing crop quality,

productivity, and resilience in strawberry and other horticultural production systems when growing conditions are less than ideal. Despite the obstacles presented by climate change and water scarcity, sustainable cultivation can be promoted by implementing appropriate mulching techniques.

10. References

1. Abdrabbo MAA, Saleh SM, Hashem FA. Eggplant production under deficit irrigation and polyethylene mulch. Egypt J Appl Sci. 2017;32:148-161.
2. Adhikari R, Bristow KL, Casey PS, Freischmidt G, Hornbuckle JW, Adhikari B. Preformed and sprayable polymeric mulch film to improve agricultural water use efficiency. Agric Water Manage. 2016;169:1-13. doi:10.1016/j.agwat.2016.02.006
3. Ahmad S, Raza MAS, Saleem MF, Zahra SS, Khan IH, Ali M, *et al*. Mulching strategies for weeds control and water conservation in cotton. J Agric Biol Sci. 2015;8:299-306.
4. Ali Mozaffari G. Climate change and its consequences in agriculture. In: Harris SA, editor. The nature, causes, effects and mitigation of climate change on the environment. 2022. doi:10.5772/intechopen.101444
5. Bakshi P, Wali VK, Iqbal M, Jasrotia A, Kour K, Ahmed R. Sustainable fruit production by soil moisture conservation with different mulches: A review. Afr J Agric Res. 2015;10:4718-4729. doi:10.5897/AJAR2014.9149
6. Bantle A, Borken W, Ellerbrock RH, Schulze ED, Weisser WW, Matzner E. Quantity and quality of dissolved organic carbon released from coarse woody debris of different tree species in the early phase of decomposition. For Ecol Manage. 2014;329:287-294. doi:10.1016/j.foreco.2014.06.035
7. Chalker-Scott L. Impact of mulches on landscape plants and the environment—A review. J Environ Hortic. 2007;25:239-249. doi:10.24266/0738-2898-25.4.239
8. Chaudhary RS, Patnaik US, Dass A. Efficacy of mulches in conserving monsoonal moisture for the Rabi crops. J Indian Soc Soil Sci. 2003;51:495-498.
9. Cook HF, Valdes GSB, Lee HC. Mulch effects on rainfall interception, soil physical characteristics and temperature under *Zea mays* L. Soil Tillage Res. 2006;91:227-235.
10. Davis AJ, Strik BC. Long-term effects of pre-plant incorporation with sawdust, sawdust mulch, and nitrogen fertilizer rate on 'Elliott' Highbush blueberry. HortScience. 2022;57:414-421. doi:10.21273/hortsci16359-21
11. Doring T, Brandt M, Heb J, Finchk M, Saucke H. Effect of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in organically grown potatoes. Field Crop Res. 2005;94:238-249.
12. Fonteyne S, Singh RG, Govaerts B, Verhulst N. Rotation, mulch and zero tillage reduce weeds in a long-term conservation agriculture trial. Agronomy. 2020;10:962. doi:10.3390/agronomy10070962
13. Frąc M, Michalski P, Sas-Paszt L. The effect of mulch and mycorrhiza on fruit yield and size of three strawberry cultivars. J Fruit Ornam Plant Res. 2009;17(2):85-94.
14. Gan Y, Siddique KH, Turner NC, Li XG, Niu JY, Yang C, *et al*. Ridge-furrow mulching systems—an innovative technique for boosting crop productivity in semiarid rain-fed environments. Adv Agron. 2013;118:429-476. doi:10.1016/B978-0-12-405942-9.00007-4
15. Gao S, Tang G, Hua D, Xiong R, Han J, Jiang S, *et al*. Stimuli-responsive bio-based polymeric systems and their applications. J Mater Chem B. 2019;7:709-729. doi:10.1039/C8TB02491J
16. Goodman BA. Utilization of waste straw and husks from rice production: A review. J Biores Bioprod. 2020;5:143-162. doi:10.1016/j.jobab.2020.07.001
17. Gosar B, Baričevič D. Ridge-furrow-ridge rainwater harvesting system with mulches and supplemental irrigation. HortScience. 2011;46:108-112. doi:10.21273/HORTSCI.46.1.108
18. Haapala T, Palonen P, Korpela A, Ahokas J. Feasibility of paper mulches in crop production, a review. Agric Food Sci. 2014;23:60-79. doi:10.23986/afsci.8542
19. Hutton MG, Handley DT. Effects of silver reflective mulch, white inter-row mulch, and plant density on yields of pepper in Maine. HortTechnology. 2007;17(2):214-219.
20. Iqbal R, Raza MAS, Valipour M, Saleem MF, Zaheer MS, Ahmad S, *et al*. Potential agricultural and environmental benefits of mulches—a review. Bull Natl Res Centre. 2020;44:1-16. doi:10.1186/s42269-020-00290-3
21. Johnson MS, Fennimore SA. Weed and crop response to colored plastic mulches in strawberry production. HortScience. 2005;40(5):1371-1375.
22. Joolka NK, Badiyala SD. Studies on the comparative performance of strawberry cultivars. Haryana J Hortic Sci. 1983.
23. Kader MA, Senge M, Mojid MA, Ito K. Recent advances in mulching materials and methods for modifying soil environment. Soil Tillage Res. 2017;168:155-166. doi:10.1016/j.still.2017.01.001
24. Kasperbauer MJ. Strawberry yield over red versus black plastic mulch. Crop Sci. 2000;40:171-174.
25. Kaur R, Bana RS, Singh T, SL M, Raj R, Govindasamy P, *et al*. Sequential herbicide application coupled with mulch enhances the productivity and quality of winter onion (*Allium cepa* L.) while effectively controlling the mixed weed flora. Front Sustain Food Syst. 2024;7:1271340. doi:10.3389/fsufs.2023.1271340
26. Kaur P, Kaur A. Effect of various mulches on the growth and yield of strawberry cv. Chandler under tropical conditions on Punjab. Int J Recent Trends Sci Technol. 2017;25:21-25.
27. Khan BA, Nijabat A, Khan MI, Khan I, Hashim S, Nadeem MA, *et al*. Implications of mulching on weed management in crops and vegetable. In: Mulching in Agroecosystems: Plants, Soil & Environment. Singapore: Springer Nature Singapore; 2022. p. 199-213.
28. Kosterna E. Organic mulches in the vegetable cultivation (a review). Ecol Chem Eng. 2014;21:481-492. doi:10.1016/j.jobab.2020.07.001
29. Kumar S, Dey P. Effects of different mulches and irrigation methods on root growth, nutrient uptake, water-use efficiency and yield of strawberry. Sci Hortic. 2011;127(3):318-324.
30. Larentzaki E, Plate J, Nault BA, Shelton AM. Impact of straw mulch on populations of onion thrips

(Thysanoptera: Thripidae) in onion. J Econ Entomol. 2008;101:1317-1324. doi:10.1093/jee/101.4.1317
31. Łukasiewicz S. Hazards of excessive use of bark mulch in green areas. Ecological Questions. 2013;18:61-65. doi: 10.2478/ecoq-2013-0006
32. Ma J, Chang L, Li Y, Lan X, Ji W, Zhang J, *et al*. Straw strip mulch improves soil moisture similar to plastic film mulch but with a higher net income. Agriculture, Ecosystems & Environment. 2024;362:108855. doi: 10.1016/j.agee.2023.108855
33. Mallory E, Smagula J. Effects of seafood-waste compost and mulch on soil health and soil nutrient dynamics in wild blueberry (*Vaccinium angustifolium* Ait.). Acta Horticulturae. 2014;1017:461-468. doi: 10.17660/actahortic.2014.1017.57
34. Paradelo R, Devesa-Rey R, Cancelo-González J, Basanta R, Pena M, Díaz-Fierros F, *et al*. Effect of a compost mulch on seed germination and plant growth in a burnt forest soil from NW Spain. Journal of Soil Science and Plant Nutrition. 2012;12:73-86. doi: 10.4067/s0718-95162012000100007
35. Puka-Beals J, Gramig G. Weed suppression potential of living mulches, newspaper hydromulches, and compost blankets in organically managed carrot production. HortTechnology. 2021;31:89-96. doi: 10.21273/HORTTECH04745-2
36. Ramakrishna A, Hoang MT, Wani SP, Ding TL. Effect of mulch on soil temperature, moisture, weed infestation, and yield of groundnut in northern Vietnam. Field Crops Research. 2006;95:115-125.
37. Ranjan P, Patle GT, Prem M, Solanke KR. Organic mulching-A water saving technique to increase the production of fruits and vegetables. Current Agriculture Research Journal. 2017;5(3):371-380. doi: 10.12944/CARJ.5.3.17
38. S X, Wang ZH, Li SQ, Gao YJ, Tian XH. Effect of plastic sheet mulch, wheat straw mulch, and maize growth on water loss by evaporation in dryland areas of China. Agricultural Water Management. 2013;116:39-49. doi: 10.1016/j.agwat.2012.10.004
39. Saroa GS, Lal R. Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in Central Ohio. Land Degradation & Development. 2003;14:481-493.
40. Sharma VP, Sharma RR. The Strawberry. New Delhi: Indian Council of Agricultural Research (ICAR); 2004.
41. Shumova NA. The impact of soil mulching on the intensity and occurrence of droughts in wheat crops of the former Soviet Union. Ecohydrology & Hydrobiology. 2002;2(1-4):315-320.
42. Singh R, Sharma RR, Goyal RK. Interacting effects of planting time and mulching on 'Chandeler' strawberry (*Fragaria* × *ananassa* Duch.). Scientia Horticulturae. 2007;111(4):344-351.
43. Sinkeviciene A, Jogaudiene D, Pupaliene R, Urboniene M. The influence of organic mulches on soil properties and crop yield. Agronomy Research. 2009;7:485-491.
44. Smets T, Poesen J, Knapen A. Spatial scale effects on the effectiveness of organic mulches in reducing soil erosion by water. Earth-Science Reviews. 2008;89(1-2):1-12.
45. Solaiman AHM, Kabir MH, Uddin AFMJ, Hasanuzzaman M. Black plastic mulch on flower production and petal coloration of aster (*Callistephus chinesis*). American-Eurasian Journal of Botany. 2008;1(1):5-8.
46. Subrahmaniyan K, Zhou W. Soil temperature associated with degradable, non-degradable plastic and organic mulches and their effect on biomass production, enzyme activities and seed yield of winter rapeseed (*Brassica napus* L.). Journal of Sustainable Agriculture. 2008;32:611-627. doi: 10.1080/10440040802394927
47. Suburika F, Mangera Y, Wahida W. Conservation of soil moisture using mulch of green bean plants (*Vigna radiata*). Musamus AE Featuring Journal. 2018;1(1):10-18. doi: 10.35724/maef-j.v1i1.1609
48. Tan Z, Yi Y, Wang H, Zhou W, Yang Y, Wang C. Physical and degradable properties of mulching films prepared from natural fibers and biodegradable polymers. Applied Sciences. 2016;6:147. doi: 10.3390/app6050147
49. Tang M, Gao X, Wu P, Li H, Zhang C. Effects of living mulch and branches mulching on soil moisture, temperature and growth of rain-fed jujube trees. Plants. 2022;11:2654. doi: 10.3390/plants11192654
50. Ullah I, Lizalo A, Emre Dogan D, Uray Y, Rashid HH. Relevance of mulching in strawberry cultivation. In: International Cappadocia Scientific Research Congress; 2021. p. 318-330.
51. Xie ZK, Wang YJ, Li FM. Effect of plastic mulching on soil water use and spring wheat yield in arid region of northwest China. Agricultural Water Management. 2005;75:71-83. doi: 10.1016/j.agwat.2004.12.014
52. Yadav GS, Das A, Lal R, Babu S, Meena RS, Patil SB, *et al*. Conservation tillage and mulching effects on the adaptive capacity of direct-seeded upland rice (*Oryza sativa* L.) to alleviate weed and moisture stresses in the North Eastern Himalayan Region of India. Archives of Agronomy and Soil Science. 2018;64:1254-1267. doi: 10.1080/03650340.2018.1423555
53. Yang N, Sun ZX, Feng LS, Zheng MZ, Chi DC, Meng WZ, *et al*. Plastic film mulching for water-efficient agricultural applications and degradable films materials development research. Materials and Manufacturing Processes. 2015;30:143-154. doi: 10.1080/10426914.2014.930958
54. Zhao H, Wang RY, Ma BL, Xiong YC, Qiang SC, Wang CL, *et al*. Ridge-furrow with full plastic film mulching improves water use efficiency and tuber yields of potato in a semiarid rainfed ecosystem. Field Crops Research. 2014;161:137-148. doi: 10.1016/j.fcr.2014.02.013
55. Zheng Y, Sun X, Li S, Zhou W, Fan Z, Du T, *et al*. Soil erodibility after the removal of wood chip mulch: A wind tunnel experiment. Journal of Soil and Water Conservation. 2022;77:493-500. doi: 10.2489/jswc.2022.00125
56. Tang D, Qin B, Liu T. Document modeling with gated recurrent neural network for sentiment classification. InProceedings of the 2015 conference on empirical methods in natural language processing 2015 Sep (pp. 1422-1432).