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MULCIREA CU MATERIE ORGANICĂ A ARBUȘTILOR FRUCTIFERI
MULCHING WITH ORGANIC MATTER OF FRUIT BUSHES

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Abstract

The paper proposes the use of natural mulch in fruit shrub plantations. During the work, the evaluation of some studies from the specialized literature regarding the efficiency of soil moisture conservation and the reduction of evaporation, the prevention of competition with weeds for nutrients and water, as well as their neutralization compared to other mulching methods, was followed. Other targeted parameters consisted in the nutrient supply provided by the mulch from plant residues, respectively the maintenance of soil temperature with a role in supporting organisms vital to soil health. One of the main advantages of the organic mulching method is that it maintains moisture in the soil and at the same time ensures the nutrition of the fruit bushes after the decomposition of the applied mulch.

Cuvinte cheie: arbuști fructiferi, metode, mulcire, sol, schimbari climatice
Key words: fruit bushes, methods, mulching, soil, climate change

1. Introduction

In addition to fruit production, fruit tree plantations offer two particularly valuable additional benefits: ecosystem preservation and soil carbon sequestration. Recent studies have highlighted the importance of the interaction between the population of microorganisms and the physico-chemical characteristics of the soil, with an impact on productivity. These researches can help us better understand the symbiotic relationships between fruit trees, microbiota and weeds in order to manage seasonal agricultural activities more effectively.

In this paper, we conducted a systematic literature review, focusing on the interaction between soil and microbiota, with the aim of reducing ecological problems such as biodiversity loss, soil erosion and desertification that are closely related to climate change. Microorganisms in the soil play a vital role in maintaining the health of crops, the balance in agriculture and the preservation of the environment. We have reviewed a number of significant studies conducted in recent years, presenting the main conclusions, in an attempt to deepen how mulching methods and microbiology affect fruit shrub crops in different geographical regions and climatic conditions. Research has shown that different mulching methods can influence productivity by maintaining moisture and temperature in the soil and bringing the required supply of nutrients especially in organic crops.

It is evident that mulching has a significant impact on water retention in agricultural systems by modifying the microclimate and decreasing soil water evaporation (Gan, Y. et al, 2013). However, each method of mulching has advantages and disadvantages, being suitable for some situations or not. Access, durability or prices of materials are important factors to consider when choosing a mulching method. The main priority when choosing the mulching method is to minimize the harmful effects of mulching on the culture and the environment where it is applied (El-Beltagi H.S. et al, 2022).

Drought is a significant problem that restricts crop yields and reduces agricultural progress worldwide for a variety of reasons, including sporadic annual rainfall and uneven temporal distribution, high evaporation, and water scarcity (Peng, H. et al, 2016). These aspects are becoming increasingly severe as a result of the significant impact of global climate change (El-Beltagi, H.S. et al, 2020). Climate change is a phenomenon that influences a series of factors with negative effects on agriculture (Fig.1.). Soil mulching is one of the solutions to counteract them.

In a study carried out regarding the impact on the soil of mulching with biodegradable plastic film or polyethylene film in the raspberry culture, aspects regarding the properties of the soil in protected production systems and in the open field were followed. The results showed that in addition to the production system used in the raspberry crop, the type of mulching had a significant impact on the soil organic carbon stock, moisture content and the number of water-stable aggregates. Soils covered with mulch had a higher amount of organic carbon, water capacity expressed as volume of capillary water

content increased and soil structure was improved compared to soils without mulch (Domagała-Świątkiewicz I. and Siwek P, 2018; Yu, Y. et al., 2018).

As for mulching with polyethylene film, it is the standard of use among raspberry growers worldwide. In open field production, plastic mulches protect the soil surface from erosion processes by mitigating the impact of precipitation and slowing down runoff, which facilitates a good soil structure. A major limitation to the use of plastic mulch involves the disposal of non-degradable materials at the end of the growing season. In horticulture, degradable materials are preferable as sustainable alternatives to traditional plastic films (Kasirajan and Ngouajio, 2012). In the same context, Askari and Holden (2015) state that the assessment and monitoring of selected soil parameters, such as bulk density, organic carbon and aggregate size distribution, provide adequate management information on the differences in soil quality between the production systems used.

According to studies for the mulching of raspberry bushes using organic mulching with straw or sawdust compared to cultivation without mulch, an impact on the development of raspberry bushes was found regarding the late onset of the phenological phases in the case of raspberry cultivation with straw or sawdust, instead a greater number large root shoot and with a higher shoot height for the straw mulching variant. The maximum yield of raspberry berries proved to be -94.5 c/ha by sawdust mulching, which is 3.1 c/ha more than straw mulching and 16.9 c/ha compared to the version without mulching. The proportion of ripe grains in the yield by sawdust mulching increased to 81.5%, which is 4.4% more than straw mulching and 9.1% more than the no-mulching option (Pantsyreva, H. V. et al, 2020). Similar in the case of vine culture, Raffa W.G. et al (2022) indicate that ground cover with mulched spontaneous vegetation brought significant increases in yield.

An experiment conducted by Forge T.A. and Kempler C. (2009) which was based on the use of organic mulch obtained from different compost recipes demonstrated the hypothesis that organic mulches improve the structure of the soil trophic network and the abundance of nematode enemy species (predatory nematodes), leading to a reduction of damage caused by *P. penetrans.* (pathogen attacking raspberry *Rubus idaeus*). Improvements in root development and stem productivity of fruit trees and beneficial changes in soil chemistry such as increased calcium and pH were also observed.

Zhang, H. et al (2019) conducted a comparative study on raspberry culture between PE (plastic film mulch), BDM (biodegradable plastic film mulch) and no-mulch (BG) mulching systems. The results show that PE and BDM provided adequate weed suppression, increased soil temperature, and promoted plant growth and fruit yield compared to BG no-mulch cultivation. Plastic mulch can help improve production efficiency and profitability by reducing labor needs for weed management. Biodegradable plastic mulch can be the solution to environmental waste disposal problems.

In another research, an experiment was conducted to evaluate the effect of 5 years of mulching on the soil and the caulk crop *(Berberis microphylla G.* Forst.). Four mulching treatments were established: no mulch (control), PE (geotextile) and mulching with plant residues (oat straw and hazelnut shell). All mulches suppressed weeds (43%) and maintained more soil moisture (5%) than un-mulched soil. Soil microbial activity increased by 46% only in the case of mulching with plant residues from hazelnut shell compared to the control. The experiment demonstrates that hazelnut shell plant residue mulch can be a microbiological improver of degraded soil, significantly increasing soil microbial activity, basal respiration and urase enzyme activity. Oat straw mulch is highly degradable and generates yield increases (Betancur, M. et al, 2023).

2. Materials and methods

In this paper we focused on the evaluation of some reference works from the specialized literature regarding the main methods of mulching with an emphasis on organic mulching. The benefits of applying different types of mulches and how they can help fruit bushes for sustainable development and optimum yield were presented. The disadvantages of certain types of mulching were also taken into account, as well as the environmental problems related to the disposal of waste resulting from the use of mulching materials.

2.1. Organic mulching

Organic mulches are of vegetable (straw, sawdust, bark, wood chips, compost, etc.) or animal origin. The effectiveness of organic mulching is reflected in minimizing nitrate migration, enhancing soil physical qualities, improving biological activity, nitrogen compensation, providing organic matter, temperature control, water retention and reducing soil erosion. The disadvantages of this type of mulching arise from the fact that natural ingredients are difficult to apply to growing crops and require a lot of labor. For this reason, the large-scale application of organic mulch is limited in the case of horticultural crop production due to cost and logistical problems (Wang, S.J. et al 2014).

2.1.2. The straws

Straw (from cereals), (Fig. 2) is among the oldest types of plant mulch used. These can be easily procured after harvest. Straw mulch is an easy material to apply and use. Straw is typically used as field mulch because it improves crop growing conditions, but it can also be used for horticultural applications. The main problem when straw is used as mulch is that it needs to be replaced every year because it is highly flammable and includes grain seeds that could germinate and deplete soil nitrogen levels as they decompose (Goodman, B.A. 2020) (Fig. 2).

2.1.3. Wood chips

Wood chips (Fig. 3) come from reclaimed wood and a variety of tree species that are used to make wood chips. Given that wood chip mulches have a high C:N ratio, they can limit the availability of available soil nitrogen for plant uptake as they decompose (Bantle, A. et al, 2014).

2.1.4. Sawdust

Sawdust (Fig. 4) is usually popular mulch in locations where it is readily available to growers. It comes from wood finishing procedures. Unlike straw, it has a lower nutritional value, having only half the nutrients. Its decomposition is very slow due to the high C:N ratio. Decomposition of sawdust will lead to a deficiency of N2 in the soil, which is why regular application of fertilizer will be necessary. Due to its acidic nature, sawdust should not be used in low pH soil. An important benefit of sawdust is that it retains soil moisture for a long period of time (Tan, Z. et al, 2016).

2.1.5. Compost

Compost (Fig. 5) is a very good quality mulch and soil conditioner that can be easily made even in households, using a variety of waste (leaves, straw, grass and plant waste, etc.). The availability and use of compost in agriculture is a long-standing tradition. Compost maintains soil health and improves soil properties as well as carbon content, which improves the soil's ability to retain water. Given its higher nitrogen content, compost is not recommended for use in vegetable fields as it may promote weed growth (Sofy, M. et al, 2021).

2.1.6. Bark mulch

This method of mulching (Fig. 6) is effective because it retains more moisture for a long time and thus prolongs the availability of water for the crop. Bark mulch is usually used for landscaping and vegetation. This type of mulch, as it is acidic, should not be used in vegetable fields. On the other hand, this mulch is ideal for covering walkways (Kosterna, E., 2014).

2.1.7. Newspaper

Mulching with newspaper (Fig. 7) is a cost-effective way to suppress weed growth by reducing the chance of germination of fallen weed seeds from the previous season. Newspaper layers biodegrade quickly in the soil unlike plastic sheeting which decomposes over a longer period of time. It is also less expensive and does not require a lot of work time (Haapala, T. et al, 2014).

2.2. Inorganic mulches

2.2.1. Mulching with plastic material

Plastic film mulching (Fig. 8) comprises the majority of mulch used in commercial crop cultivation. The plastic materials used as mulch are polyvinyl chloride or polyethylene films. This type of plastic film mulch increases the temperature around plants in winter due to its greater permeability to long-wave radiation. Polyethylene film mulching is recommended as a mulching material for growing horticultural crops (Gosar, B. and Baricevic, D., 2011).

Although a variety of plastic films based on different types of polymers have been examined for mulching purposes, the technical differences between flexible polyvinyl chloride (PVC), high density polyethylene (HDPE) and low-density polyethylene (LDPE) have been very small (Gao, H. et al, 2019). LLDPE accounts for most of the plastic mulch used today because it is more cost effective to use. Black polyethylene mulch achieved higher crop yield and quality, which increased economic value for farmers. It also decreased soil evaporation, altered the microbial community, and increased soil moisture levels (Li, C. et al, 2014).

2.2.2. Photodegradable or biodegradable mulches

Mulching with photodegradable and biodegradable materials (Fig. 9) is a simple and versatile type of mulch to use. Other mulching materials are sand, gravel and concrete. These specific types of mulches are rarely used because they lead to the absence of nutrients and are expensive to integrate. A greener alternative to polyethylene mulch is biodegradable plastic mulch. This mulch was created to prevent the accumulation of LDPE and pollution caused by plastic waste in the environment (Hayes, D.G. et al, 2019).

2.2.3. Biodegradable plastic film mulching (BDM)

This type of mulch (Fig. 10) is made up of a variety of polymers or additives that are readily available in global markets and are products similar to LDPE mulches in terms of crop productivity (Martín-Closas, L. et al, 2017). In organic farming, this type of mulch also minimizes the need for agrochemicals (Briassoulis, D. and Giannoulis, A., 2018). Selecting the type of mulch is very important

considering that it is incorporated into the soil. This is precisely why costs, local climate and the feasibility of planting the crop must be correlated with the type of mulch chosen (Wang, Z. et al, 2015). Frequent application of mulch can have negative consequences on soil profitability, crop productivity, create ecosystem problems (food and water processing, disease control, N2 cycle and O2 formation), as well as on cultural and aesthetic values (Steinmetz, Z. et al, 2016). Regarding degradation, it should be noted that there are two different levels of degradation: complete and incomplete. The degradation mechanisms are of four different types: photodegradation, water degradation, thermal oxidative degradation, and biological degradation (Liu, L. et al, 2022).

Biobased polymers usually used in BDM are: starch, cellulose, polyhydroxyalkanoates (PHA), polylactic acid (PLA) are typical polymers used. Also poly(butylene succinate) (PBS), poly(butylene succinate-co-adipate) (PBSA) and poly(butylene-adipate-co-terephthalate) (PBAT) are polyesters derived from fossil sources and used in BDMs. Which makes ester bonds or polysaccharides, which are susceptible to microbial hydrolysis, to be found in the polymers used in BDMs. In principle, soil microorganisms should completely catabolize BDMs into microbial biomass, CO 2 and water. Apart from the primary polymers, the plastic mulches also contain traces of organic (additives, plasticizers, etc.) and inorganic elements (Cu, Ni, etc.), whose effects are largely unknown. Standard plant toxicity tests were not modified to detect the effects of substances released by BDM. More succinctly, as compounds degrade, they release different compounds at different times. Normally used tests focusing only on germination do not take into account the changing needs and responses during plant development (Brodhagen, M. et al, 2015).

Previous studies have shown that biodegradable mulch has moisture and heat conservation properties similar to regular polyethylene mulch and can also improve soil water and temperature conditions (Wang, B. et al, 2019; Wang, B. et al, 2020). NPK increased following the biodegradable film mulch treatment. Plastic sheets are usually used to control soil temperature and to preserve soil moisture (Daryanto, S. et al, 2017). Mulching also has an effect on soil nutrients, as increasing soil temperature or moisture levels can enhance the mineralization of soil nutrients (Tian, Y. et al, 2010).

Research shows that biodegradable mulches are rich in organic carbon. Mulches can increase the amount of organic carbon in the soil and have a positive impact on how the soil stores carbon once they are applied. Soil microorganisms use PBAT carbon to produce energy and increase the soil carbon stock (Zumstein, M.T., et al 2018).

According to research, the effects of soil mulching treatments on soil microorganisms and enzyme activity have been observed. Biodegradable mulches have an effect on soil microbial and enzymatic activity. They increase microbial abundance, respiration and activity (Bandopadhyay, S. et al, 2018) compared to the use of polythene sheet mulch. When using biodegradable plastic film, it is assumed that microorganisms use the monomers released during degradation to grow, thereby increasing microbial biomass (Serrano-Ruiz, H. et al, 2021). The soil microclimate can also be improved by biodegradable film mulches. Favorable water and temperature conditions under the mulch impact the plant's root system, which supports root development and increases root exudation (Wang, B. et al, 2019).

2.3. Mulching methods and techniques

2.3.1. Flat mulching

Flat mulching (Fig. 11), involves covering the top layer of the soil with organic, inorganic or mixed mulching materials (Sun, H. et al, 2012). As for organic mulch materials, flat mulching can maintain the thickness of the layer depending on the desired thickness. A type of flat mulch, where part of the soil is covered, is plastic mulch with holes. Compared to conventional flat mulching, this mulching improves soil aeration and rainfall infiltration (Kader, M.A., 2016).

2.3.2. Mulching in the form of ridges

In the case of this type (Fig. 11), the ridge is covered with a plastic film, which directs the water from precipitation into the furrows or reduces surface runoff (Gan, Y. et al, 2012), increasing the efficiency of water use (Zegada- Lizarazu and W., 2011). Crops such as corn are commonly grown on the ridge area of the field, which is extensive, but crops are also grown in the furrow, which may or may not be extensive (Berliner, P.R., 2011).

3. Results and discussions

3.1. Comparative analysis of the main mulching methods applicable to fruit trees

Table 1 show the advantages, disadvantages and future prospects of the different types of mulches evaluated that can be used in the cultivation of fruit bushes. In the works, all important types of mulching were treated in order to highlight the possibility of choosing the best mulching options that farmers can opt for.

In the case of advantages, disadvantages and perspectives, the main benefits, disadvantages and opportunities that influence the growth and development of fruit bushes are exemplified depending on

which type of mulching is used. The criteria that were the basis of their selection were the fulfillment of environmental objectives such as soil sustainability, support of soil biodiversity and the natural supply of nutrients to which organic mulching lends itself very well. The achievement of economic objectives such as production increase, cost efficiency and profitability of crops where PE/BDM mulching is successfully applied was also taken into account.

The illustration in the table had as its social objective the awareness of farmers, the promotion of scientific works of this kind and communication to interested target groups. Also, studying the presentation in the table of the advantages, disadvantages and future perspectives of organic mulching and inorganic mulching can represent an information opportunity for those who want to establish fruit bushes or reconsider their strategy regarding the mulching of this type of culture.

4. Conclusions

The comparative evaluation of the three types of mulching – using organic materials (vegetable waste), biodegradable plastics and non-biodegradable films – highlights specific advantages and limitations of each method in the context of sustainability, agricultural productivity and environmental impact. Mulching with organic materials (vegetable waste) is notable for its significant ecological benefits, contributing to the improvement of soil fertility through natural decomposition and the supply of nutrients. At the same time, it favors water retention and biological activity of the soil, but may require frequent renewals of the mulch layer and more careful management against weeds. On the other hand, non-biodegradable film mulching remains an economically and technically efficient option, offering long-term durability and excellent protection against water loss and weed growth.

Methods that use mulching film have the advantage of better suppression of weeds, maintaining moisture and increasing the temperature of the soil. Organic mulching supports a natural supply of nutrients and an important increase in microbial activity compared to the other methods, which supports the sustainability of the soil. The main disadvantage of the organic method is the need for additional labor. On the other hand, PE and BDM methods present higher acquisition costs and uncertainties regarding durability and degradability, which can lead to economic and environmental problems.

Most of the identified works claim that the organic mulching method ensures soil sustainability and biodiversity, while PE and BDM mulching proposes production efficiency and profitability, but requires further studies on economic and environmental impact. In the works studied, it was emphasized that the soil without mulching is not a viable alternative for both organic and inorganic mulching.

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Tables and Figures

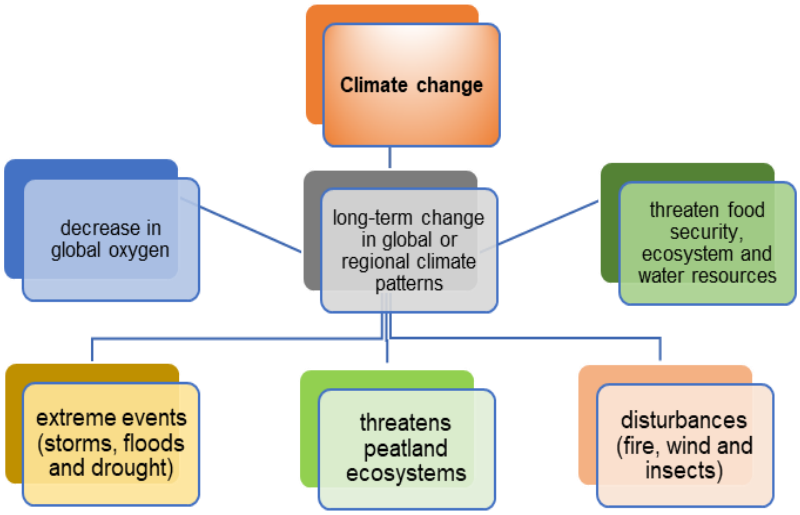

Fig. 1. Climate change and influences on agricultural systems. Adapted from (El-Beltagi H.S. et al, 2022)

Fig. 2. Mulching with straw (https://agromedia.md/agricultura-moderna/fructe-si-legume/mulcirea-la-zmeur-avantaje-ce-materiale-putem-utiliza)

Fig. 3. Mulching with wood chips
(https://seminteonline.wordpress.com/tag/aschii-de-lemn-frunze-uscate-mulci-ingrasamint-natural)

Fig. 4. Mulching with sawdust
(https://grow.decorexpro.com/ro/plodovye-kusty/mulcirovanie-maliny.html)

Fig. 5. Mulching with compost
(https://grow.decorexpro.com/ro/plodovye-kusty/mulcirovanie-maliny.html

Fig. 6. Mulching with bark
(https://www.google.com/search?q=mulcirea+cu+aschii+la+zmeura&rlz=)

Fig. 7. Mulching with newspaper
(https://www.infocasasigradina.ro/articole/practic-in-gospodarie-23/cum-sa-faci-mulci-din-ziare-si-hartii-906.html)

Fig. 8. Plastic/textile mulch
(https://www.regalfermierul.ro/agrotextil-pentru-prevenirea-buruienilor-solutia-ideala-pentrugradinata)

Fig. 9. Stone mulching
(https://sporulcasei.ro/blog/mulch-vegetal-sau-de-piatra-ce-si-cum-folosesti/?)

Fig. 10. Mulching with biodegradable film
(https://www.google.com/search?q=mulcirea+cu+folie+biodegradabila&sca_esv)

Table 1. Comparative analysis of the main mulching methods applicable to fruit trees

Presentation of the advantages, disadvantages and perspectives of different types of mulching for fruit trees	Organic mulch (plant residues)	Polyethylene (PE) mulching / geotextile	Biodegradable plastic mulch (BDM)	Reference
Benefits				
- Weed suppression	✓	✓	✓	*Haapala, T. et al, 2014*
- maintaining soil moisture	✓	✓	✓	*Gan, Y. et al, 2013; Tan, Z. et al, 2016*
- increase in soil temperature	✓	✓	✓	*Zhang, H. et al 2019*
- increased yield compared to cultivation without mulching	✓	✓	✓	*Raffa W.G. et al 2022*
- increase microbial activity	✓			*Betancur, M. et al, 2023*
- natural intake of nutrients	✓			
- workforce reduction		✓		*Gosar, B. and Baricevic, D., 2011*
- mulch replacement	✓			*Bantle, A. et al, 2014*
Disadvantage				
- acquisition costs		✓	✓	*Gao, H. et al, 2019*
- annual replacement	✓		✓	*Goodman, B.A. 2020*
- the need for labor	✓			*Wang, S.J. et al 2014*
- non-renewable raw materials		✓		*Wang, Z. et al, 2015*
- waste management with economic/environmental problems		✓		
- uncertainties regarding durability and degradability mulching		✓	✓	*Kasirajan and Ngouajio, 2012*
Perspectives				
- supports soil sustainability and biodiversity	✓			*Sofy, M. et al, 2021*
- significant production increases from the second year of mulching	✓			
- streamlining crop production and profitability		✓		*Li, C. et al, 2014*
- unknown environmental impact if not degraded			✓	*Martín-Closas, L. et al, 2017*
- additional cost-benefit studies with economic/environmental impact		✓	✓	*Hayes, D.G. et al, 2019*
- Payability mulching perennial crops with an environmental effect	✓			*Wang, S.J. et al 2014*

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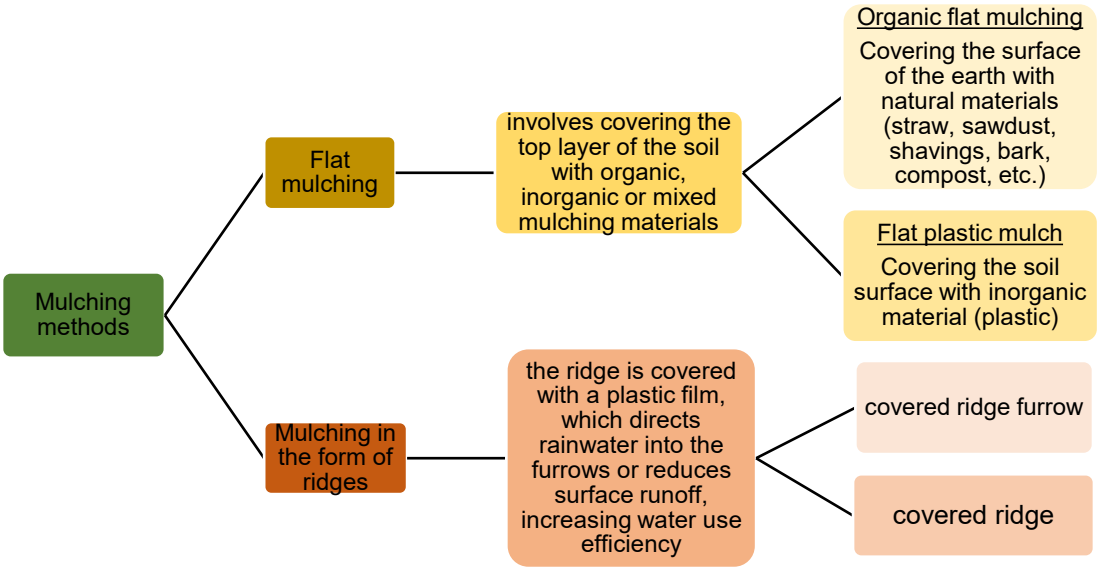

Fig. 11. Representation of mulching techniques
(Sun, H. et al, 2012; Kader, M.A., 2016; Gan, Y. et al, 2012; Zegada-Lizarazu and W., 2011; Berliner, P.R., 2011)