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ORGANIC MULCHES IN THE VEGETABLE CULTIVATION (A REVIEW)

MULCZE ORGANICZNE W UPRAWIE WARZYW

Abstract: Soil mulching is very important practice in field production. Different mulching materials can be use for different agricultural and horticultural species in different climatic environments. The main role of organic mulches is to protect the soil surface from the influence on unfavorable factors and to improve the growing conditions for the crop plants. Mulching reduces unproductive evaporation from the soil surface. Organic mulch also reduces soil wind and water erosion by protection the soil surface and reduces nutrient loss by runoff and leaching. Mulches conserve soil moisture, help maintain stable soil temperature, increase soil porosity and suppress weed growth. The main advantages of organic mulches are organic matter and nutrient supply not only for plants but also for soil organism. Mulch improves physical, chemical and biological properties of soil and ultimately enhances the growth and yield of crops. The purpose of this review is to comparative analysis of the scientific research on the benefits and drawbacks of mulches used in vegetable cultivation.

Keywords: mulch, cash crop

Nowadays, care for the environment and ecological issues, is not only a kind of ideology, but it has wide application in practice. It is said about it in the context of the development of the industry, but also in relation to agriculture. In the cultivation of plants it is very important not only yield level, but the least invasive course of all phases of cultivation. Very often are used environment-friendly, natural methods of soil conservation. According to Kołota and Adamczewska-Sowinska [1] all treatments that protect the soil from degradation and use plant protection methods other than chemicals are of great importance in organic farming. One of the natural methods which have a favourable influence on soil environment is the use of mulches [2–4]. To achieve optimum advantage from the mulch, the mulch should be applied immediately after germination of seeds, at a minimal dose of 5 ton per ha [5]. A mulch may take many forms: a living plant ground cover, loose particles of organic and inorganic matter spread over the soil or sheets of artificial or natural materials laid on the soil surface. Plants residues from preceding crops may also be used to form a mulch [6]. Organic

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mulches have the advantage of being biodegradable, but decomposition may result in a temporary reduction in soil mineral nitrogen. According to Bajoriene et al [7] natural organic mulch eventually breaks down and becomes a part of the soil and a source of plant nutrients. Increasing the amount of soil organic matter is regarded as the main advantage of organic mulch. However, the influence of mulch on soil agrochemical properties depends on the chemical composition of mulch. Organic mulch is a source of nutrients for soil microorganisms, and as a result of their activity organic residues used for mulching are decomposed to available plant nutrients [8, 9]. Organic mulches provide many of the benefits but also have few disadvantages. Natural mulch materials are often not available in adequate quantities for commercial operations or must be transported to the place of use. Natural materials are not easily spread on growing crops and require considerable hand labor. Expense and logistical problems have generally restricted use of organic mulch to home gardeners and small market gardens with only limited use on a large commercial scale [5]. In turn, synthetic mulches provide an effective barrier to most weeds and are amenable to mechanized application, but they must be removed at the end of the season. What is more non-porous plastic mulches can hinder infiltration of rainfall or overhead irrigation into the crop root zone. Some water runs into planting holes, but much of it runs off the mulch into alleys and may not reach crop roots. Other disadvantage of synthetic mulches include the labor of end-of-season removal, is generation of non-biodegradable waste, and the fact that synthetic mulches do not add organic matter or nutrients to the soil [10]. According to Zagaroza [11] inconveniences is mainly the price of plastic as well as management costs.

The effect of mulching on the soil properties and plant yield depends on the climatic and soil conditions, agro-technology practices and the kind of mulch. This treatment gives better results in less favourable soil conditions, in areas with a high abundance of weeds and at lower soil nutrients [12]. The main role of mulches in vegetable crops cultivation is to protect the soil surface from the influence of unfavorable factors and to improve the growing conditions for the crop plants [7, 13]. They reduce soil wind and water erosion [14], conserve soil moisture [15] and help maintain stable soil temperature [16]. The properties of some mulches may better benefit plants growth by preserving soil structure and acting as a barrier to the action of rainfall that can cause compaction and erosion. Less-compacted soil provides a better environment for seedling emergence and root growth [17]. Soil coverage with organic mulches is one of the natural methods of preventing weed infestation. Organic mulch can block light to the soil surface, reducing the germination and growth of weeds. Infestation is limited by both the mechanical effect of an application of mulch [18], and by the allopathic effect of chemical compounds contained in the tissue of plant mulches [19]. This allows farmers to reduce an application of herbicides and tillage operations which disturb soil structure [14].

Soil physical and chemical properties

Agricultural production is directly related to quality of soil. Maintenance of proper soil quality is essential not only for agricultural sustainability, but also for environmental protection. Many materials used for mulch have different effects on soil physical and chemical characters. According to Bezborodova et al [20] the potentialities of

mulches to improve soil structure, increase organic matter, and establish patterns of nutrient cycling more similar to natural ecosystems. Mulching positively influences the biodiversity and abundance of soil fauna [21].

The presence of mulches on the field during vegetation period reduces the need for some soil tillage operations, which can contribute to soil compaction and dispersion [1]. According to Mulumba and Lal [22] effect of mulching on bulk density are often variable and may vary due to soil type and properties, type of mulch and climate. Pervaiz et al [23] were observed that straw mulch decreased bulk density of the soil. In turn, Bottenberg et al [24] reported increase soil bulk density under mulch. Mulumba and Lal [22] were found that total soil porosity increased with increase in mulch rate by 35–46 %, however bulk density was not affected by mulch rate. The increased porosity is especially important to crop development since it may have a direct effect on soil aeration and can enhance root growth. According to Dexter [25] organic mulch also affect in a high degree on the aggregate stability. The author claim that changes in soil organic matter content can lead to changes in aggregation stability. The energy dissipation effect of organic matter helps to reduce aggregate breakdown by raindrop impact. The increased aggregation due to mulches application can also be attributed to increase in fungal and bacterial activity [22]. Jordan et al [26] reported that bulk density, total soil porosity and aggregate stability could be improved significantly with the increasing mulch rates.

In the study by Lal [27] use of crop residue mulch and no till system was an effective technique to reduce risks of erosion-induced soil degradation. The author also indicated that soil erosion decreased drastically with increasing mulch rate in all no till treatments. Lal [28] claim that the cropping systems should be developed that provide ground cover at all times especially during the periods of intense rains. According to Smets et al [29] organic mulches can be used to quickly protect the soil surface against the erosive forces of rain and runoff. This is confirmed in the study by Gholamia et al [30] in which straw mulch played an effective role in reducing the erosion in both up and down directions.

According to Cherr et al [9] the main advantages of organic mulches are organic matter and nutrient supply not only for plants but also for soil fauna. The soil organic matter increases due to decomposition of applied mulch. The remains of mulch were returned into the soil by ploughing after harvest in the autumn. Blanco-Canqui and Lal [31] were found that mulching with straw during 10 years increased soil organic carbon by 33 %. This means that 2/3 of the applied straw was not converted into SOC and probably was lost as emissions of CO_2 and CH_4. This is confirmed in the study by Yu et al [32], in which soil organic carbon content increased significantly after six years straw application. In the study by Bajoriene et al [7] peat, straw and sawdust mulch had a positive influence on the SOC content increasing it 1.3–1.9 times. The thicker (10 cm) mulch layer significantly (by 0.35–0.52 percentage points) increased the content of SOC compared with the thinner (5 cm) mulch layer. The authors also found a very strong positive linear correlation between the content of organic C carried into the soil with mulch and the content of organic C in the soil.

The conservation of soil water storage through mulching is one of the important purposes. When soil surface is covered with mulch helps to reduce evaporation and increase infiltration of rain water during growing season [5]. Sauer et al [33] reported

a 34–50 % reduction in soil water evaporation as a result of crop residues mulching and that creating a 15-cm bare strip increased soil water evaporation by only 7 % over the weathered residue cover. Mulches greatly retard the loss of soil water. As a result, higher and uniform soil water regime is maintained reducing the irrigation frequency [34]. In the study by Kosterna [35] it was found that all investigated in the experiment kinds of straw caused increase moisture the upper and lower soil layers. Tomar et al [36] demonstrated higher soil moisture at the depth of 0–30 cm in mulched plots compared with the control. According to those authors, the effect of mulching was less pronounced at the 30–90 cm depth, but mulches retained relatively more water than the control. Also Rathore et al [37] reported that straw mulch conserved more water in the soil profile during the early growth period compared to no mulch. According to Sinkeviciene et al [16], soil moisture in mulched plots is not only higher compared with control plots but also more stable during all growing periods. Studies by Shangning and Unger [15], as well as by Uwah and Iwo [38], indicated that straw mulching increases soil moisture with an increasing straw dose used for mulching. Similarly, in the study by Jordán et al [26] low mulching rates did not have a significant effect on water properties with respect to control, although the available water capacity increased greatly under high mulching rates. The authors also found that after simulated rainfall experiments the mulch layer contributed to increase the roughness and the interception of raindrops, delaying runoff generation and enhancing the infiltration of rain water during storms. Mulching contributed to a reduction in runoff generation and soil losses compared to bare soil.

Soil mulching with organic material is one way of soil water protection and also helps maintain a constant soil temperature in soil layer within the root system of crops [16, 35, 39]. Kumar and Bhardwaj [5] found that mulch reduces soil warming in summer and cooling in winter. It prevents the extremes of temperatures. The cooling effect of soil in summer promotes root development. According to the authors the effect of mulching on the temperature regime of the soil varies according to the capacity of the mulching material to reflect and transmit solar energy. In general, mulch, by maintaining proper moisture and decreasing soil warming in summer months as well as reducing the daily temperature fluctuations, improves soil conditions for plant growth and development. This was confirmed in studies by Kesik and Maskalaniec [40], in which mulch with rye straw was used effectively as an insulator and protected the soil from overheating. Mulching of soil ensured better thermal conditions during the morning hours, and protected against rapid loss of warmth accumulated in the soil during the day. The soil temperature in the study by Kosterna [39] in the plots without straw, both in the morning (measurement at 8.00 a.m.) and in the afternoon (measurement at 2.00 p.m.) was higher than in plots mulched with straw. According to Borowy [41] this phenomenon can be unfavourable for thermal plants. The covers caused decrease of soil temperature and as a result contributed to slower growth of plants and delayed fruits maturation.

Weed control effect

Soil coverage with organic mulches can suppress weed infestation. According to Ossom et al [42] very little weed growth occurs under the mulch as the mulches prevent

penetration of light or exclude certain wavelengths of light that are needed for the weed seedlings to grow. Weber and Hrynczuk [43] (in Klumper et al [44]) were found that germination of some weed species depends on the so-called light reaction which stimulates plant emergence. Cardina et al [45] and Mohler and Teasdale [46] claim that lack of light makes weeds remain dormant in the top soil layer, and as a result, no infestation of crop plants takes place. According to Creamer et al [19] infestation is also limited by the allopathic effect of chemical compounds contained in the tissue of plant mulches. The authors also found that cover crop residues remaining on the soil surface can physically modify seed germination by altering the seed environment (changes in light availability, soil temperature, and soil moisture). A positive effect of various organic mulches is particularly visible in the period of intensive weed germination in the first part of summer [47]. The authors found that in the second part of summer and in early autumn, weed emergence is weaker in comparison with that in spring and early summer, therefore, mulch has less influence. The number of weeds that germinated in the beginning of summer in mulched soil was by 30.9–50.6 times lower than in the soil without mulch. Later this positive influence weakened, but remained for the entire growing period.

In the study by Kosterna [48] all types of mulch caused a decrease in weed infestation in broccoli and tomato compared to the control plot without mulch. The most efficient for limiting infestation was mulch with buckwheat and rye straw. This was confirmed by a study by Jodaugiene et al [47] regarding kidney beans and onion cultivation, in which the most efficient weed limiter at the beginning of summer (3.5–14.1 times) was straw mulch. However, the authors pointed that straw should not to contain weed or crop seeds, which could cause secondary infestation. In turn, Yordanova and Shaban [49] found that straw mulch is more loose material, did not cover the soil tightly and could not provide effective weed control compared with other kinds of organic mulch. In a study by Mohtisham et al [50], mulch with wheat and maize straw reduced the number of germinating weeds by half compared to non-mulched control. Similarly, in the study by Sinkeviciene et al [16] straw mulch was the best for weed control in vegetable cultivation. In plots with straw mulch weed density was established at 2.8–6.4 times lower compared with weed density in plots without mulch. The influence of organic mulch with peat and sawdust was similar to straw mulch, and least effective was grass mulch. In the study by Zaniewicz-Bajkowska et al [51] straw mulch left on the field till cabbage harvest, significantly reduced the fresh mass of weeds, on average, by 38.8 % compared to the control without mulch. In the study by Din et al [52], soil mulching with wheat straw in corn cultivation contributed to a decreased mass of weeds, on average, by 27.1 %, compared to the plot without straw. Kristiansen et al [53] were found that during echinacea (*Echinacea purpurea* Moench. L.) production, hay mulch exhibited >90 % greater weed control compared to a non-weeded control and was comparable to hand-weeding. The same experiment showed 85 % weed control by hay mulch for lettuce production, compared with 96 % control by hand-weeding. According to Derek et al [13] application of mulch several weeks after pepper transplanting can improve weed suppression later into the growing season. In turn, in the studies by Johnson et al [54] straw applied at planting time of vegetables

suppressed weeds more effectively, whereas straw applied 4 weeks after planting had less effect on weeds.

In the study by Zagaroza [11], how efficient the mulch was depended on the thickness of the mulch layer on the soil surface. Hembry and Davies [18] found that weed growth still occurred at 20 Mg ·ha^{-1} of straw mulch, although there were fewer weeds. Yordanova and Shaban [49] claim that, organic mulch, irrespective of the mulch layer on the soil surface, did not provide good weed control, especially against the perennial weeds. In the study by Doring et al [55] there was no consistent effect of straw mulch on number of weeds, weed cover and above ground biomass of weeds. According to the authors the fact that weed development were not significantly affected by straw mulch is mainly attributed to the relatively low amounts of straw applied.

Ahmed et al [56] claimed that mulch with wheat straw contributed to a significant decrease in the mass of weeds, compared to the control plot, however, higher rates of mulch application controlled weeds more effectively. This is confirmed in the study by Uwah and Iwo [38], in which there was a decrease in the mass of weeds in maize cultivation when there was an increase in the grass dose applied to soil mulching. According to authors the weed dry matter yield obtained in the control, was over eleven times higher than the 8 Mg · ha^{-1} mulch rate and more than six times above the 6 Mg · ha^{-1} mulch rate.

Pests and diseases control

Mulch cover can play a neutral role or reduce the risk of insect pest attack to crop plants by preventing direct movement of insects from soil to plants, but sometimes mulch can increase the risk of insect invasion [57]. Mulching soil improves environmental conditions for soil organisms by protecting the habitat against water and wind erosion, drastic variations in humidity and temperature, and by increasing organic matter as a food source [58].

Changes in cropping systems affect insect pests and their natural enemies. Most insect populations were significantly influenced by ground cover. Organic mulches might provide hiding places to harbor populations of natural enemies [59]. In turn, Gill et al [60] were found that several insect groups, including ants, beetles and small plants feeding insects, were highest in unmulched control. The authors claim that it is possible that weeds in control plots without mulch may have led to the higher numbers of small plant-feeding insects in these plots.

According to Mohler [61] applying of organic mulch around small, succulent lettuce, brassica, or other vegetable seedlings can result in defoliation by slugs or insects, leading to poor stands or delayed establishment. However, these organisms have been observed to attack weed seedlings as well, and can reduce weed populations without seriously impacting well-established crops.

Chalker-Scott [3] state that mulches will reduce splashing of rain or irrigation water, which can carry spores of disease organisms up to the stems or leaves of susceptible species. Additionally, the populations of beneficial microbes that colonize many mulch materials can reduce soil pathogens either through direct competition for resources or

through chemical inhibition. Mulch maintains an optimal soil environments, which in turn supports healthy plants that are less susceptible to opportunistic pathogens.

Mulching soils to encourage populations of indigenous, beneficial soil microbes will increase the effectiveness of biological control in managing disease [62]. According to Davies [63] application of organic mulches such as pine bark or wood chips are more effective in suppressing disease than black polyethylene mulch.

Vegetables yield and quality

Application of mulches beneficially influences soil structure, supply organic matter, reduces negative effects of wind and water erosion, decreases soil warming in summer months, resulting in an increases crop yields [34, 35, 64]. According to Gill et al [65], the increase in yield due to mulching is higher for species grown for early harvest. Increased plant growth in response to mulching has been attributed primarily to conservation of soil moisture, moderation of soil temperature, and reduced competition with turf and other plants [66]. This was confirmed in the studies by Sajid et al [34], in which plants of peas cultivated on the organic mulch with wheat straw and sawdust were higher on average by 5.54 and 7.72 cm compared to plants from control without mulch. The results were in agreement with Makus et al [67] who observed that plant height was significantly affected by different mulching material. According to the authors application of mulch increased plant height due to soil moisture conservation and reduced water stress. Soil mulching with organic mulches in the study by Awal and Khan in maize [68] and Kar and Kumar in potato [69] resulted in greater above-ground plant biomass and quicker plant development compared with non-mulched plots. Khan and Parvej [70] were found that mulching enhanced the number of ears per plant, ear height, length and diameter, tassel length, number of seed rows and 1000-grains weight compared to cultivation without mulch.

In the study by Zaniewicz-Bajkowska et al [51], application of rye straw as a mulch in cabbage and onion cultivation influenced the increase of total and marketable yield of these vegetables as compared to cultivation without mulch. In the study by Kosterna [39] all kinds of organic mulch contributed to increase in the broccoli yield and improvement its parameters. The favourable influence of organic mulches in different weather condition on the yield level was confirmed by many researches. An increased yield of tomato as the result of organic mulch application was found by Saeed and Ahmad [64] in Pakistan as well as Rahman et al [71] in Bangladesh, sweet pepper by Derek et al [13] in United States, carrot by Olfati et al [72] in Iran, potato by Kar and Kumar [69] in India and melon by Johnson et al [54] in United States. Olfati et al [72] were found that total yield, root weight and root length for plants grown with organic mulches were better than the bare soil control. However, the authors did not find significant differences in plant height, root diameter and inner and outer core diameter. Kar and Kumar [69] higher yield and better crop growth were observed in the mulched plots, which might be due to conservation of soil moisture and reduction of soil temperature by 4–6 ^{o}C compared to the non-mulched plots. In the study by El-Shaikh and Fouda [73] carried out in Libyan conditions the yield of cucumber cultivated on the

soil with straw mulch was higher by 3.77 Mg · ha^{-1} compared to bare soil. However, in the study carried out by Döring et al [55] in Germany, mulch with straw applied to organically grown potatoes had no significant influence on the yield or tuber size fractions. In turn, Díaz-Perez [74] in the study regarding onion cultivation, found that yield with straw mulch was significantly lower compared to the control.

Wicks et al [75] in studies regarding corn cultivation found that, with increasing straw dose applied to soil mulching, there was increased average weight and number of cobs per plant. Similarly, the study by Uwah and Iwo [38] showed that increasing mulch dose from 2 to 8 Mg · ha^{-1} increased the height and number of leaves per maize plants. The grain yield obtained at 6 or 8 Mg · ha^{-1} rates was more than double that of the non-mulched control plots. In the study by Kosterna [76] it was found that all kinds of straw investigated in the experiment, irrespective of dose, contributed to a significant increase in the marketable yield, weight of marketable head and improved head quality compared to that achieved from cultivation without straw mulching.

The chemical composition of vegetables is genetically determined as well as being modified by factors affecting the plant during growth, and particularly climatic conditions and agro-technology practices [77]. The effect of organic mulches on the nutrients content is differentiated. In the studies by Samaila et al [78] mulch with straw contributed to increase in dry matter, protein and carbohydrate content in tomato. Similarly, the study by Najafabadi et al [79] showed that soil mulching with straw contributed to an increase of dry matter and vitamin C content in garlic bulbs. Majkowska-Gadomska et al [80] were found that mulching contributed to a significant increase in dry matter content in tomato fruits but had no influence on the ascorbic acid, total sugars and organic acids accumulation. Similarly in the study by Sekhon et al [81] significantly higher content of ascorbic acid in sweet pepper fruits cultivated in a control plot without mulch, compared to the plots with organic mulch was observed. In the study by Olfati et al [72], organic mulch applied in carrot cultivation did not have any influence on the dry matter content in roots. Parmar et al [82] were found that soil mulching with straw and dry leaves slightly reduced flesh acidity of melon but caused an increased monosaccharide and total sugars contents. Similarly, in the study by Kosterna [83] soil mulching with corn and rape straw caused an increase in total sugars and monosaccharide content in broccoli and tomato.

Conclusions

Soil mulching with organic material is an important element of integrated and ecological cultivation of plants. One of the most significant advantage of mulch is the addition of organic matter to the soil, especially by nutrient-rich mulch and a favorable effect on the physical and chemical properties of soil, and hence on crop productivity. This management system allows to reducing the application of chemical plant protection and mineral fertilizers. Mulches also suppress weed growth and contribute to reducing the use of herbicides in vegetable production. The effect of kind of mulch on crop growth can vary due to different production practices, growing conditions and crop

species. According to many researches retention of organic matter on the soil surface favorable effect on the growth and development of plant and increase vegetables yield.

References

[1] Kołota E, Adamczewska-Sowińska K. Living mulches in vegetable crops production: perspectives and limitations (a review). Acta Sci Pol, Hortorum Cultus. 2013;12(6):127-142.

[2] Liebman M, Davis AS. Integration of soil, crop and weed management in low-external-input farming system. Weed Res. 2000;40(1):27-47. DOI: 10.1046/j.1365-3180.2000.00164.x.

[3] Chalker-Scott L. Impact of mulches on landscape plants and the environment - A review. J Environ Hort. 2007;25(4):239-249.

[4] Campiglia E, Mancinelli R, Radicetti E, Caporali F. Effect of cover crops and mulches on weed control and nitrogen fertilization in tomato (*Lycopersicon esculentum* Mill.). Crop Prot. 2010;29(4):354-363. DOI: 10.1016/j.cropro.2009.12.001.

[5] Kumar SD, Bhardwaj RL. Effect of mulching on crop production under rainfed condition: a review. Int J Res Chem & Environ. 2012;2(2):8-20.

[6] Bond W, Grundy AC. Non-chemical weed management in organic farming systems. Weed Res. 2001;41(5):383-405. DOI: 10.1046/j.1365-3180.2001.00246.x.

[7] Bajorienė K, Jodaugienė D, Pupalienė R, Sinkevičienė A. Effect of organic mulches on the content of organic carbon in the soil. Estonian J Ecol. 2013;62(2):100-106. DOI: 10.3176/eco.2013.2.02.

[8] Blanchart E, Villenave C, Viallatoux A, Barthčs B, Girardin C, Azontonde A, Fellera C. Long-term effect of a legume cover crop (*Mucuna pruriens* var. *utilis*) on the communities of soil macrofauna and nematofauna, under maize cultivation, in southern Benin. European J Soil Biol. 2006;42:136-144. DOI: 10.1016/j.ejsobi.2006.07.018.

[9] Cherr CM, Scholberg JMS, McSorley R. Green manure approaches to crop production: a synthesis. Agron J. 2006;98:302-319. DOI: 10.2134/agronj2005.0035.

[10] Schonbeck MW. Weed suppression and labor costs associated with organic, plastic, and paper mulches in small-scale vegetable production. J Sustain Agric. 1999;13(2):13-33. DOI: 10.1300/J064v13n02_04.

[11] Zagaroza C. Weed management in vegetables. Food and agriculture organization of the United Nations. FAO plant production and protection. 2003;120:1.

[12] Zibilske LM, Makus DJ. Black oat cover crop management effects on soil temperature and biological properties on a mollisol in Texas, USA. Geoderma. 2009;149: 379-385. DOI: 10.1016/j.geoderma.2009.01.001.

[13] Derek ML, Rowell AB, Snyder JC, Williams MA. Weed control efficacy of organic mulches in two organically managed bell pepper production system. HortTech. 2006;16(2):225-232.

[14] Abdul-Baki A, Teasdale JR, Korcak R, Chitwood DJ, Huettel RN. Freshmarket tomato production in a low-input alternative system using cover crop mulch. HortSci. 1996; 31(1):65-69.

[15] Shangning J, Unger PW. Soil water accumulation under different precipitation, potential evaporation, and straw mulch conditions. Soil Sci Soc Am J. 2001;65(2):442-448. DOI: 10.2136/sssaj2001.652442x.

[16] Sinkevičienė A, Jodaugienė D, Pupalienė R, Urbonienė M. The influence of organic mulches on soil properties and crop yield. Agron. Res. 2009;7(1):485-491.

[17] Kumar S, Dey P. Effects of different mulches and irrigation methods on root growth, nutrient uptake, water-use efficiency and yield of strawberry. Scientia Hort. 2011;127:318-324. DOI: 10.1016/j.scienta.2010.10.023.

[18] Hembry JK, Davies JS. Using mulches for weed control and preventing leaching of nitrogen fertilizer. Acta Hort. 1994;371:311-316.

[19] Creamer NG, Bennett MA, Stinner BR, Cardina J, Regnier EE. Mechanisms of weed suppression in cover crop-based production systems. Hort Sci. 1996;31(3):410-413.

[20] Bezborodova GA, Shadmanovb DK, Mirhashimov RT, Yuldashevc T, Qureshid AS, Noblee AD. Mulching and water quality effects on soil salinity and sodicity dynamics and cotton productivity in Central Asia. Agric Ecosys Environ. 2010;138(1-2):95-102. DOI: 10.1016/j.agee.2010.04.005.

[21] Brévault T, Bikay S, Maldés J M, Naudin K. Impact of a no-till with mulch soil management strategy on soil macrofauna communities in a cotton cropping system. Soil Till Res. 2007;97(2):140-149. DOI: 10.1016/j.still.2007.09.006.

[22] Mulumba LN, Lal R. Mulching effects on selected soil physical properties. Soil Till Res. 2008;98:106-111. DOI: 10.1016/j.still.2007.10.011.
[23] Pervaiz MA, Iqbal M, Shahzad K, Hassan AU. Effect of mulch on soil physical properties and N, P, K concentration in maize (*Zea mays* L.) shoots under two tillage systems. Int J Agric Biol. 2009;11:119-124.
[24] Bottenberg H, Masiunas J, Eastman C. Strip tillage reduces yield loss of snapbean planted in rye mulch. Hort Tech. 1999;9(2):235-240.
[25] Dexter AR. Advances in characterization of soil structure. Soil Till Res. 1988;11(3-4):199-238. DOI: 10.1016/0167-1987(88)90002-5.
[26] Jordán A, Zavala LM, Gil J. Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Catena. 2010;81(1):77-85. DOI: 10.1016/j.catena.2010.01.007.
[27] Lal R. Mulching effects on runoff, soil erosion, and crop response on Alfisols in Western Nigeria. J Sustainable Agric. 1997;11(2-3):135-154. DOI: 10.1300/J064v11n02_10.
[28] Lal R. Soil surface management in the tropics for intensive land use and high and sustained production. Adv Soil Sci. 1986;5:1-109. DOI: 10.1007/978-1-4613-8660-5_1.
[29] Smets T, Poesen J, Knapen A. Spatial scale effects on the effectiveness of organic mulches in reducing soil erosion by water. Earth Sci Rev. 2008;89:1-12. DOI: 10.1016/j.earscirev.2008.04.001.
[30] Gholamia L, Sadeghi SH, Homaee M. Straw mulching effect on splash erosion, runoff, and sediment yield from eroded plots. Soil Sci Soc Am J. 2012;77(1):268-278. DOI: 10.2136/sssaj2012.0271.
[31] Blanco-Canqui H, Lal R. Soil structure and organic carbon relationships following 10 years of wheat straw management in no-till. Soil Till Res. 2007;95:240-254. DOI: 10.1016/j.still.2007.01.004.
[32] Yu JG, Li HX, Chen XY, Hu F. Effects of straw application and earthworm inoculation on soil labile organic carbon. Ying Yong Sheng Tai Xue Bao 2007;8(4):818-824.
[33] Sauer TJ, Hatfield JL, Prueger JH. Corn residue age and placement effects on evaporation and soil thermal regime. Sci Soc Am J. 1996;60:1558-1564. DOI: 10.2136/sssaj1996.03615995006000050039x.
[34] Sajid M, Hussain I, Khan IA, Rab A, Jan I, Fazal-I-Wahid, Shah ST. Influence of organic mulches on growth and yield components of pea's cultivars. Greener J Agric Sci. 2013;3(8):652-657.
[36] Kosterna E. The effect of covering and mulching on the temperature and moisture of soil and broccoli yield. Acta Agrophys. 2014;21(2):165-178.
[36] Tomar VPS, Narain P, Dadhwal KS. Effect of perennial mulches on moisture conservation and soil-building properties through agroforestry. Agroforestry Sys. 1992;19(3):241-252. DOI: 10.1007/BF00118782.
[37] Rathore AL, Pal AR, Sahu KK. Tillage and mulching effects on water use, root growth and yield of rainfed mustard and chickpea grown after lowland rice. J Sci Food Agric. 1998,78(2):149-161. DOI: 10.1002/(SICI)1097-0010(199810)78:2<149::AID-JSFA94>3.0.CO;2-U.
[38] Uwah DF, Iwo GA. Effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth. J Animal & Plant Sci. 2011;21(3):525-530.
[39] Kosterna E. The yield and quality of broccoli grown under flat covers with soil mulching. Plant Soil Environ. 2014b;60(5):228-233.
[40] Kęsik T, Maskalaniec T. Effect of soil mulching on air and soil temperature in strawberry field. Acta Agrophys. 2005;6(1):117-124.
[41] Borowy A. Growth and yield of stake tomato under no-tillage cultivation using hairy vetch as living mulch. Acta Sci Pol, Hortorum Cultus. 2012;11(2):229-252.
[42] Ossom EM, Pace PF, Rhykerd RL, Rhykerd CL. Effect of mulch on weed infestation, soil temperature, nutrient concentration, and tuber yield in *Ipomoea batatus* (L.) lam. in Papua New Guinea. Tropical Agric. 2001;78(3):144-151.
[43] Weber R, Hryńczuk B. Influence of forecrop and mode of tillage on weed infestation of winter wheat. Ann. UMCS, sec. E, LX. 2005;60:93-102.
[44] Klümper H, Gerhards R, Kühbauch. Einfluss des Lichtes auf die Keimung von Unkrauten. Z. für Pflanzenkrankheiten und Pflanzenschutz, Sonderheft. 1996;15:71-73.
[45] Cardina J, Regnier E, Harrison K. Long-term tillage effects of seed banks in three Ohio soils. Weed Sci. 1991;39(2):186-194.
[46] Mohler CL, Teasdale JR. Response of weed emergence to rate of *Vicia villosa* Roth and *Secale cereale* L. residue. Weed Res. 1993;33(6):487-499. DOI: 10.1111/j.1365-3180.1993.tb01965.x.
[47] Jodaugienė D, Pupalienė R, Urbonienė M, Pranckietis V, Pranckietienė I. The impact of different types of organic mulches on weed emergence. Agron Res. 2006;4:197-201.

[48] Kosterna E. The effect of soil mulching with organic mulches, on weed infestation in broccoli and tomato cultivated under polypropylene fibre, and without a cover. J Plant Prot Res. 2014c;54(2):188-198. DOI: 10.2478/jppr-2014-0029.
[49] Yordanova M, Shaban N. Effect of mulching on weeds of fall broccoli. Buletinul USAMV-CN. 2007;64(1-2).
[50] Mohtisham A, Ahmad R, Ahmad Z, Aslam MR. Effect of different mulches techniques on weed infestation in aerobic rice (*Oryza sativa* L.). American-Eurasian J Agric Environ Sci. 2013;13(2):153-157. DOI: 10.5829/idosi.aejaes.2013.13.02.73.
[51] Zaniewicz-Bajkowska A, Franczuk J, Kosterna E. Direct and secondary effect of soil mulching with straw on the fresh mass and number of weeds and vegetable yield. Polish J Environ Stud. 2009;18(6):1183-1188.
[52] Din S, Ramzan M, Khan R, Rahman M, Haroon M, Khan TA, Samad A. Impact of tillage and mulching practices on weed biomass and yield components of maize under rainfed condition. Pak J Weed Sci Res. 2013;19(2):201-208.
[53] Kristiansen P, Sindel BM, Jessop RS. Weed management in organic echinacea (*Echinacea purpurea*) and lettuce (*Lactuca sativa*) production. Ren Agric Food Sys. 2008;23(2):120-135. DOI: http://dx.doi.org/10.1017/S1742170507001950.
[54] Johnson JM, Hough-Goldstein JA, Vangessel MJ. Effects of straw mulch on pest insects, predators, and weeds in watermelons and potatoes. Environ Entomology. 2004;33:1632-1643. DOI: http://dx.doi.org/10.1603/0046-225X-33.6.1632.
[55] Döring TF, Brandt M, Heß J, Finckh MR, Saucke H. Effect of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in organically grown potatoes. Field Crop Res. 2005;94(2-3):238-249. DOI: 10.1016/j.fcr.2005.01.006.
[56] Ahmed ZI, Ansar M, Iqbal M, Minhas NM. Effect of planting geometry and mulching on moisture conservation, weed control and wheat growth under rainfed conditions. Pak J Bot. 2007;39(4):1189-1195.
[57] Haapala T, Palonen P, Korpela A, Ahokas J. Feasibility of paper mulches in crop production: a review. Agric Food Sci. 2014;23:60-79.
[58] Kladivko EJ. Tillage systems and soil ecology. Soil Till Res. 2001;61(1-2):61-76. DOI: 10.1016/S0167-1987(01)00179-9.
[59] Hummel RL, Walgenbach JF, Hoyt GD, Kennedy GG. Effects of production systems on vegetable arthropods and their natural enemies. Agric Ecosys Environ. 2002;93(1-3):165-176. DOI: 10.1016/S0167-8809(01)00345-0.
[60] Gill HK, McSorley R, Branham M. Effect of organic mulches on soil surface insects and other arthropods. Florida Ent. 2011;94(2):226-232. DOI: http://dx.doi.org/10.1653/024.094.0215.
[61] Mohler CL. Ecological bases for the cultural control of annual weeds. J Prod Agric. 1996;9(4):468-474. DOI: 10.2134/jpa1996.0468.
[62] Entry JA, Strausbaugh CA, Sojka RE. Compost amendments decrease *Verticillium dahliae* infection on potato. Compost Sci Utilization. 2005;13(1):43-49. DOI: 10.1080/1065657X.2005.10702216.
[63] Davis JM. Comparison of mulches for fresh-market basil production. Hort Sci. 1994;29(4):267-268.
[64] Saeed R, Ahmad R. Vegetative growth and yield of tomato as affected by the application of organic mulch and gypsum under saline rhizosphere. Pak J Bot. 2009;41(6):3093-3105.
[65] Gill KS, Gajri PR, Chaudry M R, Singh B. Tillage, mulch and irrigation effects on corn (*Zea mays* L.) in relation to evaporative demand. Soil Till Res. 1996;39(3-4):213-227. DOI: 10.1016/S0167-1987(96)01061-6.
[66] Iles JK, Dosmann MS. Effect of organic and mineral mulches on soil properties and growth of fairview flame red maple trees. J Arboriculture. 1999;25(3):163-167.
[67] Makus DJ, Tiwarl SC, Pearson HA, Haywood JD, Tirks AE. Okra introduction with pine straw mulch. Agroforestry Sys. 1994;27(2):121-127.
[68] Awal MA, Khan MAH. Mulch induced eco-physiological growth and yield of maize. Pak J Biol Sci. 2000;3(1):61-64. DOI: 10.3923/pjbs.2000.61.64.
[69] Kar G, Kumar A. Effects of irrigation and straw mulch on water use and tuber yield of potato in eastern India. Agric Water Manage. 2007;94(1-3):109-116. DOI: 10.1016/j.agwat.2007.08.004.
[70] Khan MAH, Parvej MR. Impact of conservation tillage under organic mulches on the reproductive efficacy and yield of quality protein maize. J Agric Sci. 2010;5(2):52-63. DOI: 10.4038/jas.v5i2.2782.

[71] Rahman MJ, Uddin MS, Bagum SA, Mondol ATMAI, Zaman MM. Effect of mulches on the growth and yield of tomato in the costal area of Bangladesh under rainfed conditions. Int J Sustain Crop Prod. 2006;1(1):6-10.
[72] Olfati JA, Peyvast Gh, Nosrati-Rad Z. Organic mulching on carrot yield and quality. Int J Veg Sci. 2008;14(4):362-368. DOI: 10.1080/19315260802303404.
[73] El- Shaikh A, Fouda T. Effect of different mulching types on soil temperature and cucumber production under Libyan conditions. Misr J Ag Eng. 2008;25(1):160-175.
[74] Díaz-Pérez JC. Effects of mulch and irrigation system on sweet onion: I. Bolting, plant growth and bulb yield and quality. J Amer Soc Hort Sci. 2004;129(2):218-224.
[75] Wicks GA, Crutchfield DA, Burnside OC. Influence of wheat (*Triticum aestivum*) straw mulch and metolachlor on corn (*Zea mays*) growth and yield. Weed Sci. 1994;42(1):141-147.
[76] Kosterna E. Soil mulching with straw in broccoli cultivation for early harvest. J Ecol Eng. 2014d;15(2):100-107. DOI: 10.12911/22998993.1094985.
[77] Lee SK, Kader AA. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biol Tech. 2000;20:207-220. DOI: org/10.1016/S0925-5214(00)00133-2.
[78] Samaila AA, Amans EB, Abubakar IU, Babaji BA. Nutritional quality of tomato (*Lycopersicon esculentum* Mill) as influenced by mulching, nitrogen and irrigation interval. J Agric Sci. 2011;3(1):266-270. DOI: 10.5539/jas.v3n1p266.
[79] Najafabadi Mahdieh MB, Peyvast GH, Hassanpour Asil M, Olfati JA, Rabiee M. Mulching effects on the yield and quality of garlic as second crop in rice fields. Int J Plant Prod. 2012;6(3):279-290.
[80] Majkowska-Gadomska J, Wierzbicka B, Arcichowska K. Yield and quality of tomato (*Lycopersicon esculentum* Mill.) fruit harvested from plants grown in mulched soil. Acta Agrobot. 2012;65(4):149-156. DOI: 10.5586/aa.2012.032.
[81] Sekhon NK, Singh CHB, Sidhu AS, Thind SS, Hira GS, Khurana DS. Arch. Agron. Effect of straw mulching, irrigation and fertilizer nitrogen levels on soil hydrothermal regime, water use and yield of hybrid chilli. Soil Sci. 2008;54(2):163-174. DOI: 10.1080/03650340701817014.
[82] Parmar HN, Polara ND, Viradiya RR. Effect of mulching material on growth, yield and quality of watermelon (*Citrullus Lanatus* Thunb) cv. Kiran. Univ J Agric Res. 2013;1(2):30-37. DOI: 10.13189/ujar.2013.010203.
[83] Kosterna E. The effect of soil mulching with straw on the yield and selected components of nutritive value in broccoli and tomatoes. Fol Hort. 201426/1:31-42. DOI: 10.2478/fhort-2014-0003.

MULCZE ORGANICZNE W UPRAWIE WARZYW

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Abstrakt: Mulczowanie gleby jest bardzo ważnym zabiegiem w uprawie polowej. Różne materiały mulczujące mogą być użyte dla różnych gatunków roślin rolniczych i ogrodniczych w różnych warunkach klimatycznych. Głównym zadaniem ściółek organicznych jest ochrona powierzchni gleby przed wpływem niekorzystnych czynników oraz poprawa warunków wzrostu roślin uprawnych. Mulczowanie zmniejsza bezproduktywne parowanie z powierzchni gleby. Mulcz organiczny zmniejsza także erozję wodną i wietrzną gleby poprzez ochronę jej powierzchni oraz straty składników pokarmowych na skutek wypłukiwania. Ściółki zatrzymują wilgoć w glebie, pomagają utrzymać stałą temperaturę gleby, zwiększają jej porowatość i ograniczają wzrost chwastów. Główną zaletą ściółek organicznych jest dostarczanie materii organicznej i składników odżywczych nie tylko roślinom, ale także organizmom glebowym. Mulcz poprzez poprawę biologicznych, chemicznych i fizycznych właściwości gleby przyspiesza wzrost roślin oraz zwiększa plon. Celem pracy jest analiza porównawcza badań naukowych na temat korzyści i wad ściółek organicznych stosowanych w uprawie warzyw.

Słowa kluczowe: mulcz, uprawa