Agronomy Research **21**(X), xxx–ccc, 2023
https://doi.org/10.15159/AR.23.057

Study of the effectiveness of different methods of mulching potatoes (Solanum tuberosum) with cereal straw in eastern Ukraine

O. Melnyk[1,*], V. Pastukhov[2], S. Shcherbina[1], N. Dukhina[1], O. Vitanov[1], O. Shabetya[1], O. Semenchenko[3], V. Rud[1], E. Dukhin[1] and N. Bashtan[1]

[1]Institute of Vegetable & Melon Growing of the National Academy of Agrarian Sciences Ukraine, Instytutska Str., 1, village Selektsiyne, UA62478 Kharkiv rg., Ukraine
[2]State Biotechnologikal University, Alchevskih Str., 44, UA61002 Kharkiv, Ukraine
[3]Dnipro State Agrarian and Economic University, Agronomical faculty, S. Efremova Str., 25, UA49600 Dnipro, Ukraine
[*]Correspondence: melnik.matilda@gmail.com

Received: March 19th, 2023; Accepted: June 16th, 2023; Published: July 2nd, 2023

Abstract. Under the conditions of global climate change, there has recently been a tendency to worsen weather conditions during the growing season in the East of Ukraine. The significant increase in average daily air temperatures and the uneven nature of rainfall do not meet the biological requirements of potato plants, which leads to a decrease in their productivity. The purpose of the research. Improve the microclimate on potato plantations by mulching them with different types of materials. Results of research. Using wheat straw or basalt mineral wool as mulch reduces overheating of the upper layers of the soil by 6.6–7.0° and contributes to moisture conservation. At the same time, there is a significant decrease in temperature and relative humidity fluctuations under the mulch layer compared to the soil surface. The use of spent mineral basalt wool for this purpose, which was previously used as a substrate in greenhouses, solves the disposal problem. Deterioration of soil chemical parameters and product quality was not noted. The use of nitrogen fertilizers (urea) or microbial preparations Azotofit-r and Ecostern before mulching with wheat straw has a positive effect on plant nutrition, which contributes to the improvement of biometric indicators and increases the yield of potatoes by 4.2–4.7 t ha^{-1}. Potato mulching with zero tillage involves planting tubers on its surface. At the same time, their contact with the soil is significantly reduced, decreasing the supply of nutrients from it after the transition of potato plants to autotrophic nutrition. Under these conditions, minimal tillage of the soil during its pre-planting preparation improves the development of the root system and promotes the formation of stolons and tubers at a certain depth. Depending on the number of technological operations, the degree of loosening of the soil significantly affects the yield of potatoes. Its growth with minimal tillage is from 1.3 to 10.7 t ha^{-1} compared to zero tillage. This allows you to compensate for additional costs related to mulching and collecting additional products. The improvement of the main economic indicators confirms the high efficiency of mulching potatoes with wheat straw with minimal tillage. Results were expressed as averages. Chemical composition was analyzed using analysis of variance with $P \leq 0.05$ for yield and plant height using the program of statistical analysis (SAS) v. 9.1.3.

Key words: potatoes, mulching, zero tillage, minimal tillage, mineral basalt wool, straw, microbial preparations.

INTRODUCTION

The efficiency of agriculture is largely determined by weather conditions. In this regard, the cultivation of agricultural products as a rule has a zonal character. Changes in the hydrothermal regime that have taken place in Eastern Europe over the last 30 years do not always meet the biological requirements of plants, which leads to a decrease in their productivity (Adamenko, 2017; Walz et al., 2018; EU Science Hub, 2020; Hurska, 2020). In Ukraine, in particular, the increase in the average annual temperature during this period was 1.5 °C, and according to weather forecasts, it will increase by another 1.1–5.4 °C in the next 50–80 years (Met Office Hadley Centre. 2010; Lindsey & Dahlman, 2021). The number and duration of periods of extreme heat will increase significantly, while the amount of summer precipitation in the southern and eastern parts of Ukraine will decrease significantly. At the same time, the frequency and intensity of very heavy precipitation, which will differ in significant variability, will increase by 10–25% (Coppola et al., 2021; Huo et al., 2021). A decrease in snow cover will lead to a decrease in spring runoff and a drop in groundwater levels (Hirschi et al., 2010; United Nations Office for Disaster Risk Reduction, 2021). According to meteorologists, this will lead to water shortages, aridization of territories, shifting of climatic zones to the north, soil erosion, and deterioration of its condition (Barnosky et al., 2012; The World Bank, 2012; IPCC. Summary for Policymakers, 2021). This is likely to create conditions for the deterioration of the country's food, environmental and economic situation (WEF, 2020; Mclennan, 2021).

The tendency towards climate change, which is observed in particular in the conditions of the eastern forest-steppe of Ukraine, leads to the need to change or adapt the elements of technologies for growing agricultural plants. Most agricultural crops are seriously affected by prolonged hot and dry periods, which have become increasingly common in recent years. Due to the fact that over the past twenty years, there has been a constant increase in the number of thermal anomalies in Ukraine, 2020 became the hottest year, exceeding the average of 1961–1990 by 2.8 °C (Copernicus Climate Change Service, 2020; WMO, 2021). A significant number of agricultural plants, which require a large amount of water and moderate temperatures to form their productive part, require significant regulation of cultivation technologies. At the same time, it is necessary to attract additional resources to ensure the sustainable production of crops traditional for certain regions. Issues of energy saving and economic efficiency, in this case, justify the feasibility of additional technological operations.

Due to its plasticity, potato culture is grown in different climatic zones. At the same time, the potato plant can fully realize its productive potential only in regions with relatively favorable weather conditions and at a high level of production intensification.

The growth and development of potato plants takes place well at an air temperature of no more than 22–24 °C and with sufficient moisture supply. Otherwise, the processes of stolon and tuber formation are inhibited, which leads to a significant decrease in productivity. High average daily air temperatures lead to overheating of the upper soil layer and the occurrence of physiological and biochemical disorders of the tubers. Due to the fact that the processes of growth and development of tubers take place mainly at night, the productive potential of potato varieties is not used to the full extent. The search for economical and energy-justified technological solutions that would allow obtaining high and stable yields of this agricultural crop is of particular importance in potato farming in this region. Among the most widely used is the mandatory use of irrigation, the selection of drought- or heat-resistant varieties, the pre-planting preparation of tubers, measures to preserve moisture in the soil, etc.

Therefore, the development of methods of guaranteed obtaining of stable potato crops is relevant. The conditions regulating of its cultivation allows obtaining high-quality products and reducing costs.

MATERIALS AND METHODS

The efficiency of growing potatoes under a layer of mulch was determined in field conditions according to the ‘Methodology of experimental work in vegetable growing and melon growing’ (Bondarenko & Yakovenko, 2001) and ‘Methodology of field experiment’ (Dospekhov, 1985): repetition was four times, the plot area was 10 m^2, planting scheme - 70×25 cm. The field experiment was established in vegetable crop rotation on the Sifra potato variety in the first or second decade of May 2020–2022. Mineral fertilizers in the amount of N90P90K90 were applied before planting. Irrigation was carried out by the drip method. Soil moisture was maintained at 70–80% RH. The irrigation rate was 80–120 m^3 ha^{-1}.

There was used general accounting method on the experimental plots. The laboratory method was used to determine the content of dry matter, starch, ascorbic acid and sugar in the products, as well as the content of nitrogen, phosphorus and potassium in the soil samples from the experimental variants.

Experiment 1 determined the effectiveness of different types of mulch material with zero tillage. The potato spread over the surface manually with a layer of wheat straw 20–25 cm thick. Spent mineral basalt wool in the form of mats was spread in a layer of at least 5 cm on the surface of the field after planting potatoes. During the growing season, every 2–3 weeks, there was used the instrumental methods to record the daily dynamics of temperature and humidity under the mulch layer. Control is a variant of conventional potato cultivation without mulching (Table 1).

Table 1. Scheme of experiment 1 comparing the effectiveness of mulch materials for growing potatoes

No.	A type of mulch material for sheltering potatoes
1	No mulching (control)
2	Straw (standard)
3	Mineral basalt wool

During experiment 2 there was a comparative assessment of the effectiveness of microbial preparations and nitrogen fertilizers for mulching potatoes with wheat straw at zero tillage (Table 2). The complex use of microbial preparations was studied for the possibility to replace mineral fertilizers.

Treatment with Azotofit-r was carried out by spraying the tubers before planting at a dose of 0.3 L t^{-1}. Nitrogen fertilizers in the form of urea at a dose of 30 kg ha^{-1} and the drug Ecostern at a dose of 1.5 L ha^{-1} were applied to the surface of the field before covering it with straw.

Table 2. Scheme of experiment 2 comparing the effectiveness of microbial preparations and nitrogen fertilizers for potato mulching

No.	A type of preparation for mulching potatoes with straw
1	Straw (standard)
2	Straw + urea (30 kg ha^{-1})
3	Straw + a complex of microbial preparations Azotofit-r (0.3 L t^{-1}) та Ecostern (1.5 L ha^{-1})

Azotophyt-r is a biological preparation, a natural growth stimulator with living cells of the associative nitrogen-fixing bacteria *Azotobacter chroococcum* (titer 1×109 CFU cm^{-3}), biologically active products of their vital activity (phytohormones, vitamins, amino acids). The use of the biological preparation provides active fixation of molecular nitrogen in the air, stimulates growth processes and the development of the root system of plants, increases the resistance of plants to stress factors, improves the assimilation of nutrients, and contributes to an increase in productivity. It is used both for processing seeds and seedlings, as well as for application during the growing season of plants with the help of fertigation or foliar fertilization.

Ecostern is a biodestroyer, and soil improver. The concentrated preparation is specially designed to accelerate the decomposition of crop residues, ciders and improve the soil. Contains spores and mycelium of antagonistic fungi *Trichoderma lignorum*, *Tr. viride* and a set of spores of living cells of natural cellulose-destroying and fungicidal bacteria (Azotobacter chroococcum, Bacillus subtilis, Enterobacter, Enterococcus, etc.) (titer 2.5×109 CFU cm^{-3}).

In experiment 3, there was carried out a comparative evaluation of the methods of minimal pre-planting soil cultivation for growing potatoes under a layer of mulch (Table 3).

Table 3. Scheme of the experiment comparing the effectiveness of methods of pre-planting soil preparation for mulching potatoes with straw

No.	The method of pre-planting soil preparation by mulching potatoes
1	Standard technology (control)
2	Zero tillage (standard)
3	Minimal tillage by disking after harvesting the previous crop (winter wheat)
4	Minimal tillage by disking after harvesting the previous crop and pre-planting cultivation in 2 tracks
5	Minimal tillage by disking after harvesting the previous crop and pre-planting cultivation in 2 tracks and milling

Disking of the soil surface in two tracks to a depth of 6–8 cm was performed after harvesting the previous crop (winter wheat) using the LGD-15 unit. Pre-sowing cultivation in two tracks to a depth of 6–8 cm was carried out using C-11U units with BZTS-1.0. Milling of the soil surface with the help of KPU was carried out before planting. The standard technology used as a control involved disking the soil surface after harvesting the previous crop (winter wheat), deep plowing up to 30 cm, early spring harrowing, cultivation at 6–8 cm in two furrows and pre-planting cultivation at 8–10 cm in two furrows.

Results were expressed as averages. Chemical composition was analyzed using analysis of variance with $P \leq 0.05$ for yield and plant height using the program of statistical analysis (SAS) v. 9.1.3.

RESULTS AND DISCUSSION

The traditional way of growing potatoes with planting material to a given depth in the soil and subsequent inter-row cultivation of crops in modern economic conditions is not only labor- and energy-consuming, but also due to climatic changes, often does not ensure obtaining a full harvest of high-quality potatoes (Muraviov et al., 2019). A promising direction for improving the microclimate in potato crops is the use of mulch after planting the tubers in the soil or after their decomposition on the surface. This will reduce overheating of the upper layers of the soil and moisture consumption due to evaporation and intensive transpiration by plants in the hottest growing season. In this case, minimizing soil treatment will ensure the preservation of its fertility due to the arrival of additional organic substances in the form of plant residues and the activation of useful microbiota. The combination of this technology for growing potatoes with biological systems of fertilization and protection against harmful objects will make it possible to obtain high-quality products.

In modern conditions of production, the method of growing potatoes on the surface of the soil under a layer of organic mulch material with a thickness of 20–25 cm is becoming more and more widespread. There is a known method of mechanized cultivation of potatoes on the surface of the field, according to which the straw of cereal crops and the non-grain parts of other agricultural plants are used as mulch material along with fallen leaves, and other organic materials (Method of mechanized cultivation of potatoes on the surface of the field: pat. 81963 Ukraine: IPC A01C 9/00. No. 2013 02420; application 26.02.2013; publ. 10.07.2013, Bull. No. 13). There is also a well-known method of growing potatoes, which includes the layer-by-layer arrangement of various plant mulching materials. According to it, seed potatoes are laid out on the surface of the ridges and covered with two layers of plant material: the first layer is made of dry uncrushed material with a tubular structure of stems made of straw or reeds (or cattails), and the second layer is made of hay, grass or leaves. After the tops sprout above the mulch to a height of 5–10 cm, the ridges are covered with a third layer of plant material made of hay, grass or leaves. The height of the first layer of mulch was 8–10 cm, and the second and third layers are 5 cm each. The plant material was removed after the potatoes matured, and the tubers were collected (Potato cultivation method: pat. 149918 Ukraine: IPC A01C 9/00. No.u 2021 03701; application 06/29/2021; publ. 12/15/2021, Bull. No. 50).

Double mulching of potatoes is also known when growing by the ridge method using straw mulching material and agricultural film in the area of the ridges. This method includes the following stages: soil preparation and fertilization, formation of ridges, placement of seed potatoes on the ridge; crushing straw and evenly covering the surface of the ridges with it; covering ridges with planted potatoes previously covered with a straw film and sprinkling the film with a thin layer of soil and plantation care. This method contributes to the realization of a high yield of potatoes in irrigated areas (Double mulching by ridge method of growing potatoes using straw mulching material and agricultural film in the ridge zone: patent CN110972866A People's Republic of China: IPC A01G22/25, No. CN201911335724.0A; application 12/23/2019; published 04/10/2020).

It is also known to grow crops hydroponically using a modern high-quality substrate - mineral basalt wool in the form of mats and cubes. This material consists of basalt, limestone, and coke twisted into fibers. Due to this, the cubes and mats made of mineral wool do not change and keep their shape for a long time. It also contains iron, copper, and zinc, which can be absorbed by plants. Basalt mineral wool is characterized by low density (0.1 $g\ cm^{-3}$) and thermal conductivity and high porosity (98%) and moisture capacity. It is light, inert, and has a neutral pH, but over time, pathogens accumulate in it, which reduces the efficiency of growing vegetable crops on it. Such mothers are disinfected and used again for growing vegetables hydroponically, and more often they are simply disposed of. At the same time, the mother of basalt mineral wool completely preserves its geometric dimensions and shape, as well as its low density and thermal conductivity and high porosity and moisture capacity. Such indicators are especially important for materials used in crop production for mulching crops in extreme weather conditions (Electronic source. https://leplants.ru/tsvetovodstvo/mineralnaya-vata-kak-substrat-v-gidroponike/; SAINT-GOBAIN CULTILENE. Quality certificate 113251/7.2568 TUV Nederland 15.01.2020 (according to NEN-EN-ISO 14001:2020). The layer of mineral basalt wool, due to its low density and thermal conductivity and high porosity and moisture capacity, regulates the temperature and humidity of the soil, which ensures the uniform development of all formed tubers and thereby the formation of high yields of high-quality potatoes.

All the described methods make it possible to improve the microclimate in plantations, reduce the evaporation of moisture from the soil, and reduce the development of weeds (Jodaugienė et al., 2006; Pastukhov et al., 2020). Even under critical weather conditions, they make it possible to obtain a full harvest of marketable potato tubers (Pastukhov et al., 2021). By growing potatoes on the surface of the soil under a layer of mulch, the cost of such technological operations as turning and harvesting are reduced. Caring for planted potatoes with this method of cultivation consists only of protection from pests and diseases by spraying with insecticides and fungicides.

According to the results of the research, it was found that mulching with mineral basalt wool with a layer of 5–6 cm provides an average temperature in the zone of tuber development that is 6.6 ° lower than in the control and is practically not inferior to the standard, where the thickness of the layer of straw was 20–25 cm. At the same time, its fluctuations during the day for the use of mineral basalt wool is 3.9°, while for the standard - 7.1°, and the control - 18.1° (Table 4).

Table 4. The effect of mulching on the temperature regime in the zone of potato tuber formation, 2020–2022

No.	A type of mulch material for sheltering potatoes	Temperature, °C	
		middle	fluctuations during the day
1	No mulching (control)	27.7	from 14.6 to 32.7
2	Straw (standard)	20.7	from 16.1 to 23.2
3	Mineral basalt wool	21.1	from 18.7 to 22.6

A high level of relative humidity under the layer of mineral basalt wool was also established - it is 11.9% higher than in the standard and 47% higher than the control version. Daily fluctuations of this indicator according to the developed method are 17.0%, in the standard - 27.8%, and in the control - 48.0% (Table 5).

Table 5. The effect of mulching on the moisture regime in the zone of potato tuber formation, 2020–2022

No.	A type of mulch material for sheltering potatoes	Relative humidity, %	
		middle	fluctuations during the day
1	No mulching (control)	41.3	from 25.3 to73.3
2	Straw (standard)	76.4	from 62.7 to 90.5
3	Mineral basalt wool	88.3	from 79.2 to 96.2

It is known that different types of mulching can increase the yield of potatoes and improve the availability of phosphorus (Sinkevičienė et al., 2009; Timilsina et al., 2022). Mulching with polyethylene film reduces moisture and heat losses (Wang et al., 2022; Chen et al., 2022), and changes in leaf stomatal conductance and photosynthesis occur (Li et al., 2022).

The use of polyethylene film for mulching the remains of cover crops increases the content of labile carbon in the soil (Papdi et al., 2022) and reduces CO_2 leakage from 74 to 36% (Lee et al., 2022). At the same time, half mulching with polyethylene film at zero tillage due to higher water availability leads to greater infiltration of seasonal precipitation, increased yield, and organic carbon content (Ren et al., 2023).

However, the use of straw as mulch significantly increases the relative number of nitrogen-fixing bacteria, inhibits fermentation, and reduces nitrate content in the soil (Liu et al., 2022), which leads to improved soil fertility (Zhang et al., 2022). This is especially noticeable for mulching the gentle slopes of arable land when there is an increase in nutrient levels and an increase in the number and diversity of bacteria (Sun et al., 2022). Compared to no-tillage, straw mulching is more effective in improving soil properties, including reducing soil bulk density, and increasing organic carbon concentration in deeper (0 to 30 cm) soil layers. At the same time, the rate of absorption of organic carbon is more than two times higher than with minimal cultivation. However, the best results regarding the accumulation of organic carbon in the subsoil were obtained by combining mulching with minimal tillage (Xiao et al., 2023).

Germination of tubers under a layer of mulch occurs in favorable temperature and humidity conditions, which leads to the intensive formation of the root system and vegetative mass. According to the obtained data, a slight lag in plant growth was observed when straw was used as mulch. This can be explained by the strengthening of nitrification processes during the decomposition of straw at the boundary between mulch and soil, which causes nitrogen starvation of plants in the initial stages of vegetation. Fertilization with urea at a dose of 30 kg ha^{-1} improves the biometric and productive indicators of plants. An alternative to accelerating the process of destruction of plant mulch materials is also the use of microbial preparations (Table 6).

Table 6. The effect of microbial preparations and nitrogen fertilizers on plant height after mulching potatoes with straw, 2020–2022

No.	Type of preparations for mulching potatoes with straw	Plant height, m
1	Straw (standard)	0.62
2	Straw + urea (30 kg ha^{-1})	0.70
3	Straw + a complex of microbial preparations Azotofit-r (0.3 L t^{-1}) та Ecostern (1.5 L ha^{-1})	0.70

The analysis of the content of the main chemical elements indicates a tendency to reduce the content of total nitrogen in the soil with mulching: when using straw up to 110 μg kg^{-1}, when using mineral basalt wool - up to 118 μg kg^{-1} (control - 139 μg kg^{-1}). This is explained by the activation of biochemical and microbiological processes under the layer of mulch. However, there is a significant increase in the potassium content in the soil - up to 164 μg kg^{-1} when using straw, and up to 153 μg kg^{-1} - when using mineral basalt wool (control - 93 μg kg^{-1}) (Table 7).

As a result of the formation of a favorable microclimate in potato plantations with the use of mulching materials, the processes of stolon and tuber formation took place in optimal conditions for this crop, which led to an increase in productivity in areas under a layer of straw by 2.6–7.1 t ha^{-1}, and in areas under a layer of spent mineral of basalt wool by 7.2 t ha^{-1} compared to the control (Table 8).

It should be noted that the use of microbial preparations is not inferior to the use of mineral nitrogen fertilizers, which makes it possible to recommend them for involvement in organic production technologies.

Table 7. The effect of mulching on the content of the main nutrients in the soil, the average for 2020–2022

No.	A type of mulch material for sheltering potatoes	The content of the main nutrients in the soil, μg kg^{-1} of dry matter		
		N	P	K
1	No mulching (control)	139	112	93
2	Straw (standard)	110	112	164
3	Mineral basalt wool	118	102	153

The high yield of potatoes under the shelter of mineral basalt wool is largely explained by the absence of harmful effects on plants and soil. Due to the fact that basalt mineral wool is chemically neutral, it does not need to be collected and can be worked into the soil.

Table 8. The effect of mulching on the yield of potato tubers, 2020–2022.

No.	Type of mulch material and preparations for mulching potatoes with straw	Yield, t ha^{-1}
1	No mulching (control)	21.2
2	Straw (standard)	23.8
3	Straw + urea (30 kg ha^{-1})	28.0
4	Straw + a complex of microbial preparations Azotofit-r (0.3 L t^{-1}) та Ecostern (1.5 L ha^{-1})	28.3
5	Mineral basalt wool	28.4

Biochemical analysis of the tubers indicates the absence of negative changes in the main indicators of the investigated options for using mulch. At the same time, there is a trend towards an increase in the content of starch and ascorbic acid with a corresponding decrease in the total content of sugars (Table 9).

Table 9. The effect of mulching on the biochemical composition of potatoes, the average for 2020–2022

No.	A type of mulch material for sheltering potatoes	Dry matter, %	Starch, %	Ascorbic acid, mg kg^{-1}	Sugars, %
1	No mulching (control)	21.21	9.08	4.96	1.11
2	Straw (standard)	19.18	10.87	5.42	0.92
3	Mineral basalt wool	21.79	11.13	5.33	0.74

The effectiveness of potato mulching is largely determined by the degree of loosening of the soil surface. Depending on the method of its pre-planting preparation, the relative density and ability of the root system to penetrate into the soil depth change (Saue et al., 2010). At the same time, a significant number of stolons and tubers are formed at a certain depth, which requires additional costs during harvesting. At the same time, a significant increase in yield compensates for these costs. Depending on the number of operations during pre-planting soil preparation, the increase in productivity is from 4.5 to 13.9 t ha^{-1} compared to standard technology and from 1.3 to 10.7 t ha^{-1} compared to zero tillage (Table 10).

Table 10. The influence of pre-planting soil preparation methods on potato yield under straw mulching, the average for 2020–2022

No.	The method of pre-planting soil preparation by mulching potatoes	Yield, t ha^{-1}
1	Standard technology (control)	18.6
2	Zero tillage (standard)	21.8
3	Minimal tillage by disking after harvesting the predecessor (winter wheat)	23.1
4	Minimal tillage by disking after harvesting the precursor and pre-planting cultivation in 2 tracks	26.2
5	Minimal tillage by disking after harvesting the predecessor and pre-planting cultivation in 2 tracks and milling	32.5

Increase in total costs for zero tillage by 3.1 thousand UAH ha^{-1} compared to the standard growing technology occurs due to additional costs for mulching the surface with straw and harvesting an increased harvest. Depending on the number of operations for pre-planting soil preparation, the increase in costs is from 1.5 to 11.5 UAH ha^{-1} compared to zero tillage. However, they are compensated by the increase in productivity in these options. At the same time, the cost price of potatoes for mulching decreases from UAH 5.43 thousand t^{-1} for zero cultivation up to 4.19 thousand UAH t^{-1} with minimal processing (standard technology - UAH 6.11 thousand t^{-1}). The profitability of production under zero cultivation increases by 1.2 times, and under minimal cultivation - by 1.3-1.9 times (Table 11).

Table 11. The influence of pre-planting soil preparation methods on the economic efficiency of potato cultivation with straw mulching, the average for 2020–2022

No.	The method of pre-planting soil preparation by mulching potatoes	Total expenses, thousand UAH ha^{-1}	Cost, thousand UAH t^{-1}	Profitability, %
1	Standard technology (control)	78.6	6.11	96.3
2	Zero tillage (standard)	81.7	5.43	120.9
3	Minimal tillage by disking after harvesting the predecessor (winter wheat)	83.2	5.23	129.4
4	Minimal tillage by disking after harvesting the precursor and pre-planting cultivation in 2 tracks	86.7	4.81	149.3
5	Minimal tillage by disking after harvesting the predecessor and pre-planting cultivation in 2 tracks and milling	93.2	4.19	186.3

Thus, the effectiveness of potato mulching can be significantly improved with the use of basalt mineral wool, the use of nitrogen fertilizers and microbial preparations, as well as with various degrees of minimal processing. At the same time, there is no deterioration in the chemical composition of the soil and quality indicators of products.

CONCLUSIONS

The use of wheat straw as a mulching material allows for the improvement of the microclimate in potato plantations and increases their yield. At the same time, the use of spent mineral basalt wool as mulch can help solve the problem of its disposal and be an equivalent analog to the use of a wheat straw.

The use of nitrogen fertilizers (urea) at a dose of 30 kg ha^{-1} or microbial preparations Azotophyt-r (0.3 L t^{-1}) and Ecostern (1.5 L ha^{-1}) for mulching potatoes with wheat straw contributes to the improvement of biometric indicators and plant productivity due to the activation of biochemical and microbiological processes under the layer of mulch.

Minimal pre-planting soil preparation allows for significantly improving the efficiency of the method of growing potatoes under a layer of mulch. At the same time, additional costs for mulching are compensated by a significant increase in productivity and an increase in economic efficiency.

REFERENCES

Adamenko, T. 2017. *Agricultural drought monitoring in Ukraine: Presentation during EvIDENz Workshop 2017*.

Barnosky, A.D., Hadly, E.A., Bascompte, J., Berlow, E.L., Brown, J.H., Fortelius, M., Getz, W.M., Harte, J., Hastings, A., Marquet, P.A., Martinez, N.D., Mooers, A., Roopnarine, P., Vermeij, G., Williams, J.W., Gillespie, R., Kitzes, J., Marshall, C., Matzke, N., Mindell, D.P., Revilla, E. & Smith, A.B. 2012. Approaching a state shift in Earth's biosphere. *Nature* **486**, 52–58. doi: https://doi.org/10.1038/nature11018

Bondarenko, H.L. & Yakovenko, K.I. 2001. *Methods of research in vegetable growing and melon growing*. Kharkiv: Osnova, 369 pp. (in Ukrainian).

Chen, L., Zhu, X., Chen, J., Wang, J. & Lu, G. 2022. Effects of Mulching on Early-Spring Green Asparagus Yield and Quality under Cultivation in Plastic Tunnels. *Horticulturae* **8**, 395–401. https://doi.org/10.3390/horticulturae8050395

Copernicus Climate Change Service. 2020. *European State of the Climate 2020*.

Coppola, E., Nogherotto, R., Ciarlo', J.M., Giorgi, F., Meijgaard, E., Kadygrov, N., Iles, C., Corre, L., Sandstad, M., Somot, S., Nabat, P., Vautard, R., Levavasseur, G., Schwingshackl, C., Sillmann, J., Kjellström, E., Nikulin, G., Aalbers, E., Lenderink, G., Christensen, O.B., Boberg, F., Sørland, S.L., Demory, M.-E., Bülow, K., Teichmann, C., Warrach-Sagi, K., Wulfmeyer, V. 2021. Assessment of the European Climate Projections as Simulated by the Large EURO-CORDEX Regional and Global Climate Model Ensemble. *J. Geophys. Res. Atmos*. **126**, e2019JD032356. doi: https://doi.org/10.1029/2019JD032356

Dospekhov, V.A. 1985. Field experiment methodology. M.: Agropromizdat. 286 pp. (in Ukrainian).

Double mulching by the ridge method of growing potatoes using straw mulching material and agricultural film in the ridge zone : pat. CN110972866A. People's Republic of China: MPK A01G22/25, No. CN201911335724.0A; declared 23.12.2019; published 10.04.2020.

EU Science Hub. Severe drought in south-eastern Europe. *EU Science Hub* https://ec.europa.eu/jrc/en/scienceupdate/severe-drought-south-eastern-europe. 2020.

Hirschi, M., Seneviratne, S.I., Alexandrov, V., Boberg, F., Boroneant, C., Christensen, O.B., Formayer, H., Orlowsky, B. & Stepanek, P. 2010. Observational evidence for soil-moisture impact on hot extremes in southeastern Europe. *Nat. Geosci*. **41**, 17–21. doi: https://doi.org/10.1038/ngeo1032

https://leplants.ru/tsvetovodstvo/mineralnaya-vata-kak-substrat-v-gidroponike/.
https://openknowledge.worldbank.org/handle/10986/11860.
Huo, R., Li, L., Chen, H., Xu, C.-Y., Chen, J. & Guo, S. 2021. Extreme Precipitation Changes in Europe from the Last Millennium to the End of the Twenty-First Century. *J. Clim*. **34**, 567–588. doi: https://doi.org/10.1175/JCLI-D-19-0879.1
Hurska, A. 2020. The Risk of Water Shortage and Implications for Ukraine's Security. *Eurasia Dly*. Monit, **17**.
IPCC. Summary for Policymakers. in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. (eds. Masson-Delmotte, V. et al.). 2021.
Jodaugienė, D., Pupalienė, R., Urbonienė, M., Pranckietis, V. & Pranckietienė, I. 2006. The impact of different types of organic mulches on weed emergence. *Agronomy Research* **4**(Special issue), 197–201.
Lee, J.G., Chae, H.G., Das, S., Kim, G.W. & Kim, P.J. 2022. Cover crops offset recalcitrant soil organic carbon losses under plastic-film mulching by altering microbial functional genes. *Biology and Fertility of Soils*, 1–12. doi: https://doi.org/10.1007/s00374-022-01691-4
Li, C., Wang, N., Luo, X., Li, Y., Zhang, T., Ding, D., ... & Zhang, W. 2022. Introducing water factors improves simulations of maize stomatal conductance models under plastic film mulching in arid and semi-arid irrigation areas. *Journal of Hydrology*. doi: https://doi.org/10.1016/j.jhydrol.2022.128908
Lindsey, R. & Dahlman, L. 2021. Climate Change: Global Temperature. *NOAA Climate News.*
Liu, B., Dai, Y., Cheng, X., He, X., Wang, Y., Zhu, B., ... & Wang, L. 2022. Straw mulch improves soil carbon and nitrogen cycle by mediating soil microbial community structure in maize field. *Research Square.* doi: https://doi.org/10.21203/rs.3.rs-2183865/v1
Mclennan, M. 2021. *The Global Risks Report 2021 16th Edition Strategic Partners*.
Met Office Hadley Centre. *Impacts of Climate Change - Ukraine*. 2010.
Method of growing potatoes : pat. 149918 Ukraina: MPK A01C 9/00. No.u 2021 03701; declared 29.06.2021; published 15.12.2021, Biul. No. **50**.
Method of mechanized potato cultivation on the field surface : pat. 81963 Ukraina: MPK A01S 9/00. No. 2013 02420; declared 26.02.2013; published 10.07.2013, Biul. No. **13**.
Muraviov, V.O., Melnyk, O.V. & Dukhina, N.H. 2019. Growing potatoes (recommendations). Kharkiv: IVMB NAAS, 40 pp. (in Ukrainian).
Papdi, E., Veres, A., Kovács, F. & Juhos, K. 2022. How Different Mulch Materials Regulate Soil Moisture and Microbiological Activity. *Journal of Central European Green Innovation* **10**(Suppl 3), 26–38. doi: https://doi.org/10.33038/jcegi.3560
Pastukhov, V., Mogilnay, O., Bakum, M., Grabar, I., Melnyk, O., Kyrychenko, R., ... & Semenchenko, O. 2021. Potato growth in moisture deficit conditions. *Ukrainian Journal of Ecology* **11**(2), 184–190.
Pastukhov, V., Mogilnay, O., Bakum, M., Melnyk, O., Grabar, I., Kyrychenko, R., Krekot, M., Tesliuk, H., Boiko, V. & Sysenko, I. 2020. Energy-efficient and ecologically friendly technology for growing potatoes under straw mulch. *Ukrainian Journal of Ecology* **10**(1), 317–324.
Ren, A.T., Li, J.Y., Zhao, L., Zhou, R., Ye, J.S., Wang, Y.B., ... & Xiong, Y.C. 2023. Reduced plastic film mulching under zero tillage boosts water use efficiency and soil health in semiarid rainfed maize field. *Resources, Conservation and Recycling* **190**. doi: https://doi.org/10.1016/j.resconrec.2022.106851
Saint-gobain cultilene. Sertyfykat kachestva 113251/7.2568 TUV Nederland ot 15.01.2020 (sohlasno NEN-EN-ISO 14001:2020).
Saue, T., Viil, P. & Kadaja, J. 2010. Do different tillage and fertilization methods influence weather risks on potato yield? *Agronomy Research* **8**(Special Issue II), 427–432.

Sinkevičienė, A., Jodaugienė, D., Pupalienė, R. & Urbonienė, M. 2009. The influence of organic mulches on soil properties and crop yield. *Agronomy Research* **7**(Special issue I), 485–491.
Sun, Z., Wang, Y. & Sun, L. 2022. Effects of straw mulching on soil nutrient content and microbial community on the gentle slope arable land in dryland farming. *Archives of Agronomy and Soil Science*, 1–12. doi: https://doi.org/10.1080/03650340.2022.2160976
Timilsina, S., Khanal, A., Timilsina, C.K. & Poon, T.B. 2022. Effect of mulch materials on potato production and soil properties in high hill of Parbat, Gandaki Province, Nepal. *Journal of Agriculture and Natural Resources* **5**(1), 19–26. doi: https://doi.org/10.1080/03650340.2022.2160976
The World Bank. 2012. *Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided - Executive Summary*.
United Nations Office for Disaster Risk Reduction. 2021. *GAR Special Report on Drought 2021*. https://www.undrr.org/publication/gar-special-report-drought-2021.
Walz, Y., Dall, K., Graw, V., León, V., Juan, C., Haas, S., Kussul, N. & Jordaan, A. 2018. Understanding and reducing agricultural drought risk: Examples from South Africa and Ukraine, *Policy Report* No. **3**.
Wang, D., Wang, Z., Ding, H., Zhou, B., Zhang, J., Li, W., ... & Zong, R. 2022. Effects of biodegradable mulching films on soil hydrothermal conditions and yield of drip-irrigated cotton (Gossypium hirsutum L.). *International Journal of Agricultural and Biological Engineering* **15**(6), 153–164. doi: 10.25165/j.ijabe.20221506.7353
WEF. 2020. *The Global Risks Report 2020 Insight Report 15th Edition. Weforum.Org* https://www.weforum.org/reports/the-globalrisks-report-2019.
WMO. 2021. *State of the Global Climate 2020*. https://library.wmo.int/index.php?lvl=notice_display&id=21880#.YJfRi3VKiHt.
Xiao, L., Zhou, S., Zhao, R. & Wei, C. 2023. The net and combined effects of minimum tillage and straw mulching on carbon accumulation in global croplands. *European Journal of Agronomy* **143**. doi: https://doi.org/10.1016/j.eja.2022.126719
Zhang, D., Mak-Mensah, E., Zhou, X., Wang, Q. & Obour, P.B. 2022. Impact of Plastic Film with Wheat Straw Mulching on Maize Water Use Efficiency, Evapotranspiration, and Grain Yield in Northern China: a Meta-analysis. *Journal of Soil Science and Plant Nutrition*, 1–14. doi: https://doi.org/10.1007/s42729-022-01089-z