

INVESTIGATIONS IN TECHNOLOGICAL METHOD OF GROWING POTATOES UNDER MULCH OF STRAW AND ITS EFFECT ON THE YIELD

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Abstract. Aspirations to increase the potato yield are often connected with an attempt to apply increased doses of mineral fertilisers and herbicides. Optimum conditions for formation of potato stalks and tubers arise at the temperature 16-20 °C. A temperature above 27 °C impedes the growth of tubers. The aim of the research is to determine the impact of an agrotechnical method on potato growing under a mulching layer of straw upon the condition of the soil, the development of tubers, and their crop yield. The experiments were conducted in the years 2013-2015 with the medium early sort of potatoes “Santa”. The reference (control) variant was the traditional ridge technology of potato growing with double interrow loosening, without applying herbicides. As a result of the conducted field studies it was established that growing potatoes under a layer of straw reduces the maximum temperature of the soil and provides a possibility to produce ecologically safe food without herbicide application. In comparison with the reference value, in the experiments the potato yield reached 30-40 %

Key words: potatoes, temperature and water conditions of soil, layer of straw.

Introduction

Potatoes are a valuable foodstuff. The average yield of potatoes in Ukraine during the last 5 years was only 15.2 t·ha⁻¹, in Latvia – 18.0 t·ha⁻¹, in the countries of Western Europe – at the level of about 29.0 t·ha⁻¹ [1; 2]. An attempt to increase the productivity is often connected with application of higher norms of mineral fertilisers and uncontrolled use of herbicides for weed control. However, this attitude deteriorates the quality of the foodstuff and leaves unfavourable impact upon the surrounding environment.

The productivity of potatoes depends also on the weather conditions and the condition of the soil [3-5]. The global changes of the climate, so typical for the recent time, provoke both prolonged droughts and rain showers during the spring-summer period and lead either to the productive moisture deficiency destroying the structure of the soil or its temporary excess. The contrasting temperature differences cause an active process of moisture evaporation from the soil and have an adverse effect on formation of the potato yields [6].

It is well-known that optimal conditions for formation of potato stalks and tubers arise at the temperature 16-20 °C [7; 8]. From the tubers formed at a temperature above 23-25 °C there appears low-quality planting stock and, as a result, a considerably lower yield [9]. At the temperature of air above 27-30 °C the growth of the potato tubers stops. Therefore, it is an urgent problem how to find new potato growing agro-technical measures and technologies, which would ensure lessening of the negative impact of high temperatures and preservation of moisture in the soil.

The systems of organic farming, which find ever-growing popularity, envisage growing agricultural crops (including potatoes) with limited application of fertilisers, and without pesticides. However, the attitude to the choice of a rational cultivation technology should be based on consideration of regional soil and climate peculiarities. Unfortunately, on the whole, the ecological value of the products obtained in the system of organic agriculture is not often taken into account in the market. And this means that the producers lose material interest. Yet, the consumers, whose standards of life are improving, become more exigent to the quality of the consumed foodstuffs, and the lesser negative effect of the chemical substances on the surrounding environment finds all-round understanding and is promoted by the national normative acts [5].

It has been established in preliminary investigations that a perspective technology of organic farming is growing potatoes with the use of mulching materials, which allows improvement of the water and heat conditions of the soil and achieving full-fledged formation of the potato yield [10-11]. Depending on the material of the mulch, its colour, the mulching times, the time of the day and the period of the year, this farming method may either increase or decrease the soil temperature and

smooth out the temperature fluctuations: both heating of the soil by day and its cooling at night are reduced. Reduced heating of the soil by day under the conditions of hot climate has a positive effect on the potato plants, which display negative reaction to overheating the soil.

In order to create optimal conditions for the growth and development of potatoes, we have invested a technology of their growing under a layer of straw, excluding application of herbicides for weed control. The aim of the research is to determine the impact of the agrotechnical method of potato growing under a mulching layer of straw upon the condition of the soil, the development of tubers, and their crop yield.

Materials and methods

The experiments were conducted in the years 2013-2015 with the medium early sort of potatoes "Santa". Testing of the potato growing technology under a layer of straw was carried out at the experimental site of the Institute of Mechanisation in Vasilkovsky Region, Kiev District, with monitoring of the water and temperature conditions and evaluation of the potato yields. The reference (control) variant was the traditional ridge technology of potato growing with double interrow loosening (also without applying herbicides). The type of the soil was podzolic with elements of black soil. The basic and the pre-planting soil cultivation were the same as with the usual potato growing technology: ploughing to the depth of 25-28 cm with subsequent hoeing to the depth of 12 cm. The planting of potatoes took place during the first ten days of May, the row width being 70 cm. At the experimental sites the covering disks on the potato planters were not used but, immediately after planting, the tubers were subject to mulching with a layer of straw, 20 ± 2 cm thick, which is equivalent by weight to $4.0 \dots 4.5 \text{ kg} \cdot \text{m}^{-2}$ (Fig.1). Mulching was carried out using machines for the disintegration and distribution of straw on animal farms. In addition, to achieve higher accuracy of the experiments, checkup and manual correction of the thickness of the layer of straw were carried out. The experiments were conducted according to a standard methodology [12] with threefold repetition but the experimental data were processed by mathematical and statistical methods with the help of the programme Matlab. The plots for comparison of the potato crop capacity were 80.0 m long and 5.6 m wide. They were situated next to each other. The experiments were repeated 3 times. The plots were located on a smooth, sunny place with orientation of the rows of potatoes from north to south. In order to determine the potato crop capacity more accurately, the potatoes were dug out by hand; the tubers were cleaned from soil, weighed with accuracy ± 2 g. In order to determine the weight fraction of the tubers, each tuber was weighed separately.



Fig. 1. A view of a plot of the potato field after planting and mulching with straw

Results and discussion

The mulching layer of straw over the growing region of potatoes serves as a thermal insulator preventing overheating of the soil surface during the hot hours of the day. The results of the conducted experimental studies showed that, in order to grow potatoes under a layer of straw, the daily temperature of the soil surface in sunny days varies within the limits from 16.5 to 20.5 °C (i.e. it is in

the optimal range for the growth and development of the potato plants in the region). The temperature on the reference (control) plot varies within the limits 16.0-32.0 °C, that is, the potato plants are under a stress condition one third of the twenty-four hour period, which has an adverse effect on formation of a full-fledged yield (Fig. 2).

In the experiments of the year 2015 it was found that provision of the potato plants with moisture under a layer of straw in the region of the root crop formation was uniform during the entire period of vegetation, whereas in the ridges there was its deficit. For instance, the absolute moisture of the soil under the layer of straw at the budding and blossoming stage of the potato plants (Fig. 3) was within the limits 16.1...16.2 %, at the stage of the yield formation – 13.7 %, while in the ridges – 9.3...14.0 % and 6.4...7.8 % respectively.

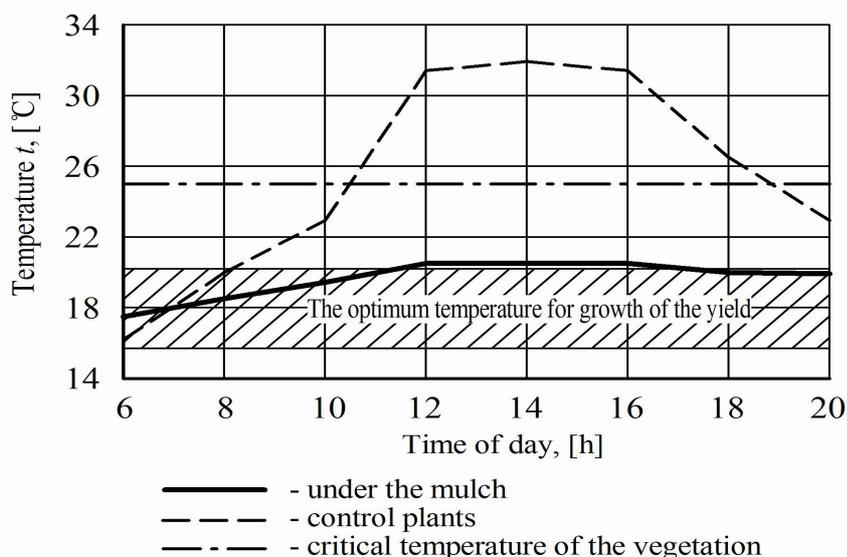


Fig. 2. Dynamics of the daily temperature of the soil surface (a sunny day in the middle of July with a daily temperature of air +25...+28 °C)

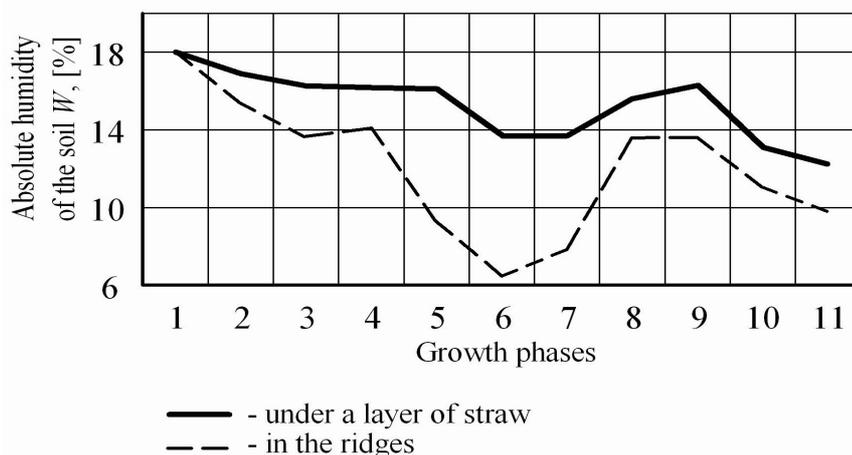


Fig. 3. Dynamics of absolute moisture of the soil in the region of the tuber location during the potato vegetation, in percent. Stages of development: 1 – planting; 2 – appearance of sprouts; 3 – appearance of sprouts; 4 – start of budding; 5 – start of blossoming; 6, 7, 8 – accumulation of the yield; 9 – start of yellowing of the leaves; 10 – atrophy of the leaves; 11 – harvesting

The mulching layer of straw protects the soil from overheating and heavy penetration of solar radiation. Therefore, moisture evaporates insignificantly, which makes it possible to maintain a favourable water balance in the soil. In many regions the moisture deficiency is a factor that limits the growth of the potato plants, and in such regions skilful application of mulching may not only raise the crop capacity but also help saving the irrigation water. Besides, in comparison with the control plot,

conditions improved for the vital activity of soil microorganisms, enhancing the decomposition rate of the organic matter, which leads to better provision of soil with nutrients. Thus, in the experiments (23.06.2014) the nitrogen content in the layer of soil 0-10 cm, covered with straw, was by 45 % higher than in the control plot.

As a result of three year experimental investigations it was established that straw is a reliable way of weed control – during the entire vegetation period of the potato plants the mulched plot was actually free of weeds (Fig. 4).



Fig. 4. A view of an experimental plot during the potato vegetation

Owing to this, there was no need anymore for weed control either by mechanical or chemical means. The reference (control) plot was situated to the right and to the left from the plot mulched with straw, which, after several loosening and hoeing, is overgrown with weeds, particularly at the end of vegetation. Therefore, growing potatoes under a layer of straw makes it possible not only to reduce the impact of the weather conditions upon the yield formation but also to grow them in the organic farming system and obtain also an ecologically pure product without herbicide application.

In order to raise the crop yield of potatoes, it is expedient in this case to apply both the organic fertilisers and siderates. Such investigations, taking into consideration the expenses, will be made by us later on. To protect the potato plants from the Colorado beetle, one should apply the biological preparations actofit and bitoxibacilline. By providing favourable conditions for growing potatoes under a layer of straw the crop yield of potatoes on the experimental plots was by 30-40 % higher than on the reference (control) plot (Table 1).

Table 1

Data about the crop yield of potatoes on the comparative plots

Crop yield of potatoes on the plots, t·ha ⁻¹					
Year 2013		Year 2014		Year 2015	
Under a layer of straw	In ridges (control)	Under a layer of straw	In ridges (control)	Under a layer of straw	In ridges (control)
42.21	24.14	23.41	19.49	21.48	18.35
30.04	26.10	26.70	18.50	23.85	13.17
30.20	21.53	27.69	20.35	22.67	15.76
Average value of the crop capacity on the plots					
34.15	23.92	25.93	19.45	22.67	15.76
Coefficient of variation, %					
18.8	8.6	5.2	9.6	4.8	16.4
Minimal essential difference LSD _{0,5} (variety) = 6.21 t·ha ⁻¹					

Statistical processing of the experimental data shows that the minimal essential difference $LSD_{0,5}$ is less than the actual average difference between the variations, which confirms the hypothesis about increased crop capacity of potatoes under a layer of straw in contrast to the reference (control) plots.

One of the positive sides of mulching is an increased weight ratio of the potato tubers with a mass over 120 grams (Fig. 5). The ratio of such tubers under the layer of straw was 54.6 %, while on the reference (control) plots it was 37.3 %.

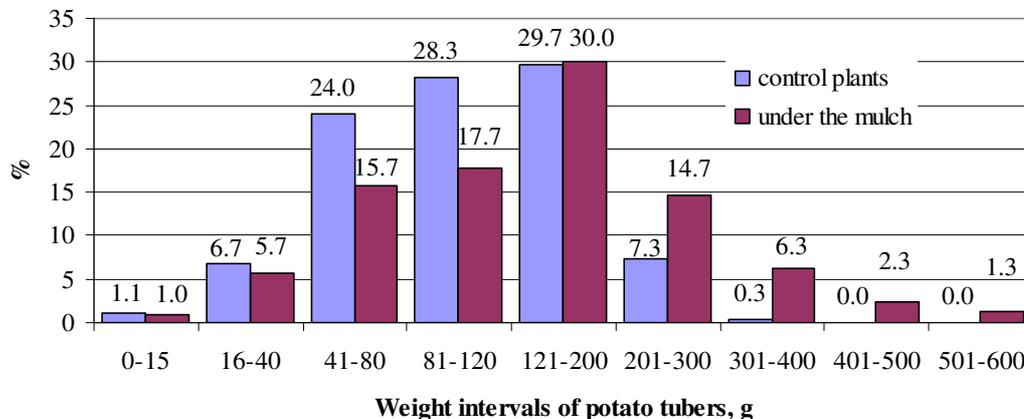


Fig. 5. Weight distribution of the potato tubers by fractions

Growing potatoes under the mulching layer of straw eliminates late interrow loosening with the accompanying damage of the roots. Availability of straw on the surface prevents appearance of an unfavourable crust over sticky soils.

As the three year observations showed, the medium early and early sorts of potatoes are better suitable for growing potatoes under a layer of straw. At the moment of harvesting their leaves die off completely simplifying the straw removal before the potato harvest. It is recommended to use clean straw of cereals without remaining seeds that can germinate in the soil.

In addition, the tubers of potatoes grown under a layer of straw have a regular, not a deformed shape. They are located in a layer of soil less than 10 cm and partly on the surface. The tubers of potatoes which are placed on the surface of soil do not turn green under the layer of straw (Fig. 6). The tubers of potatoes grown in ridges are placed in the soil 5-20 cm deep.



Fig. 6. Yield of potatoes grown under a layer of straw

In the future it is intended to carry out more extensive production tests in order to adjust the implementation technology of the particular agrotechnical method and estimate the economic efficiency of using definite technical means.

Conclusions

1. Mulching potatoes with a layer of straw, 20 cm deep, provides a possibility to improve the temperature condition of the soil, to optimise the microclimate and creates favourable conditions for the development of the tubers.
2. By using the agrotechnical method of growing potatoes under a mulching layer of straw the average additional yield, in comparison with the potatoes grown on the reference (control) plots, was: in the year 2013 – 42.7 %, in 2014 – 33.3 %, in 2015 – 43.8 %.

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